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**FORTESCUE METALS GROUP LTD
MT MACLEOD PROJECT
TERRESTRIAL VERTEBRATE FAUNA ASSESSMENT**

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ecologia Environment
 Level 8 Carillon City
 PERTH WA 6000
 Phone: 08 6180 4450
 Fax: 08 6180 4451
 Email: admin@ecologia.com.au

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ACRONYMS

ANOSIM	Analysis of Similarity
BoM	Bureau of Meteorology
CAMBA	China-Australia Migratory Bird Agreement
DEC	Department of Environment and Conservation (now DPaW)
DEWHA	Department of Environment, Water, Heritage and the Arts
DPaW	Department of Parks and Wildlife (formerly DEC)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
FMG	Fortescue Metals Group Limited
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australian Migratory Bird Agreement
MDS	Multidimensional Scaling
NHMRC	National Health and Medical Research Centre
PEC	Priority Ecological Community
PRI	Pilbara Regional Inventory
SAC	Species Accumulation Curve
TEC	Threatened Ecological Community
WAM	Western Australian Museum
WC Act	<i>Wildlife Conservation Act 1950</i>

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EXECUTIVE SUMMARY

Fortescue Metals Group commissioned *ecologia* Environment to undertake a Level 2 vertebrate fauna and targeted conservation significant fauna assessment of the Mt Macleod study area (study area). The study area is located immediately south of Fortescue's Solomon hub (Kings and Firetail mines), and approximately 40 km north of Tom Price. The study area comprises a total area of 10,144 ha and is divided in two separate areas (Mt Macleod North and Mt Macleod South). A Level 2 fauna assessment was previously undertaken by Rapallo (2011), to identify the location and extent of fauna habitat types and areas that support conservation significant species. This information was reviewed and utilised to establish a survey design for the second phase of the Level 2 vertebrate fauna and targeted conservation significant fauna assessment, the results of which are summarised in this document.

Several databases were consulted in the preparation of potential fauna (and conservation significant fauna) lists. The database searches and review of publications reporting on 29 vertebrate fauna surveys resulted in a total of 42 native and 11 introduced mammal, 163 bird, 108 reptile, nine amphibian and six fish species potentially occurring in the study area. Of these, 34 species are of conservation significance (nine species of mammal, 20 species of bird, four species of reptile and one species of fish).

The Level 2 vertebrate fauna survey was conducted from 3rd-13th May 2013, with a targeted conservation significant fauna survey conducted from 16th-24th July 2013. During these surveys, a total of nine trapping sites (eight during the Level 2 vertebrate fauna assessment, one during the targeted conservation significant fauna assessment) were established in six different habitat types. In addition, 15 opportunistic survey sites were located in habitat not suitable for trapping due to access limitations or difficulties in the establishment of pit-fall traps.

Survey effort expended during the Level 2 survey within the study area is presented in Table 3.6 and included the following:

- Systematic trapping grids (pit traps, funnels, Elliott traps and cage traps) were open for 2,769 trap-nights.
- Approximately 15 hours were spent surveying for birds.
- 15.6 hours were spent on opportunistic diurnal searching at 11 locations.
- 8.7 hours were spent on opportunistic nocturnal searching at four locations.
- Three motion-sensing cameras were deployed for a total of 103 hours.
- 120 hours of SM2BAT recordings were collected from 10 sites to determine bat assemblage and distribution.

Survey effort expended during the targeted survey within the study area is presented in Table 3.6 and included the following:

- Cage traps targeting Northern Quoll were open for 417 trap-nights.
- 51.5 hours were spent on opportunistic diurnal searching for secondary evidence of the Northern Quolls, Pilbara Olive Python and cave structures to provide habitat for the Pilbara Leaf-nosed Bat.
- Six motion-sensing cameras were deployed for a total of 702 hours to determine the absence or presence of Northern Quolls and Pilbara Olive Pythons.
- 144 hours of SM2BAT recordings were collected from four sites to detect the absence or presence of the Pilbara Leaf-nosed Bat and Ghost Bat.

The vertebrate fauna assessment identified five broad scale fauna habitats from the study area:

- Woodland (open);
- Hummock grassland;
- Hilltop/ridge/cliff;
- Plain(stony gibber);
- Plain(cracking clay); and
- Drainage line/river/creek.

All five fauna habitats within the study area were sampled with systematic trapping sites during the current survey. A one-way ANOSIM test and MDS plot of the trapping sites within the different habitat types was completed for data collected systematically for both birds and terrestrial trapped fauna. The results from these statistical analyses indicate that there is a slight (not significant) difference between the habitat types for both avifauna and terrestrial fauna.

Survey effort was considered adequate for sampling all fauna habitat types within the study area. Statistical analysis of the observed fauna assemblage recorded during the Level 2 vertebrate fauna assessment suggests that 85% of the expected avifauna and 71% of the expected terrestrial trappable fauna was recorded during this survey.

During the survey, a total of 18 native and one introduced mammal, 63 bird, 28 reptile and two amphibian species were recorded.

Fifteen conservation significant species were assessed as having a medium to high likelihood of occurrence within the study area, with the remaining 19 species assessed as having a low likelihood of occurrence. Four species of conservation significance were recorded, the Short-tailed Mouse, Western Pebble-mound Mouse, Australian Bustard and Rainbow Bee-eater. In addition to these, one species, Gane's blindsnake was recorded during the first phase of surveying in 2011 within the study area and 4 km outside the study area during the current survey.

1 INTRODUCTION

1.1 PROJECT OVERVIEW

Fortescue Metals Group Limited (Fortescue) is developing the Pilbara Iron Ore and Infrastructure Project, which includes a series of iron ore mines and associated rail and infrastructure in the Pilbara region of Western Australia. Fortescue is investigating options to expand its Pilbara mining operations to include three tenements in the Western Pilbara known as Mt Macleod (M47/1477, E47/1390 and E47/1391). Mt Macleod is located immediately south of Fortescue's Solomon hub (Kings and Firetail mines), and approximately 40 km north of Tom Price (Figure 1.1). Mt Macleod comprises a total area of 10,144 ha and consists of two separate areas, Mt Macleod North and Mt Macleod South.

As part of these investigations, Fortescue commissioned *ecologia* Environment (*ecologia*) to undertake the second phase of the Level 2 terrestrial vertebrate fauna survey, habitat assessment and targeted conservation significant fauna assessment of the Mt Macleod study area. This survey will assist with environmental approvals for proposed exploration and development in the study area.

1.2 LEGISLATIVE FRAMEWORK

The *Environmental Protection Act 1986* (EP Act) is "an Act to provide for an Environmental Protection Authority, for the prevention, control and abatement of environmental pollution, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing." Section 4A of this Act outlines five principles that must be addressed meet the objectives of the Act. Three of these principles are relevant to native fauna and flora:

The Precautionary Principle

Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

The Principle of Intergenerational Equity

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

The Principle of the Conservation of Biological Diversity and Ecological Integrity

Conservation of biological diversity and ecological integrity should be a fundamental consideration.

In addition to these principles, projects undertaken as part of the Environmental Impact Assessment (EIA) process are required to address guidelines produced by the Environmental Protection Authority (EPA), in this case:

- Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004);
- principles outlined in EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002); and
- the *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010).

Native flora and fauna in Western Australia that are formally recognised as rare, threatened with extinction, or as having high conservation value are protected at a federal level under the

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and at a state level under the *Western Australian Wildlife Conservation Act 1950* (WC Act).

The EPBC Act also considers four international agreements related to migratory species, which include the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), the Japan-Australian Migratory Bird Agreement, the China-Australia Migratory Bird Agreement and the Republic of Korea-Australian Migratory Bird Agreement.

The EPBC Act was developed to provide for the protection of the environment, especially those aspects of the environment that are matters of national environmental significance, to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources, and to promote the conservation of biodiversity. The EPBC Act includes provisions to protect native species (and in particular to prevent the extinction and promote the recovery of threatened species) and to ensure the conservation of migratory species. In addition to the principles outlined in Section 4A of the EP Act, Section 3A of the EPBC Act includes a principle of ecologically sustainable development dictating that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations. Schedule 1 of the EPBC Act contains a list of species that are considered Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable and Conservation Dependent.

The WC Act provides for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora and fauna within Western Australia is protected; however, the Minister may, via a notice published in the *Government Gazette*, declare a list of fauna identified as rare, likely to become extinct, or otherwise in need of special protection. These species are considered Threatened Fauna. The current listing was gazetted in November 2012.

In addition, the Department of Parks and Wildlife (DPaW) maintains a list of specially protected fauna, which includes Threatened and Priority Fauna, ranked in order of priority for conservation management. Threatened fauna listed in Schedule 1 of the WC Act are further ranked by the DPaW according to their level of threat using IUCN Red List categories and criteria. Priority Fauna are placed into five categories. The first three Priority Fauna categories are species that have not yet been adequately surveyed to be listed under Schedule 1 or 2. Species that are adequately known and are rare but not threatened, meet IUCN criteria for Near Threatened, or that have been recently removed from the Threatened list for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Species meeting criteria for the IUCN category of Conservation Dependent are placed in Priority 5.

Definitions of conservation categories as used by the DPaW and as defined in the EPBC Act and the WC Act are provided in Appendix A.

1.3 SURVEY OBJECTIVES

Fortescue commissioned *ecologia* to undertake a comprehensive biological survey of the terrestrial vertebrate fauna of the Mt Macleod study area, to contribute to the environmental approval process for the project.

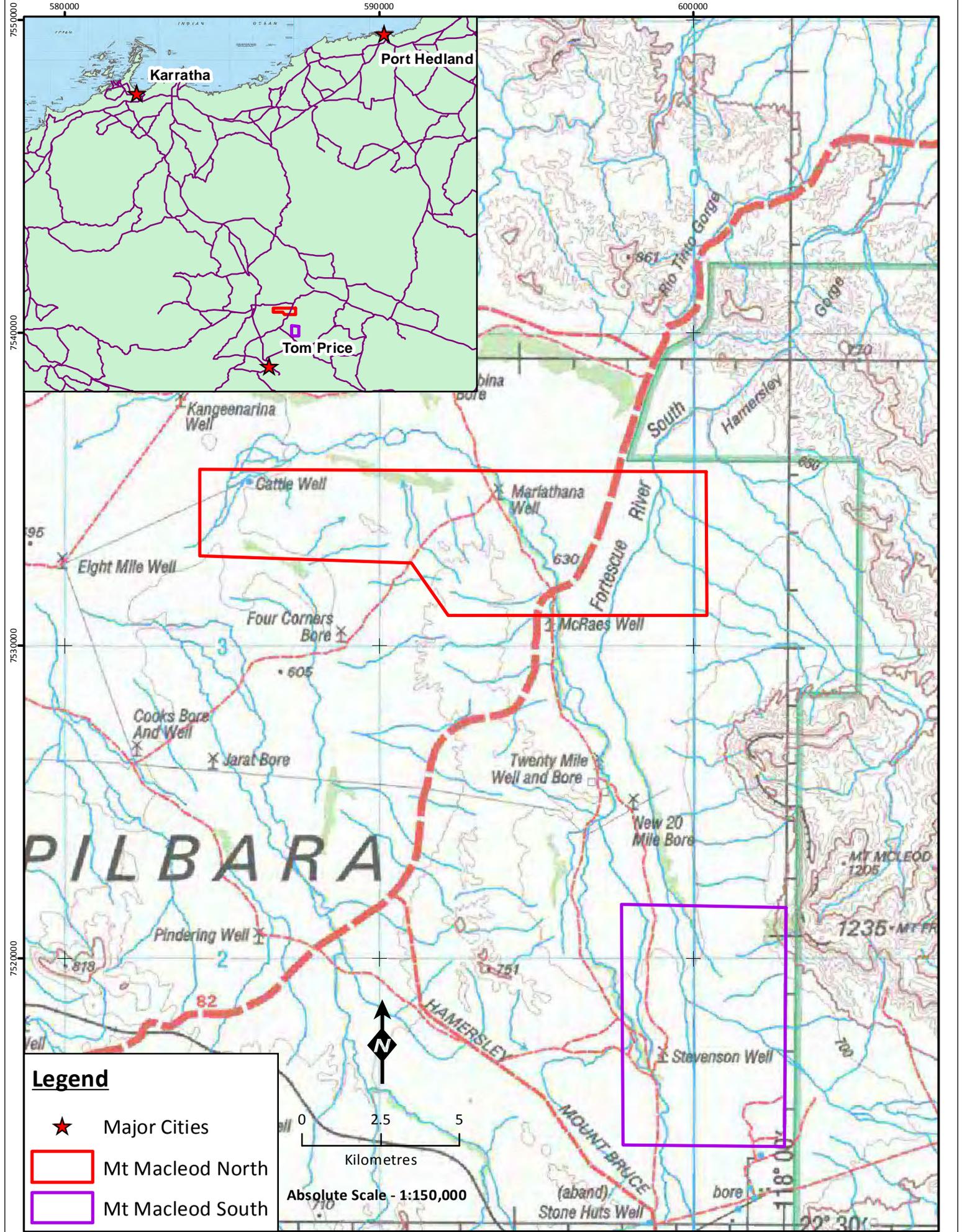
The EPA's objectives with regard to fauna management are to:

- maintain the abundance, species diversity and geographical distribution of terrestrial fauna; and
- protect Specially Protected (Threatened) fauna, consistent with the provisions of the WC Act.

Hence, the aim of this study was to provide sufficient information for the EPA to assess the impact of the project on the vertebrate fauna populations that occur in the areas associated with the project, thereby informing assessment against the relevant EPA objectives.

Specifically, the objectives were to undertake a survey that satisfies the requirements documented in *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*, EPA Guidance Statement No. 56 and Position Statement No. 3, thus providing:

- a review of background information (including literature and database searches);
- an inventory of vertebrate fauna species occurring in the study area, incorporating recent published and unpublished records;
- a discussion of the species of biological and conservation significance recorded or likely to occur within the study area and surrounds;
- a description of fauna habitats occurring in the study area;
- a description of the characteristics of the faunal assemblage;
- an appraisal of the current knowledge-base for the area, including a review of previous surveys conducted in the area that are relevant to the current study;
- a review of regional and biogeographical significance, including the conservation status of species recorded or likely to occur in the study area;
- a single phase Level 2 vertebrate fauna assessment, including systematic trapping, observations, acoustic bat recording and overall assessment of the faunal assemblage recorded within the study area; and
- a targeted conservation significant fauna assessment of EPBC listed species identified to potentially occur during the Level 2 vertebrate fauna assessment.



Legend

- ★ Major Cities
- ▭ Mt Macleod North
- ▭ Mt Macleod South

Absolute Scale - 1:150,000

Location of the Mt Macleod study area

Figure: 1.1
Project ID: 1514

Drawn: CK
Date: 30/08/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CK020



2 EXISTING ENVIRONMENT

2.1 CLIMATE

The Mt Macleod study area is located in the Pilbara region of Western Australia, where the climate is arid-tropical, with two distinct seasons: a hot summer from October to April and a mild winter from May to September (BoM 2014). Temperatures are generally high, with summer temperatures frequently exceeding 40°C. Light frosts occasionally occur inland during July and August (BoM 2014).

Rainfall is generally localised and unpredictable (some years have recorded zero rainfall), and temperatures are high, resulting in annual evaporation exceeding rainfall by as much as 500 mm per year. Most of the Pilbara has a bimodal rainfall distribution (BoM 2014). Nearly 75% of the yearly rainfall is associated with thunderstorms and cyclonic activity between the months of December and March. Cold fronts continue to bring somewhat less rain to the region until June. Surface water can be found in some pools and springs in the Pilbara all year round, although watercourses generally flow intermittently due to the short wet season (Beard 1975).

Average rainfall and temperature data for the study area were obtained from the nearest Bureau of Meteorology (BoM) station Hamersley (Site No. 005005) located 14 km west of Mt Macleod North and 33 km north-west of Mt Macleod South. This location has a typical Pilbara climate of hot summers with sporadic summer storms and warm, dry winters (Figure 2.1). Hamersley has an average annual rainfall of 384.0 mm based on data from 1912 to 2013 (BoM 2014). Hamersley's rainfall data, although incomplete, depicts higher (92.4 mm) than average rainfall for the month of April, which preceded the survey (Table 2.1).

The nearest BoM station to the study area with complete rainfall data is Wittenoom (Site No. 005026), approximately 40 km east of the study area. In addition, a weather station was set up within the Solomon Mine in September 2012. The recorded rainfall data is displayed in Table 2.1 below and is in a similar range as the data recorded in Wittenoom. The table shows that Wittenoom has an average annual rainfall of 461.7 mm based on data from 1912 to 2013 (BoM 2014). Data from the Wittenoom station and the Solomon Mine weather station show that rainfall in the vicinity of the study area in the three months prior to the Level 2 survey (February to April) was below average (Figure 2.1). Conversely, above-average rainfall of 339.87 mm (Solomon Mine) and 430.6 mm (Wittenoom) was recorded for the month of January.

Table 2.1 – Rainfall for the 12 months preceding the survey (BoM 2014)

Month	Weather station Solomon Mine	Wittenoom		Hamersley	
	Mean rainfall in preceding months (mm)	Mean rainfall in preceding 12 months (mm)	Mean rainfall 1950–2013 (mm)	Mean rainfall in preceding 12 months (mm)	Mean rainfall 1912–2013 (mm)
May	-	0	27.2	182.3	24.3
June	-	13	27.8	6.4	25.2
July	-	0	13.9	85.2	10.5
August	-	0	8.5	25.6	7.1
September	0	0	3.2	-	2.2
October	0	24.2	3.9	6.8	5.1
November	0	0	9.4	-	11.7
December	124.41	64.4	49.6	-	36.1
January	339.87	430.6	113.7	-	84.2
February	59.21	20.6	109	-	83.8
March	23.4	23.4	69	-	68
April	33.4	11.2	28	119.2	26.8

Source: BoM (2014)

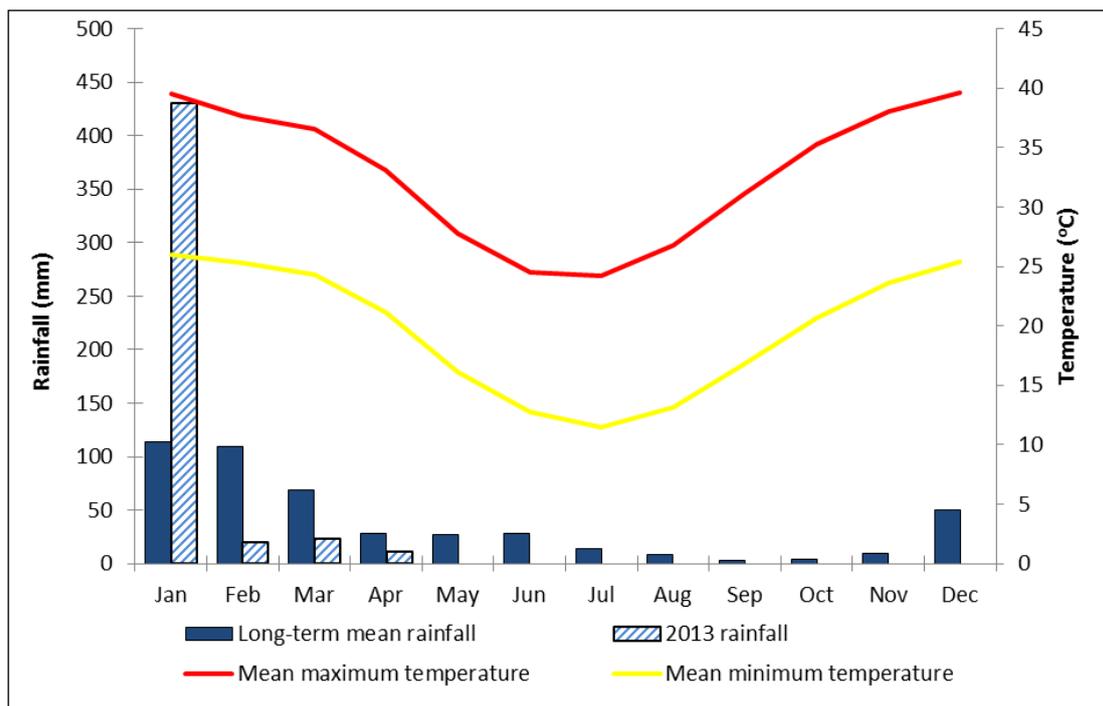


Figure 2.1 – Climatic data for the Wittenoom weather station (1950-2013, BoM 2014)

2.2 WEATHER DURING SURVEY

The weather conditions experienced during the fauna survey, as recorded by the Wittenoom Aero weather station (BoM 2014), are listed in Appendix B. The Level 2 vertebrate fauna assessment was conducted from 3rd-13th May 2013. The weather during the survey was warm, with an average daily maximum of 31.4°C and minimum of 18.1 °C. Based on the mean climatic data (Figure 2.1), these temperatures were within the normal range for the time the survey was conducted.

The targeted conservation significant fauna assessment was conducted over a nine day period, from 16th-24th July 2013. The weather during this survey was significantly cooler, with an average daily maximum of 23.8 °C and minimum of 11.8 °C. Based on the mean climatic data (Figure 2.1), these temperatures were within the normal range for the time the targeted survey was conducted.

The amount of rainfall recorded at the Wittenoom weather station in January 2013 was more than four times the mean for January. Following the heavy rainfall in January, precipitation was close to average for the three months preceding the survey. A single day of rain (0.2mm) was recorded on site during the Level 2 vertebrate fauna assessment (May) and no rain was recorded during the targeted conservation significant fauna assessment (July).

2.3 BIOGEOGRAPHY

The Mt Macleod study area is situated within the Pilbara region of the Interim Biogeographic Regionalisation of Australia (IBRA), version 7 (DSEWPaC 2013a). The Pilbara biogeographic region comprises four subregions: Hamersley, Fortescue Plains, Chichester and Roebourne. The Mt Macleod study area is situated entirely in the Hamersley (PIL3) subregion (Figure 2.2).

The Hamersley subregion of the Pilbara is generally characterised by mountain ranges and plateaux of Proterozoic sedimentary rock, dissected by gorges (Kendrick 2001). This structure is noticeable in areas surrounding the study area, with significant hilltops, hillslopes and gorges, especially given the proximity of the study area to Karijini National Park, however the majority of the study area is

situated on a flat to slightly undulating sedimentary plain at the base of the rocky ranges and plateaux.

The typical vegetation of the Hamersley subregion is low mulga woodland over tussock grasses on the fine soils in valley floors, combined with snappy gum (*Eucalyptus leucophloia*) over spinifex (*Triodia brizoides*) on the skeletal soils of the ranges (Kendrick 2001).

2.4 LAND SYSTEMS

Land systems are described using the biophysical characteristics of geology, landforms, vegetation and soils (van Vreeswyk *et al.* 2004a). Van Vreeswyk *et al.* (2004b) undertook a regional inventory of the Pilbara rangelands to document the land systems present and their condition. The Pilbara Regional Inventory (PIR) covered 181,723 km², bounded by the Indian Ocean and Roebourne Plains to the north and west, extending to Broome in the north-east and the Ashburton River catchment in the south.

The study area intersects five of the land systems mapped by van Vreeswyk *et al.* (2004a) (Table 2.2, Figure 2.3). The largest land system within the study area is the Boolgeeda land system, occupying 38.5% of the study area. This land system typically consists of stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands. Other land systems of the study area include Jurawarrina (36.9%), Newman (14%), Brockman (5.5%) and Egerton (5.1%), all of which typically consist of shrublands and/or tussock and spinifex grasslands (Table 2.2). All land systems are well represented outside of the study area, with less than 1% of each land system described within the study area (Table 2.2).

Table 2.2 – Land systems of the study area

Land System	Description	Survey Sites	Total Area in Western Australia (ha)	Area in the Mt Macleod study area (ha)	Extent in the Mt Macleod study area (%)	Extent of the total WA area in the Mt Macleod study area (%)
<i>Land type 18 - Stony plains with spinifex grasslands</i>						
Boolgeeda	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands.	MM05, MM07	99,960,861	3,910	38.5	0.004
<i>Land type 31 - Wash plains on hardpan with mulga shrublands</i>						
Jurawarrina	Hardpan plains and alluvial tracts supporting mulga shrublands with tussock and spinifex grasses.	MM03, MM06, MM09	6,647,469	3,742	36.9	0.06
<i>Land type 2 - Hills and ranges with spinifex grasslands</i>						
Newman	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.	MM02, MM10	199,977,138	1,418	14.0	0.001
<i>Land type 39 - Alluvial plains with tussock grasslands</i>						
Brockman	Gilgai alluvial plains with cracking clay soils supporting tussock grasslands.	MM04, MM08	7,410,806	558	5.5	0.01
Egerton	Highly dissected hardpan plains supporting mulga shrublands and hard spinifex hummock grasslands.	MM01	392,474	517	5.1	0.13

2.5 VEGETATION

The vegetation of Western Australia was originally mapped at a 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the National Vegetation Information System standards (Shepherd *et al.* 2002). The study area lies within the Eremaean Botanical Province of the Pilbara (Beard 1975). Three vegetation associations (Beard's units 18, 82 and 175) occur in the study area (Shepherd *et al.* 2002) and are described Table 2.3 and displayed in Figure 2.4.

Low woodland with mulga (*Acacia aneura*) is the most dominant vegetation type (18) accounting for 46.7% of the study area. The remaining 53.3% is represented by short bunch grassland savannah/grass plain vegetation type (175) (37.9%) and hummock grasslands with snappy gum over *Triodia wiseana* vegetation type (82) (15.3%). Broadly, all of these vegetation associations are well represented outside of the study area.

Table 2.3 – Vegetation associations of the study area

Shepherd/Beard Vegetation Unit	Vegetation Description	Total Area in WA (ha)	Area in the study area (ha)	Percent of study area (%)	Percent of Total Vegetation Unit (%)
18	Low woodland; mulga (<i>Acacia aneura</i>)	24,751,239	4745 ha	46.6	0.8
175	Short bunch grassland - savanna/grass plain	685,785	3844 ha	37.9	0.5
82	Hummock grasslands, low tree steppe; snappy gum over <i>Triodia wiseana</i>	2,565,571.7	1555	15.3	0.06

(Shepherd *et al.* 2002)

2.6 PREVIOUS SURVEYS AND LAND USE

Several databases were consulted in the preparation of potential fauna (and conservation significant fauna) lists (Table 2.4). In addition, 28 publications reporting on vertebrate fauna surveys conducted within 100 km of the study area were consulted (Table 2.5). The results of all database searches and previous surveys are presented in Appendix C. The online NatureMap database encompasses several datasets which include the WA Museum (WAM), DPaW Threatened and Priority Fauna database and DPaW Survey Returns database.

The Mt Macleod study area is within the Hamersley pastoral lease. Karijini National Park is situated approximately 6 km east of Mt Macleod North and is adjacent to the Mt Macleod South study areas (DPaW 2014).

Table 2.4 – Fauna databases searched

Database	Custodian	Search Details
NatureMap	DPaW	40 km radius around the centre of the study area. Coordinates: 596105 e; 7519076 n Date accessed: 28/03/2013
Species Profile and Threats (SPRAT) Database	Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)	Records within 100 km of the study area from point 22°23'22.87"S 117°45'58.47"E
Birdata	BirdLife Australia	Records within one degree of the study area Date accessed: 28/03/2013

Database	Custodian	Search Details
Threatened and Priority Fauna Database	DPaW	Rectangle around study area with a 50 km buffer from point 22°23'22.87"S 117°45'58.47"E

Table 2.5 – Previous biological survey reports within 100 km of the study area

Survey Location and Author(s)	Distance to Study area (km)	Comments
Internal <i>ecologia</i> database	15 – 100	Two level 1 and seven level 2 vertebrate fauna surveys. Three conservation significant fauna surveys.
Mt Macleod (Rapallo 2011)	0	Single-phase Level 2 survey
Mt Macleod West (Ecoscape 2013)	9	Level 1 survey
Solomon Hub (<i>ecologia</i> 2014a)	15	Single-phase Level 2 survey
Central Pilbara Project Mine (<i>ecologia</i> 2011a)	15	Two phase level 2 survey
Marandoo to Great Northern Highway Road (Kendrick 1995)	15	Single-phase Level 2 survey
Solomon King Area (<i>ecologia</i> 2010)	15	Single-phase Level 2 survey
Solomon Mine (Coffey 2008)	15	Single-phase Level 2 survey
Firetail (Ecoscape 2010c)	15	Level 1 survey
Solomon Rail Re-alignment (Ecoscape 2010b)	20	Level 1 survey
Solomon Rail Camps 1, 2, 3 (Ecoscape 2010a)	20	Level 1 survey
Hamersley Range National Park (Muir 1983)	25	Single-phase Level 2 survey
Marandoo Mine (Biota 2008)	27	Two-phase Level 2 survey
West Turner Syncline Section 10 Development (Biota 2009)	38	Two-phase Level 2 survey
Brockman 2 Detritals (Mattiske and Ninnox 1990)	50	Level 1 survey
Brockman Syncline 4 (Biota 2005)	64	Single-phase Level 2 survey
Northern Transport Corridor Option (Ninnox 1995)	73	Level 1 survey
Raven (Ecoscape 2012e)	84	Level 1 survey
Western Range (Biota 2011)	93	Two-phase Level 2 survey
Flying Fish (Ecoscape 2012c)	94	Level 1 survey
Eliwanna (Ecoscape 2012b)	94	Level 1 survey

2.6.1 Results of literature review

The database searches and review of publications reporting on 29 vertebrate fauna surveys (Table 2.5) resulted in a total of 42 native and 11 introduced mammal, 163 bird, 108 reptile, nine amphibian and six fish species potentially occurring in the study area (Table 2.6). Of these, 34 species are of conservation significance (10 species of mammal, 20 species of bird, three species of reptile and one species of fish). Previous records of conservation significant fauna from the surrounding region are mapped in Figure 2.5, Figure 2.6 and Figure 2.7, and discussed in greater detail in Section 5.2.

Table 2.6 – Number of species recorded during previous surveys and database searches

Source/Report	Mammals (Native/introduced)	Birds	Reptiles	Amphibians	Fish
Internal <i>ecologia</i> database	29/4	99	71	2	2
Mt Macleod (Rapallo 2011)	13/1	82	51	0	0
Mt Macleod West (Ecoscape 2013)	4/2	34	12	1	0
Solomon Hub (<i>ecologia</i> 2014a)	20/3	80	68	3	4
Central Pilbara Project Mine (<i>ecologia</i> 2011a)	24/4	100	84	4	0
Marandoo to Great Northern Highway Road (Kendrick 1995)	15/3	67	49	3	0
Solomon King Area (<i>ecologia</i> 2010)	22/3	92	55	3	4
Solomon Mine (Coffey 2008)	20/3	63	73	4	0
Firetail (Ecoscape 2010c)	18/2	63	48	1	0
Solomon Rail Re-alignment (Ecoscape 2010b)	1/1	17	0	0	0
Solomon Rail Camps 1, 2, 3 (Ecoscape 2010a)	2/2	14	6	0	0
Hammersley Range National Park (Muir 1983)	21/1	135	86	6	0
Marandoo Mine (Biota 2008)	9/2	55	47	3	0
West Turner Syncline Section 10 Development (Biota 2009)	18/2	68	52	1	0
Brockman 2 Detritals (Mattiske and Ninnox 1990)	4/4	64	15	0	0
Brockman Syncline 4 (Biota 2005)	15/4	82	54	2	0
Northern Transport Corridor Option (Ninox 1995)	4/2	46	5	1	0
Raven (Ecoscape 2012e)	3/0	37	7	0	0
Western Range (Biota 2011)	8/1	51	39	1	0
Flying Fish (Ecoscape 2012c)	5/3	38	1	0	0
Eliwana (Ecoscape 2012b)					
NatureMap (DPaW 2014)	32/5	138	98	7	3
DPaW Threatened Fauna Database	7/0	14	3	0	0
SPRAT Database	5/9	12	1	9	0
Birdata	N/A	122	N/A	N/A	N/A
Total	42/11	163	108	9	6

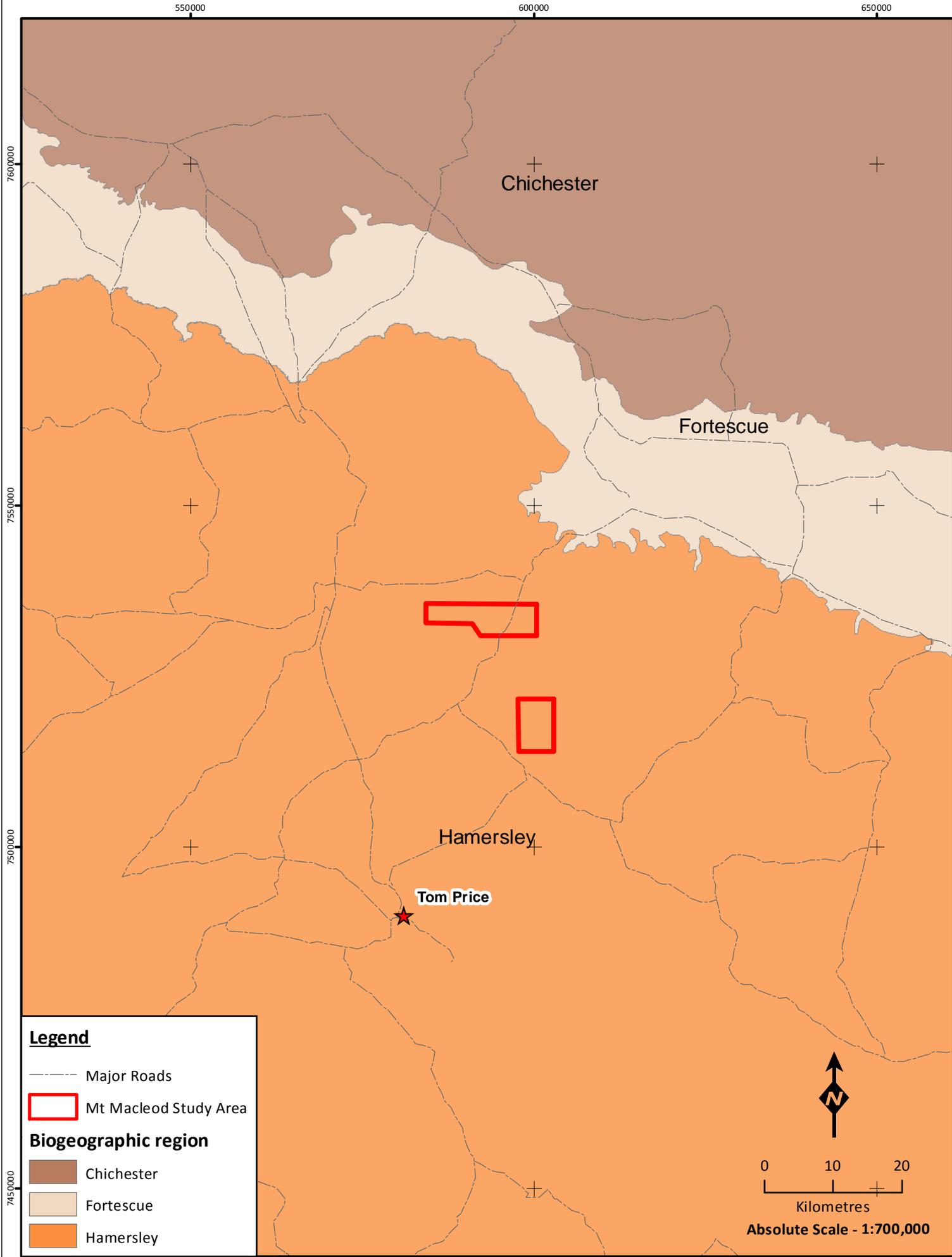
Potential habitat of the Northern Marsupial Mole (*Notoryctes caurinus*) consisting of longitudinal sand dunes and interdunal flats is listed as likely to occur in the wider region (DSEWPaC 2013). However, based on the previous surveys (Coffey 2008; *ecologia* 2010, 2011a, 2012a, 2014a; Ecoscape 2010c, 2013; Rapallo 2011), review of aerial photography and information about landsystems within the study area (Shepherd *et al.* 2002), no suitable habitat is present within and surrounding the Mt Macleod study area. In addition, there are no records within 300 km of the study area, therefore the species is not likely to occur within the Mt Macleod study area and therefore will not be discussed in this assessment.

Due to the proximity of the study area to the Fortescue River and Karijini National Park, several waterbirds have a potential to occur in the wider region but are not expected to utilise habitats on a regular basis due to the lack of wetland habitats which may contain small amounts of water after seasonal heavy rainfalls. Rivers and large pools in the region will contain water at these times and therefore the importance of the drainage lines within the study area will be reduced. For this reason, these species are not included in this assessment due to a very low likelihood of their occurrence (Table 2.7).

In addition, one species of fish (Fortescue Grunter) is known to occur along major rivers and large creeklines in the wider region, but based on previous surveys in the vicinity of the study area (Coffey 2008; *ecologia* 2010, 2011a, 2012a, 2014a; Ecoscape 2010c, 2013; Rapallo 2011) and review of aerial photography, no suitable habitat is present within or surrounding the study area. Therefore this species will also not be included in this assessment.

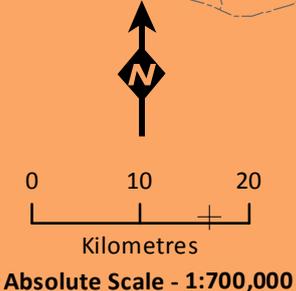
Table 2.7 – Bird species with very low likelihood to occur within the study area

Species	Conservation Status		
	EPBC Act	WC Act	DPaW
Eastern Great Egret <i>Ardea modesta</i>	M	S3	-
Cattle Egret <i>Ardea ibis</i>	M	S3	-
Glossy Ibis <i>Plegadis falcinellus</i>	M	S3	-
Eastern Osprey <i>Pandion cristatus</i>	M	-	-
White-bellied Sea-Eagle <i>Haliaeetus leucogaster</i>	M	S3	-
Oriental Plover <i>Charadrius veredus</i>	M	S3	-
Swinhoes's Snipe <i>Gallinago megala</i>	M	S3	-
Common Sandpiper <i>Actitis hypoleucos</i>	M	S3	-
Oriental Pratincole <i>Glareola maldivarum</i>	M	S3	-
White-winged Black Tern <i>Chlidonias leucopterus</i>	M	S3	-



Legend

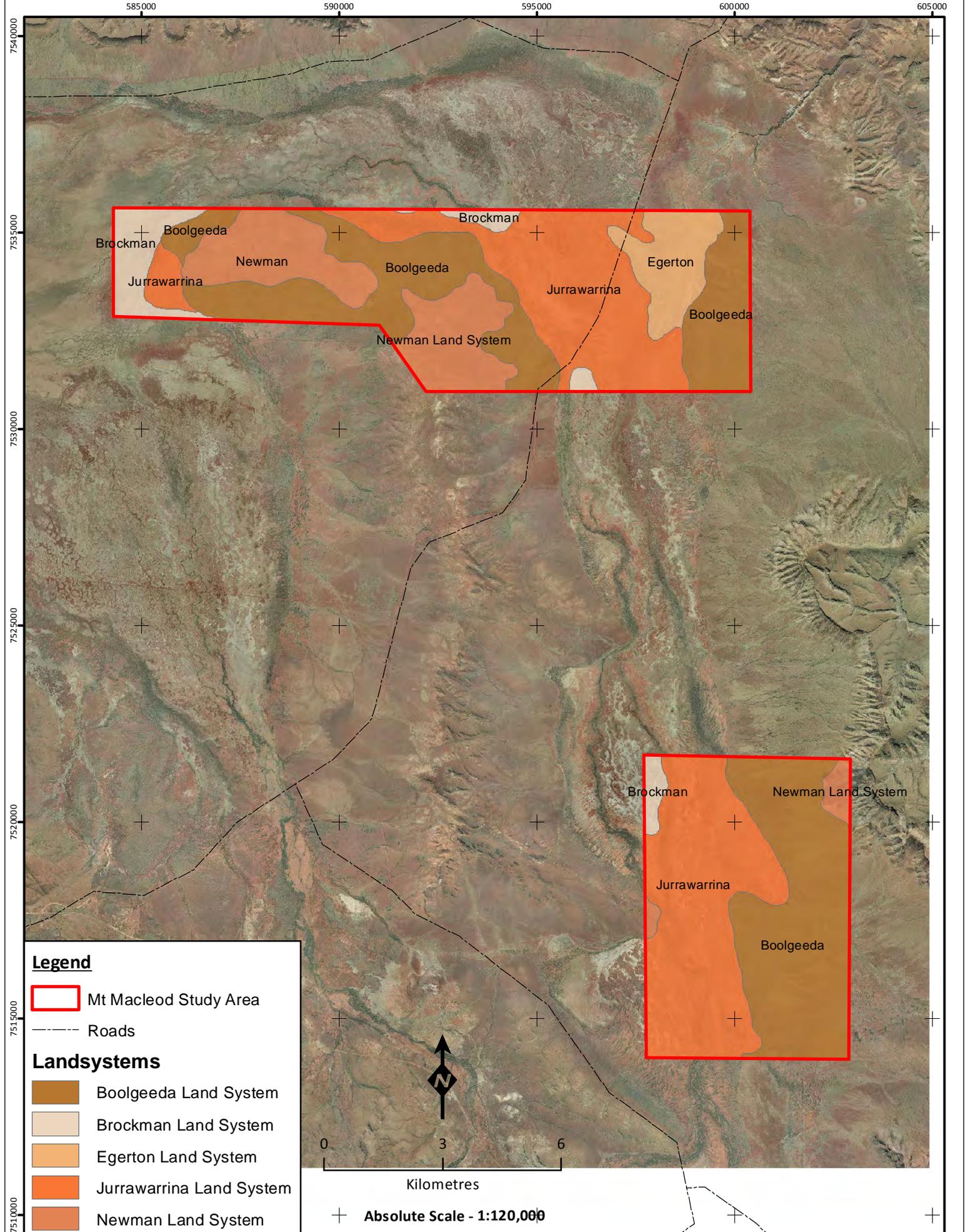
- Major Roads
 - Mt Macleod Study Area
- Biogeographic region**
- Chichester
 - Fortescue
 - Hamersley



Biogeographic regions of the study area

<p>Figure: 2.2 Project ID: 1514</p>	<p>Drawn: NJ Date: 12/09/13</p>
<p><small>Coordinate System Name: GDA 1994 MGA Zone 50 Projection: Transverse Mercator Datum: GDA 1994</small></p>	
<p>Unique Map ID: NJ042</p>	
<p>A4</p>	





Legend

- Mt Macleod Study Area
- Roads

Landsystems

- Boolgeeda Land System
- Brockman Land System
- Egerton Land System
- Jurrawarrina Land System
- Newman Land System

Land systems of the study area

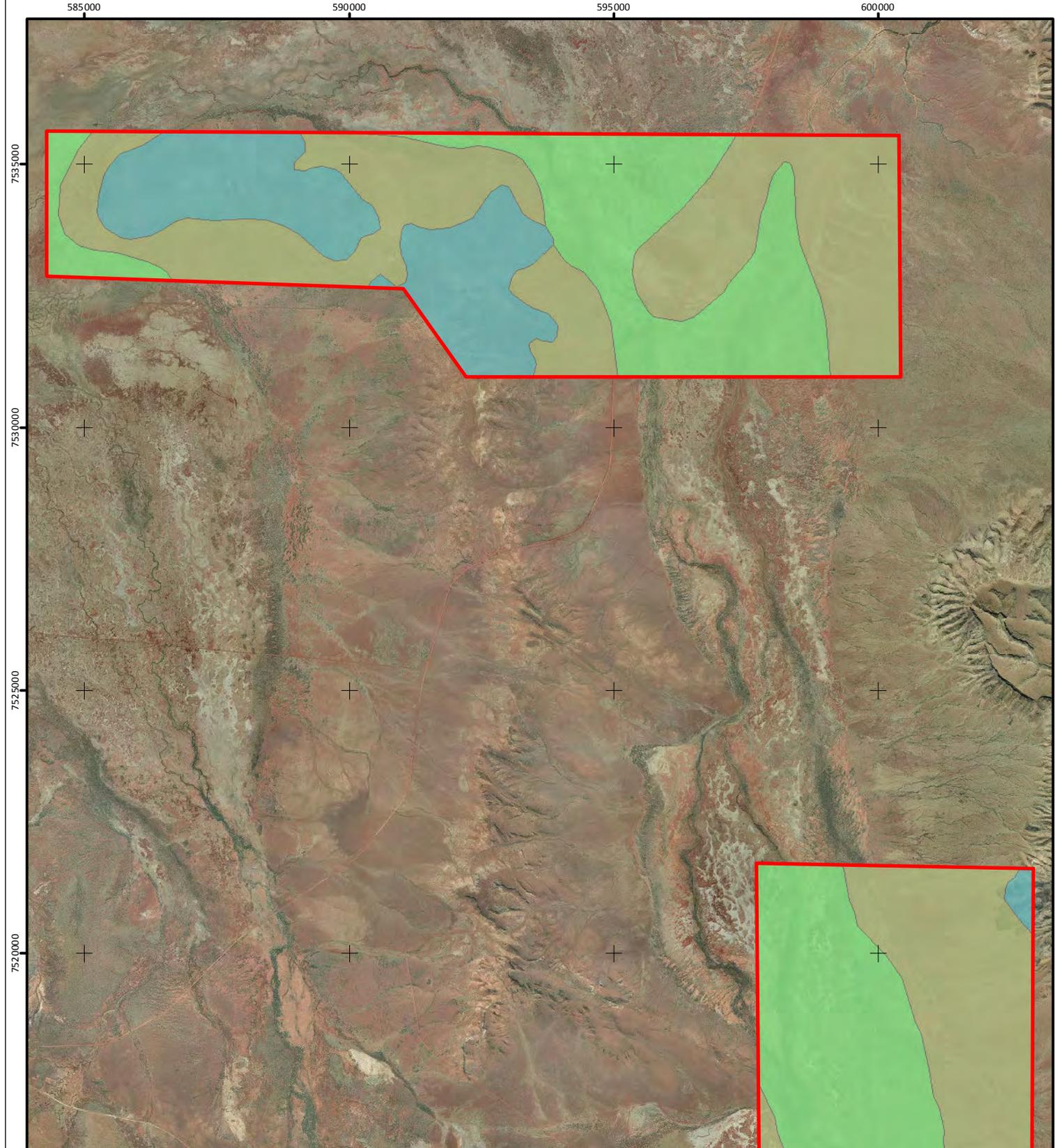
Figure: 2.3
Project ID: 1514

Drawn: CK & AH
Date: 11/12/14

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CK022



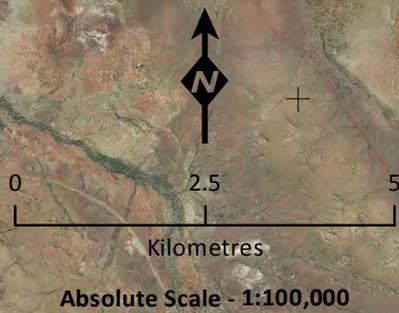


Legend

 Mt Macleod Study Area

Beard Vegetation Associations

-  18
-  82
-  175



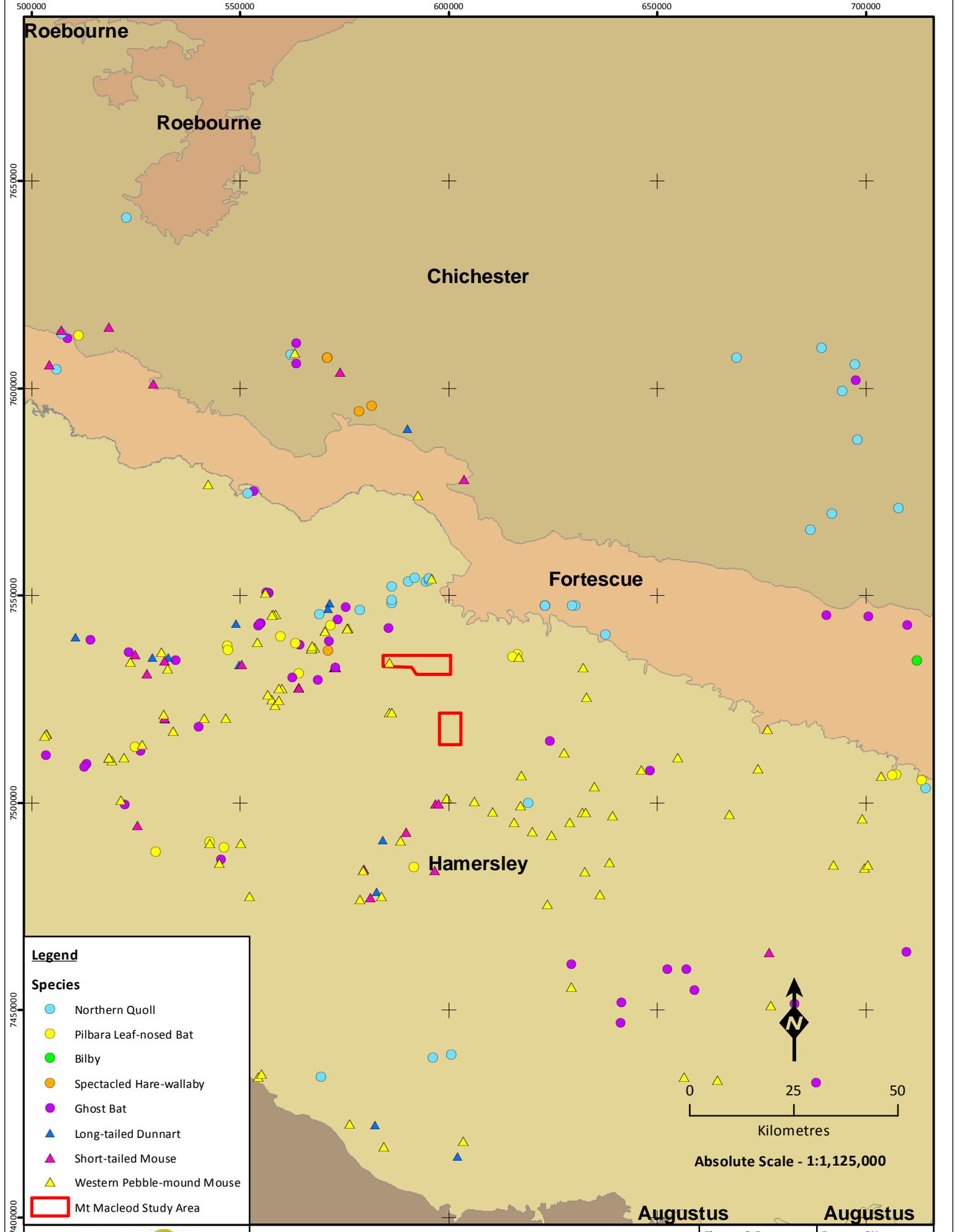
**Vegetation associations
of the study area**

Figure: 2.4
Project ID: 1514

Drawn: CK
Date: 11/12/14

Coordinate System
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Datum: GDA 1994

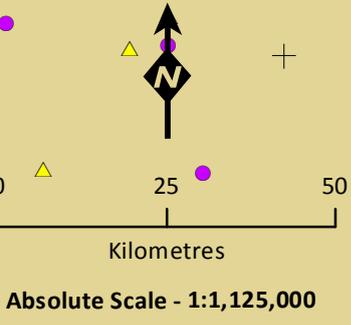
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Legend

Species

- Northern Quoll
- Pilbara Leaf-nosed Bat
- Bilby
- Spectacled Hare-wallaby
- Ghost Bat
- ▲ Long-tailed Dunnart
- ▲ Short-tailed Mouse
- ▲ Western Pebble-mound Mouse
- Mt Macleod Study Area



August August



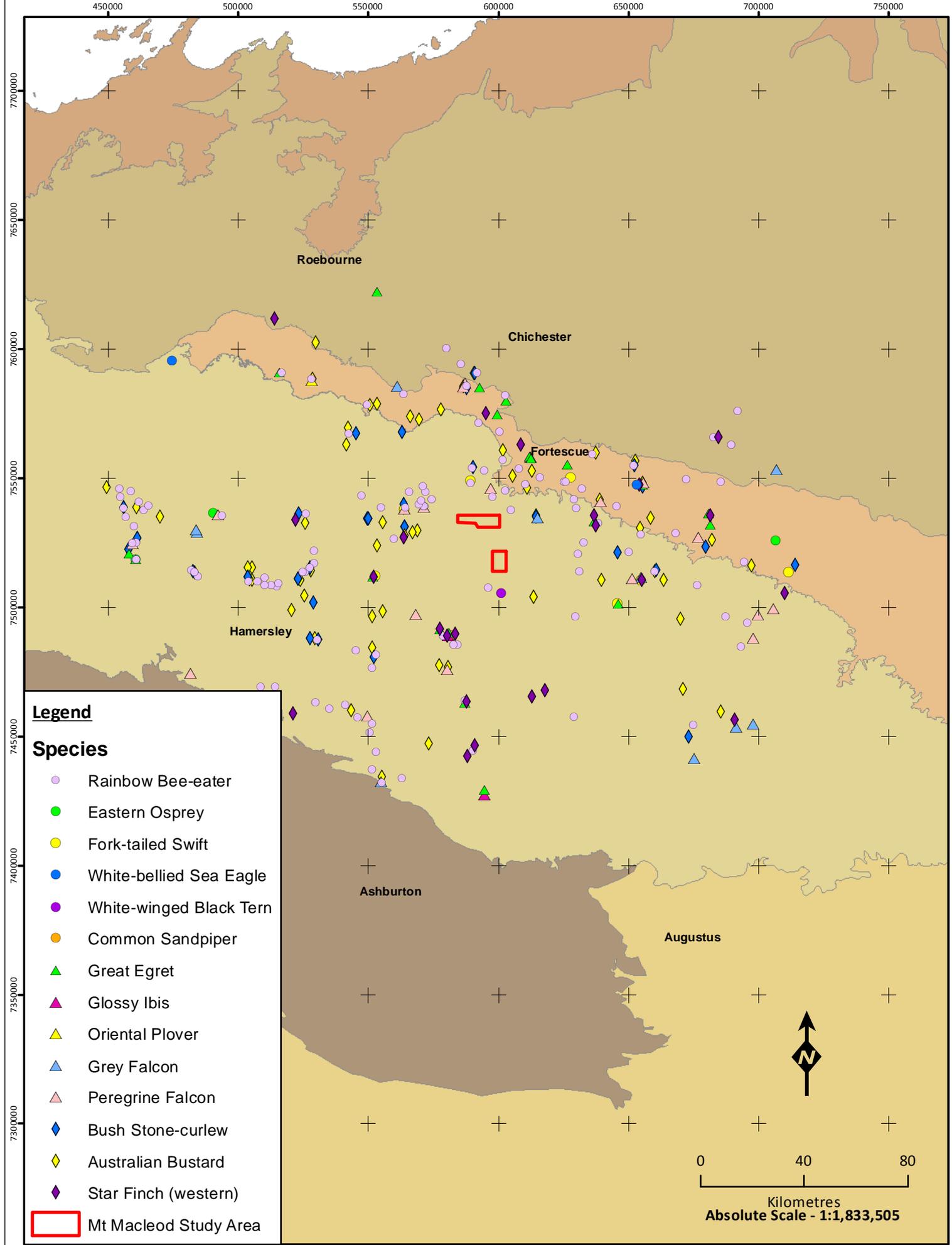
**Regional records
of conservation significant mammals**

Figure: 2.5
Project ID: 1514

Drawn: CK
Date: 23/08/13

Coordinate System
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Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CK024



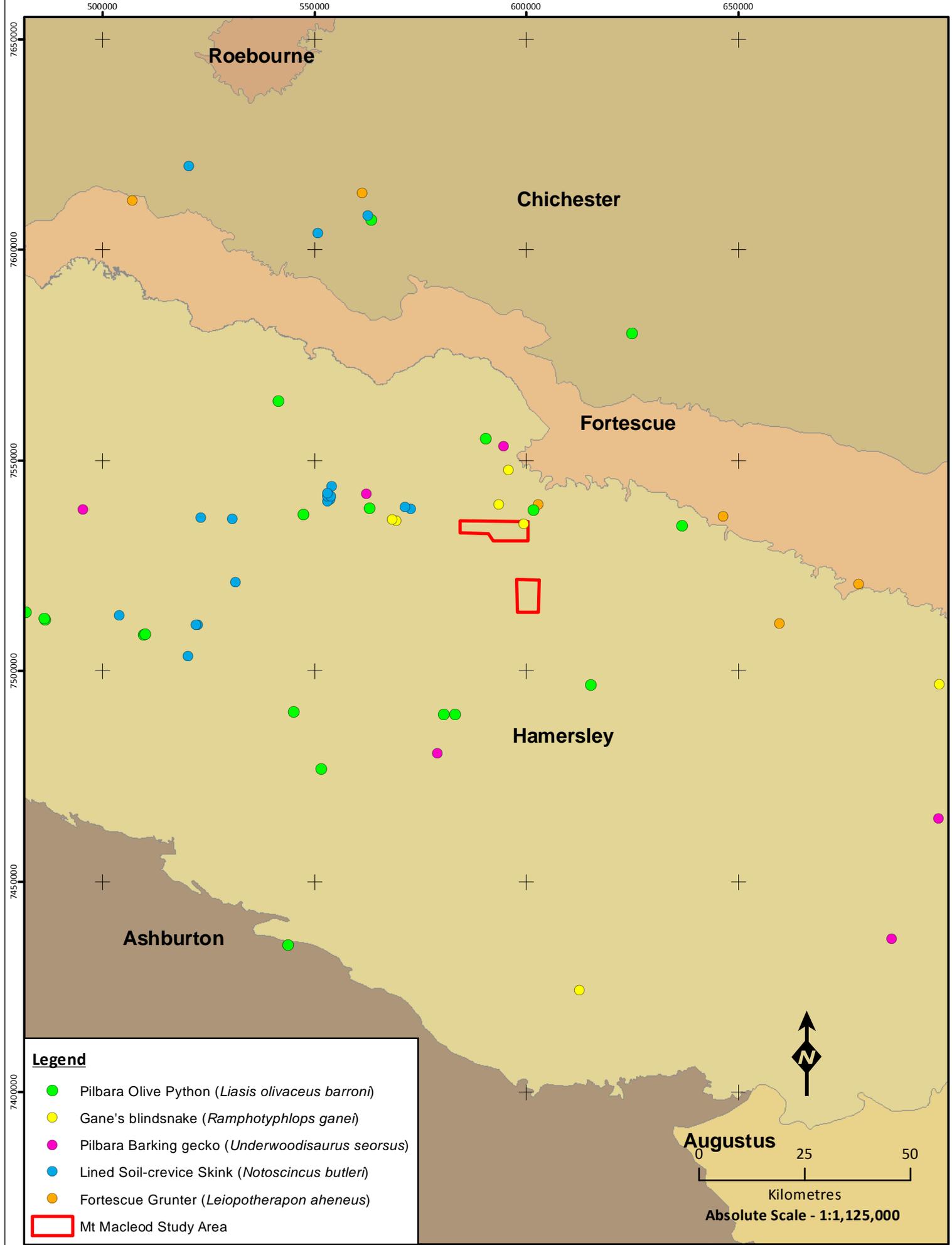
**Regional records
of conservation significant birds**

Figure: 2.6
Project ID: 1514

Drawn: CK
Date: 23/08/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CK025



**Regional records
of conservation significant herpetofauna and fish**

Figure: 2.7
Project ID: 1514

Drawn: CK
Date: 23/08/13

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CK026

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3 METHODS

3.1 DETERMINATION OF SURVEY SAMPLING DESIGN AND INTENSITY

Prior to the development of field survey methods, a review was undertaken of factors likely to influence survey design and intensity (Table 3.1). Based on this review, it was deemed necessary for both a Level 2 vertebrate fauna and a targeted conservation significant fauna assessment to be conducted within the Study area.

Table 3.1 – Factors likely to influence survey design (EPA 2004)

Factor	Relevance
Bioregion – level of existing survey-knowledge of the region and associated ability to predict accurately.	The Pilbara bioregion (including the Hamersley subregion) has been well studied, and information was readily available.
Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region.	The landforms associated with the study area are typical for the region and do not present any rare or special characteristics.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	The best survey time for birds and amphibians is following seasonal rain events. Best survey timing for reptiles is during warm weather conditions from September to April. Survey timing for mammals is not constrained.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	Thirty-one previous terrestrial vertebrate fauna surveys have been carried out within 100 km of the study area. Regional and local knowledge for the area is available.
Number of different habitats or degree of similarity between habitats within a study area.	Six fauna habitat types were identified based on on-site observation, and mapped land systems and vegetation units. These were: drainage line/river/creek, hilltop/ridge/cliff, hummock grassland, plain (cracking clay), plain (stony gibber) and woodland (open)
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods).	The Pilbara region experiences hot summers with occasional cyclonic rain events, followed by warm winters with little rain. Rainfall is highly unpredictable.
Sensitivity of the environment to the proposed activities.	The study area contains habitat types which are well represented in the surrounding region.
Size, shape and location of the proposed activities.	The study area comprises the Mt Macleod exploration tenement and covers an area of 10,144 ha.
Scale and impact of the proposal.	The scale and impact of the proposal was not known and did not influence the design of this survey.

3.2 SURVEY TIMING

The Level 2 vertebrate fauna assessment was conducted in autumn (3 – 13 May 2013). The targeted conservation significant fauna assessment was conducted in winter (16 – 24 July 2013). The survey timing was determined as per guidelines (DEWHA 2010a, b; DSEWPaC 2011b, c, d; EPA 2004; EPA and DEC 2010; FMG 2011).

Table 3.2 – Summary of survey timing and duration

Survey	Dates	Duration (days)	Person Days
Phase 1 Level 2 vertebrate fauna assessment	19 - 30 April 2011	12	48
Phase 2 Level 2 vertebrate fauna assessment	3 - 13 May 2013	11	44
Targeted conservation significant fauna assessment	16 - 24 July 2013	9	18
Total		32	110

3.3 CONSERVATION SIGNIFICANT FAUNA

After the results of the literature review, database searches and survey results were compiled, fauna species that are listed under current legislative frameworks were identified. Three conservation lists have been developed at national (EPBC Act) and state level (WC Act and DPaW priority list).

The likelihood of a conservation significant species being present within the project was determined by examining the following:

- fauna habitats known to exist within the study area and their condition as assessed during the survey;
- distance of previously recorded conservation significant species from the Study area;
- frequency of occurrence of conservation significant species records in the region; and
- time passed since conservation significant species were recorded within, or nearby the study area.

Each conservation significant or biologically significant species potentially occurring in the study area was assigned a likelihood of occurrence based on the four categories described below (Table 3.3). The level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information or cryptic behaviours and ecology, in accordance with the precautionary principle.

Table 3.3 – Likelihood of occurrence categories

RECORDED	Species recorded during current survey
HIGH	Species recorded within, or in proximity to, the survey area within 20* years; suitable habitat occurs in the survey area
MEDIUM	Species recorded within, or in proximity to, the survey area more than 20 years ago. Species recorded outside survey area, but within 50 km; suitable habitat occurs in the survey area
LOW	Species rarely, or not recorded, within 50 km, and/or suitable habitat does not occur in the survey area

**ecologia* chooses to incorporate regional data from the last 20 years to assess a high likelihood of occurrence of species. Species that have previously been recorded from an area within the last 20 years and where high quality, suitable habitat still persists within an area are considered by *ecologia* to still have potential for a high likelihood of occurrence, following the precautionary principle.

3.4 FAUNA HABITAT ASSESSMENT

A fauna habitat type broadly describes an area of vegetation and land features that are characteristic of that habitat type and distinguishable from other surrounding habitat types, and that is likely to support fauna assemblages which are different to those in other fauna habitats. Fauna habitat types were identified, described and mapped using following information:

- previous habitat mapping (Rapallo 2011)
- landsystems mapped by Van Vreeswyk *et al.* (2004b)
- vegetation associations (Beard 1975; Shepherd *et al.* 2002);
- aerial photography; and
- on ground observations.

To determine fauna habitat types and their characteristics, the following parameters were taken into consideration:

- vegetation type and structure;
- soil characteristics (soil structure and substrate);
- composition of terrestrial fauna species; and
- Habitat condition (Table 3.4).

These observations did not take into account any degradation as a result of exploration or other recent mining activities (e.g. drilling, clearing).

Table 3.4 – Habitat condition assessment

Habitat Condition	Criteria
Excellent	Pristine or nearly so, no obvious sign of damage caused by modern humans or introduced fauna (cattle, feral cat, dog, rabbit). No signs of recent, extensive fires.
Very good	Some relatively slight signs of damage caused by the activities of modern humans. e.g. damage to tree trunks by repeated fires, no significant signs of introduced fauna or occasional vehicle tracks.
Good	More obvious signs of damage caused by the activities of modern humans, including some obvious impact to vegetation structure such as that caused by low levels of grazing or by selective logging. Some tracks or secondary evidence of introduced fauna. Some signs of recent fires.
Poor	Still retains basic vegetation structure or ability to regenerate it after very obvious impacts of modern humans such as partial clearing or very frequent fires. Presence of introduced fauna.
Very poor	Severely impacted by grazing, introduced fauna, fire, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management.
Completely Degraded	Areas that are completely or almost completely without vegetation communities and are heavily impacted by extensive fires and/or introduced species e.g. cow paddock

Note: Based on vegetation condition scale from Trudgen (1991, cited in Department of Environmental Protection 2000).

3.5 SAMPLING METHODS

The methods utilised during the first phase of the Level 2 assessment are provided in the Rappallo vertebrate fauna survey report of the Mt Macleod Project Area (Rappallo 2011). The following survey methodology adopted by *ecologia* for the second phase of the Level 2 vertebrate fauna and targeted conservation significant fauna assessment of the study area was in accordance with:

- Guidance Statement No. 56 “Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia” (EPA 2004);
- Position Statement No. 3 “Terrestrial Biological Surveys as an Element of Biodiversity Protection” (EPA 2002);
- *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010);
- Survey Guidelines for Australia’s Threatened Mammals, Reptiles Bats and Birds (DEWHA 2010b; DSEWPaC 2011b, c, d); and
- Fortescue’s *Terrestrial Vertebrate Fauna Assessment Guidelines* (FMG 2011).

The survey was undertaken using a variety of sampling techniques, both systematic and opportunistic. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically, facilitating comparisons between habitats. Opportunistic sampling includes data collected non-systematically from both fixed sampling sites (foraging sites) and as opportunistic records from chance encounters with fauna.

3.5.1 Systematic Sampling

Terrestrial Mammals and Herpetofauna

Trapping for terrestrial mammals and herpetofauna was undertaken using a standardised trapping format comprising a combination of pit-fall traps, Elliott box traps, funnel traps and cage traps.

Each trapping site consisted of the following (Figure 3.1):

- Pit-trap and drift fence: Five PVC pipe (16 x 50 cm) and five 20 L plastic buckets (30 x 40 cm) were established at each site. A 10 metre flywire drift fence (30 cm high) bisected the pits, directing fauna into the traps.
- Elliott box traps: Ten medium sized Elliott box traps (9 x 9 x 32 cm) were placed at each site, and baited with Universal Bait (a mixture of peanut butter, rolled oats and sardines). Each Elliott trap was placed between the pit trap setups. Elliott traps were shaded using Air Cell roof insulation.
- Funnel traps: Funnel traps (Ecosystematica Type III) were placed in association with drift fences. Twenty funnel traps were used per site, with a trap being placed at each end of the drift fence. Funnel traps were shaded using Air Cell roof insulation.
- Cage traps: Two Sheffield small animal traps (22 cm x 22 cm x 55 cm) were used per site with one trap placed at each end of the trap line. Traps were baited with Universal Bait.

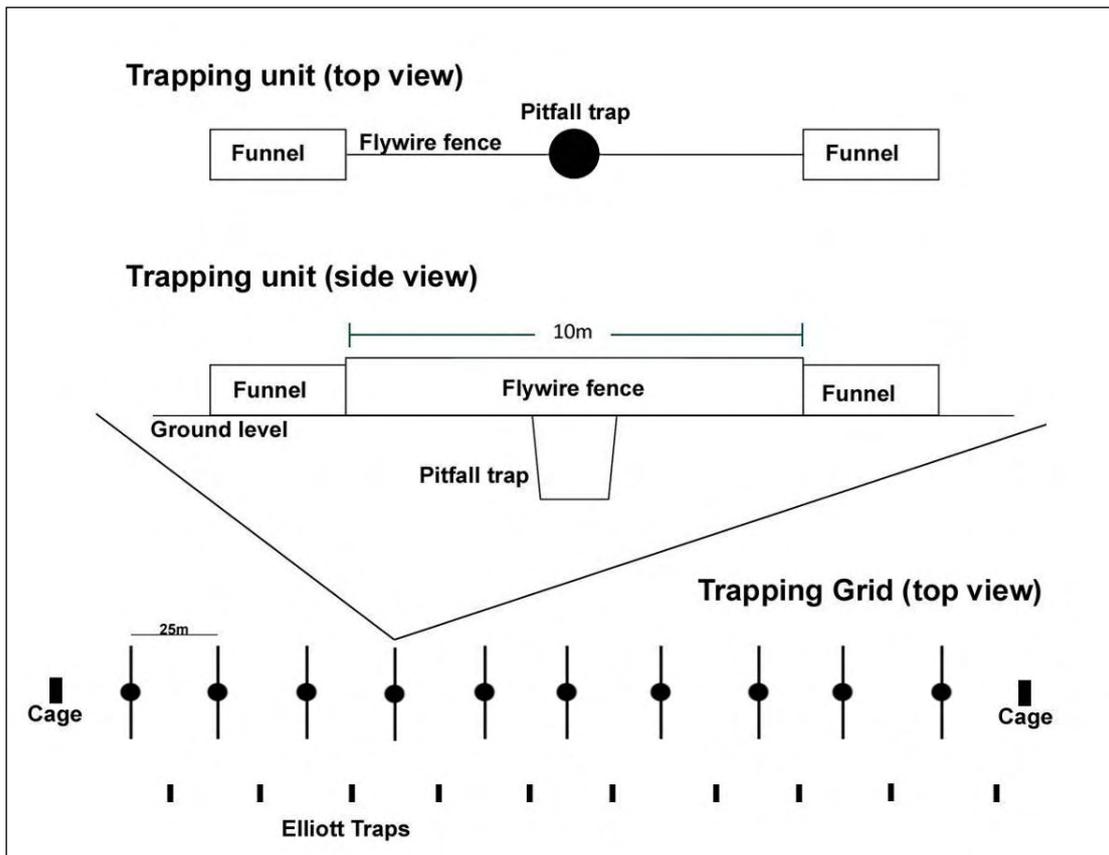


Figure 3.1 – Diagram of the systematic sampling trap arrangement



Figure 3.2 – Image of single *ecologia* trap point

Avifauna

Thirty minute set-time surveys were used to document the avifauna present at each of the systematic trapping sites. During each set-time survey, an ornithologist recorded the number of individuals of each species seen while actively searching similar habitat within 500 m of the survey site. This is aligned with survey methodology for the ongoing Birds Australia *Atlas of Australian Birds* project.

Survey effort was concentrated at survey sites within 3 hours of dawn, as this time is deemed to be the optimal times to record most bird species. Additional surveys during the day and near dusk were also conducted, as they may yield species less frequently observed in the early morning, e.g. diurnal raptors.

Bats

Bat echolocation calls were recorded using SM2BAT 384 kHz long term passive recorder. The SM2BAT has a high sampling frequency, enabling the full spectrum of the calls to be recorded without being transformed allowing greater accuracy and sensitivity. The SM2BAT was programmed to record from dusk to dawn (approximately 720 minutes) for each night that was surveyed. A single overnight recording was made at each bat survey site. One night of recording is sufficient to provide an accurate record of the bat assemblage found in the area, as experience from previous surveys indicates that the species of bats recorded tend to remain the same over multiple nights.

SM2BAT recorders were set up at a total of 14 locations within the study area. Of these, ten locations were sampled during the Level 2 vertebrate fauna assessment (totalling 120 hours of bat recordings) (Table 3.6), and an additional four locations (totalling 144 hours) were sampled from areas of suitable foraging habitat for Pilbara Leaf-nosed Bats within the drainage line and hillslope habitat types.

3.5.2 Opportunistic Data

Nocturnal Searching

Areas of the study area were searched at night using a combination of spotlighting whilst driving road transects and opportunistic ground searches using head torches and hand held spotlights to uncover nocturnal species, including geckos, snakes, frogs and birds.

Diurnal Searching

Both trapping and opportunistic sites were searched by hand for cryptic species, which comprised searching beneath the bark of dead trees, breaking open old logs, stumps and dead free-standing trees, investigating burrows and over-turning logs and stones. Sites were selected on the basis of fauna habitat (targeting uncommon habitats or habitats poorly represented by trapping sites) and the possibility of their harbouring conservation significant fauna.

Fauna were also recorded while searching, travelling and during trap establishment within the study area during the day and night. Tracks, diggings, scats, burrows mounds and nests were recorded where possible.

Camera Trapping

A total of three motion sensor cameras (Bushnell Trophy Cam, model number 119415) were used during the Level 2 survey in areas with a high likelihood of animal activity, such as rocky outcrops and boulder piles, drainage lines and other water sources, to detect fauna species. A further six motion cameras were deployed during the targeted survey in areas identified during the Level 2

survey as potentially suitable Northern Quoll habitat. The motion cameras are triggered by movement, via a highly sensitive passive infra-red motion sensor, and functions day and night taking either video footage or photographs (Bushnell Outdoor Products 2009).

3.6 TARGETED CONSERVATION SIGNIFICANT FAUNA SURVEYING

Prior to the commencement of survey activity, the preferred habitat of the conservation significant species that potentially occur in the study area was determined. These habitats were identified and targeted during survey activities using both systematic survey sites and opportunistic surveys.

On the basis of the habitats observed during the Level 2 survey, a targeted survey was undertaken in the north-east of the Mt Macleod South study area, which was identified as potentially suitable for Northern Quoll. Further supplementary survey effort was expended throughout the study area specifically targeting Pilbara Leaf-nosed Bat (*Rhinioncteris aurantius*; EPBC Act Vulnerable) and Ghost Bat (*Macroderma gigas*; DPaW Priority 4), as well as detailed mapping of the cracking clays habitat for the Short-tailed Mouse (*Leggadina lakedownensis*; DPaW Priority 4).

Trapping sites were restricted to one small area (60 ha) of potential Northern Quoll habitat identified during the Level 2 assessment, in the north-east of Mt Macleod South (Figure 4.1). Based on the formula in the Northern Quoll referral guidelines (DSEWPaC 2011a) 387 trapnights are required to adequately trap the 60 ha of suitable Northern Quoll habitat. Searches for secondary evidence of the Northern Quoll (*Dasyurus hallucatus*; EPBC Endangered) and Pilbara Olive Pythons (*Liasis olivaceus barroni*; EPBC Act Vulnerable) were completed within suitable habitats concurrently. SM2BAT recorders were also deployed during the targeted conservation significant fauna assessment for further survey effort for Ghost Bat and Pilbara Leaf-nosed Bat.

3.7 SITE SELECTION

Habitat types previously described and mapped by Rapallo (2011) were reviewed and interpreted for survey site selection of the second phase survey, with locations of access tracks, land systems and the abundance of habitat types taken into consideration. Survey sites were selected to provide a good geographic spread over the study area and to be representative of the habitat types in the study area.

Half the trapping sites (four out of eight) were installed within the Jurrawarrina Land System (the most common land system of the study area), with the remaining four sites located within Brockman, Egerton, Newman and Boolgeeda land systems with one trap site within each landsystem.

In addition to trapping, opportunistic searches were undertaken, targeting habitats scarcely sampled by trapping sites and habitats that potentially support conservation significant species. Locations and details of all survey sites sampled during both phases of the Level 2 survey as well as targeted survey sites are listed in

Table 3.5 and mapped in Figure 3.3. Site photographs and descriptions are presented in Appendix D.

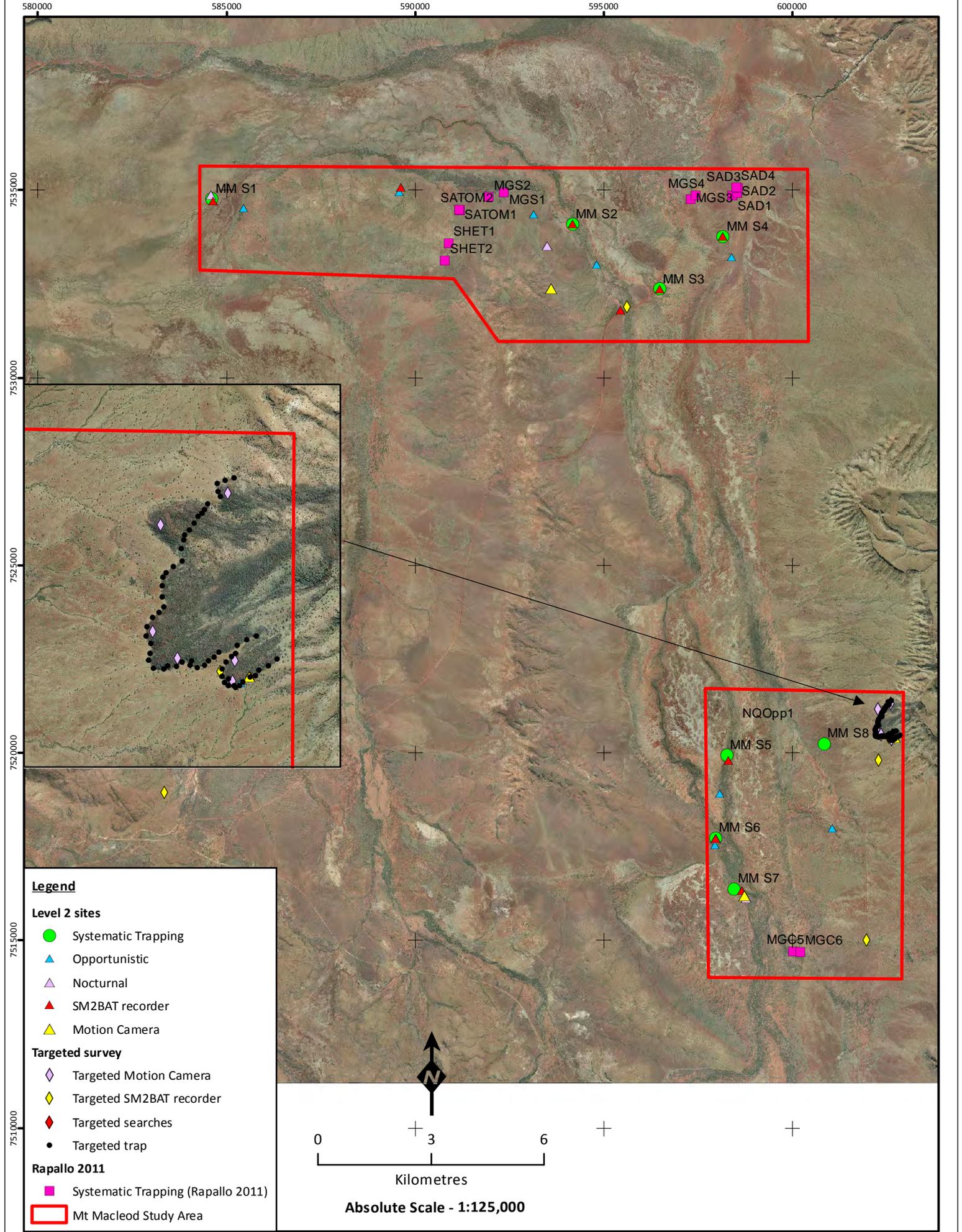
Table 3.5 – Level 2 Survey site information

Site	Survey Site	Location		Land System	Vegetation Community
		Easting	Northing		
Level 2 (Phase 2) - ecologia (2013)					
MM S1	Systematic Trapping	584610	7534777	Brockman	175
MM S2	Systematic Trapping	594171	7534109	Jurrawarrina	175

MM S3	Systematic Trapping	596483	7532374	Jurrawarrina	18
MM S4	Systematic Trapping	598164	7533757	Egerton	175
MM S5	Systematic Trapping	598260	7519929	Jurrawarrina	175
MM S6	Systematic Trapping	597963	7517723	Newman	175
MM S7	Systematic Trapping	598459	7516367	Jurrawarrina	175
MM S8	Systematic Trapping	600844	7520241	Boolgeeda	18
MM OS1	Opportunistic searches	598081	7518923	Jurrawarrina	175
MM OS2	Opportunistic searches	585461	7534536	Jurrawarrina	82
MM OS3	Opportunistic searches	602667	7520360	Newman	18
MM OS4	Opportunistic searches	594817	7533026	Jurrawarrina	175
MM OS5	Opportunistic searches	593597	7532397	Newman	18
MM OS6	Opportunistic searches	602710	7520392	Newman	82
MM OS7	Nocturnal searches	584589	7534882	Brockman	175
MM OS8	Nocturnal searches	593492	7533528	Newman	82
MM OS9	Opportunistic searches	601063	7517996	Jurrawarrina	18
MM OS10	Opportunistic searches	597943	7517552	Newman	175
MM OS11	Nocturnal searches	597963	7517723	Newman	175
MM OS12	Nocturnal searches	598772	7516122	Jurrawarrina	175
MM OS13	Opportunistic searches	589581	7534945	Newman	82
MM OS14	Opportunistic searches	593140	7534368	Boolgeeda	82
MM OS15	Opportunistic searches	598392	7533218	Egerton	175
MM Bat 1	SM2BAT recorder	584641	7534716	Brockman	18
MM Bat 2	SM2BAT recorder	594171	7534109	Jurrawarrina	175
MM Bat 3	SM2BAT recorder	596483	7532374	Jurrawarrina	18
MM Bat 4	SM2BAT recorder	598164	7533757	Egerton	175
MM Bat 5	SM2BAT recorder	598311	7519798	Jurrawarrina	175
MM Bat 6	SM2BAT recorder	597963	7517723	Newman	175
MM Bat 7	SM2BAT recorder	598671	7516312	Jurrawarrina	175
MM Bat 8	SM2BAT recorder	602715	7520397	Newman	18
MM Bat 9	SM2BAT recorder	595451	7531788	Boolgeeda	175
MM Bat 10	SM2BAT recorder	589614	7535076	Newman	18
MC 1	Motion Camera	602710	7520392	Newman	18
MC 2	Motion Camera	598740	7516182	Jurrawarrina	175
MC 3	Motion Camera	593597	7532397	Newman	18
Targeted survey – <i>ecologia</i> (2013)					
NQ S1	Targeted Trapping (60 Northern Quoll traps)	602669	7520873	Newman	18
NQOpp1	Targeted searches	598672	7516383	Jurrawarrina	175
MM Bat T1	Targeted SM2BAT recorder	602288	7519808	Boolgeeda	18
MM Bat T2	Targeted SM2BAT recorder	601972	7514997	Boolgeeda	18

MM Bat T3	Targeted SM2BAT recorder	602566	7520420	Newman	18
MM Bat T4	Targeted SM2BAT recorder	595625	7531904	Jurrawarrina	175
MC A	Motion Camera	602626	7520369	Newman	18
MC B	Motion Camera	602228	7520621	Boolgeeda	18
MC C	Motion Camera	602351	7520483	Newman	18
MC D	Motion Camera	602641	7520474	Newman	18
MC E	Motion Camera	602603	7521317	Newman	82
MC F	Motion Camera	602266	7521159	Boolgeeda	18
Level 2 (Phase 1) - Rapallo (2011)					
MGS1	Systematic Trapping	592361	7534957	Boolgeeda	18
MGS2	Systematic Trapping	591954	7534832	Boolgeeda	18
MGS3	Systematic Trapping	597322	7534761	Egerton	18
MGS4	Systematic Trapping	597447	7534873	Egerton	18
SAD1	Systematic Trapping	598414	7534871	Egerton	18
SAD2	Systematic Trapping	598531	7534940	Egerton	18
SAD3	Systematic Trapping	598563	7535058	Egerton	18
SAD4	Systematic Trapping	598511	7535070	Egerton	18
SATOM1	Systematic Trapping	591189	7534468	Boolgeeda	18
SATOM2	Systematic Trapping	591179	7534479	Boolgeeda	18
SHET1	Systematic Trapping	590886	7533593	Newman	18
SHET2	Systematic Trapping	590783	7533136	Boolgeeda	18
SATOM3	Systematic Trapping	601957	7518890	Boolgeeda	18
SATOM4	Systematic Trapping	602079	7518759	Boolgeeda	18
MGC5	Systematic Trapping	600027	7514695	Jurrawarrina	175
MGC6	Systematic Trapping	600209	7514685	Jurrawarrina	175

Datum: GDA 94
 Zone: 50K



Legend

Level 2 sites

- Systematic Trapping
- ▲ Opportunistic
- ▲ Nocturnal
- ▲ SM2BAT recorder
- ▲ Motion Camera

Targeted survey

- ◆ Targeted Motion Camera
- ◆ Targeted SM2BAT recorder
- ◆ Targeted searches
- Targeted trap

Rapallo 2011

- Systematic Trapping (Rapallo 2011)
- Mt Macleod Study Area



Kilometres
Absolute Scale - 1:125,000



Location of fauna survey sites

Figure: 3.3
Project ID: 1514

Drawn: CK & AH
Date: 11/12/2014

Coordinate System
 Name: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator
 Datum: GDA 1994

Unique Map ID: MD'A001

3.8 SURVEY EFFORT

Survey effort expended during the phase 1 Level 2 survey is detailed in the previous survey report (Rapallo 2011). Survey effort conducted during the phase 2 survey within the study area is presented in Table 3.6 and included the following:

- Systematic trapping grids (pit traps, funnels, Elliott traps and cage traps) were open for 2,769 trap-nights.
- Approximately 15 hours were spent surveying for birds.
- 15.6 hours were spent on opportunistic diurnal searching at 11 locations.
- 8.7 hours were spent on opportunistic nocturnal searching at four locations.
- Three motion-sensing cameras were deployed for a total of 103 hours.
- 120 hours of SM2BAT recordings were collected from 10 sites to determine bat assemblage and distribution.

Survey effort expended during the targeted survey within the study area is presented in Table 3.6 and included the following:

- Cage traps targeting Northern Quoll were open for 417 trap-nights .
- 51.5 hours were spent on opportunistic diurnal searching for secondary evidence of the Northern Quolls, Pilbara Olive Python and cave structures to provide habitat for the Pilbara Leaf-nosed Bat.
- Six motion-sensing cameras were deployed for a total of 702 hours to determine the absence or presence of Northern Quolls and Pilbara Olive Pythons.
- 144 hours of SM2BAT recordings were collected from four sites to detect the presence or absence of the Pilbara Leaf-nosed Bat and Ghost Bat.

Table 3.6 – Survey effort

Site	Pit Traps (trap nights)	Funnels (trap nights)	Elliott's (trap nights)	Cages (trap nights)	Bird Survey (min)	Diurnal Opp Search (min)	Bat Recording (hours)	Nocturnal Opp Search (min)	Camera Trapping (hours)
Level 2 (Phase 2) – ecologia 2013									
MM S1	70	140	70	14	120	0	12	0	0
MM S2	70	140	70	14	120	60	12	0	0
MM S3	70	140	70	14	120	120	12	0	0
MM S4	70	140	70	14	120	0	12	0	0
MM S5	70	140	70	14	120	0	12	0	0
MM S6	70	140	70	14	120	0	12	0	0
MM S7	70	140	70	14	150	0	12	0	0
MM S8	70	140	70	14	150	0	0	0	0
Opportunistic	0	0	0	0	0	760	36	520	103
Targeted Conservation Significant Fauna Assessment – ecologia (2013)									
Targeted trapping site	0	0	0	417	0	2700	0	0	0
Opportunistic	0	0	0	0	0	390	144	0	702
Total	560	1120	560	529	1,020	4,030	264	520	805

3.9 DATA ANALYSIS

3.9.1 Survey Adequacy

There are three general methods of estimating species richness from sample data: extrapolating species-accumulation curves (SACs), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). In this report, the level of survey adequacy was estimated using SACs, which graphically illustrate the accumulation of new species as more individuals are recorded. Ultimately, the asymptote is reached at the level at which no new species are present. To eliminate features caused by random or periodic temporal variation, the sample order was randomised 1,000 times using EstimateS (version 8, Colwell 2009). In order to estimate the theoretical maximum for each fauna group, a Michaelis-Menten enzyme kinetic curve was calculated and used as a stopping rule technique.

Only the results of trapping are included in SAC analysis, as this form of analysis assumes a standard sampling effort. Therefore, species recorded through opportunistic methods are not included. Separate analyses were carried out for avifauna and terrestrial trappable fauna (mammals and reptiles). Analysis was not conducted on the amphibian fauna due to the paucity of results.

3.9.2 Habitat Assessment

Analysis of the fauna survey data was undertaken to determine the similarities in fauna communities and identify any unique fauna habitats.

To analyse differences in species diversity between habitats, the data was subjected to log+1 transformation. To test whether the differences in species diversity between habitat types were significant, analyses of similarity (ANOSIM) (Clarke 1993) comparisons were made using the one-way ANOSIM function. ANOSIM was calculated using the Bray-Curtis Similarity Index with 999 permutations. Non-metric multidimensional scaling (MDS) was also applied to the Bray-Curtis similarity matrix. Resulting stress values below 0.20 were considered to indicate a good fit of the scaling to the matrix. The dimensions that reduced the majority of the “raw stress” were chosen for the final scaling. Analysis was undertaken using the PAST software package (Hammer *et al.* 2001).

Separate analyses were carried out for terrestrial fauna (mammal and reptile) and avifauna.

3.10 TAXONOMY AND NOMENCLATURE

Nomenclature for mammals, reptiles and amphibians within this report is as per *Western Australian Museum Checklist of the Vertebrates of Western Australia*, birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 3.7.

Table 3.7 – References used for identification

Fauna Group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (Churchill 2008), Menkhorst and Knight (2011)
Birds	Simpson and Day (2004)
Reptiles	Cogger (2000), Wilson and Swan (2010)
Geckos	Storr <i>et al.</i> (1990), Wilson and Swan (2010)
Skinks	Storr <i>et al.</i> (1999), Wilson and Swan (2010)
Dragons	Storr <i>et al.</i> (1983), Wilson and Swan (2010)
Varanids	Storr <i>et al.</i> (1983), Wilson and Swan (2010)
Legless Lizards	Storr <i>et al.</i> (1990), Wilson and Swan (2010)
Snakes	Storr <i>et al.</i> (2002), Wilson and Swan (2010)
Amphibians	Tyler and Doughty (2009), Cogger (2000)

3.11 ANIMAL ETHICS

Surveying was conducted as per *ecologia's* Animal Ethics Code of Practice, which conforms to Section 5 of the *Australian code of practice for the care and use of animals for scientific purposes* (NHMRC 2004). In most cases, fauna were identified in the field and released at the point of capture.

3.12 SURVEY TEAM AND LICENCES

Field survey team members are listed in Table 3.8 and external consultants listed in Table 3.9. The survey was conducted under DEC (now DPaW) Regulation 17 Licence SF009218.

Table 3.8 – Field survey personnel

Survey Member	Expertise	Qualification	Experience
Mimi d'Auvergne	Mammalogy	BSc. (Hons)	5 years
Sean White	Zoology	-	10 years
MC Leng	Zoology	BSc. (Hons)	8 years
Gabriella Eiris	Mammalogy	PhD	8 years
Jordan Vos	Herpetology/Ornithology	-	8 years
Farhan Bokhari	Invertebrates	BSc. (Hons)	6 years
Jordan de Jong	Herpetology	BSc. (Hons)	5 years
Chris Knuckey	Herpetology	BSc. (Hons)	3 years

Table 3.9 – External consultant

External Consultant	Institution	Relevant Experience
Bob Bullen	Bat Call WA	16 years – bat call IDs

4 RESULTS

4.1 FAUNA HABITATS

Rapallo (2011) previously identified eight habitat types within the study area and its immediate vicinity. These habitat types were based on vegetation communities and did not consider how fauna assemblages can utilise several vegetation communities that have similar structural components. During the current Level 2 vertebrate fauna assessment, these habitat types were reassessed and reclassified (Table 4.1) into six broad fauna habitat types to reflect vegetation structure and potential fauna assemblages, land systems and geographical features. In addition, habitats mapped during the fauna assessment at the Solomon Hub project were taken into consideration to determine the extent of each habitat type outside the study area (within 20 km of the study area (*ecologia* 2014a)). The extent of habitat types inside the study area is listed in Table 4.2 and shown in Figure 4.1. Details to the regional habitat extent is listed in Table 4.2 and shown in Figure 4.2.

The six fauna habitats identified from the study area during the current Level 2 vertebrate fauna assessment were:

- Woodland (open);
- Hummock grassland;
- Plain (stony gibber);
- Hilltop/ridge/cliff;
- Plain (cracking clay); and
- Drainage line/river/creek.

Table 4.1 – Habitat comparisons between previous and current vertebrate fauna assessment

Habitat types identified during current assessment	Habitat types identified by Rapallo (2011)
Woodland (open)	Stony plains and slopes supporting woodlands and shrublands
	Mulga woodlands on loamy soils with spinifex grasslands
	Mulga woodlands on loamy/clay soils with perennial grasses
Hummock grassland	Spinifex grasslands with sparse <i>Acacia</i> shrubland calcrete pebbles and loams
Plain (stony gibber)	Scree slopes with tussock grasslands and sparse woodlands
Plain (cracking clay)	Cracking clay grasslands
Drainage line/river/creek	<i>Acacia</i> lined drainage
	Eucalyptus lined drainage
Hilltop/ridge/cliff	Stony plains and slopes supporting woodlands and shrublands

The area of occupation of each habitat is shown in Table 4.2 and mapped in Figure 4.1.

Table 4.2 – Summary of fauna habitat areas

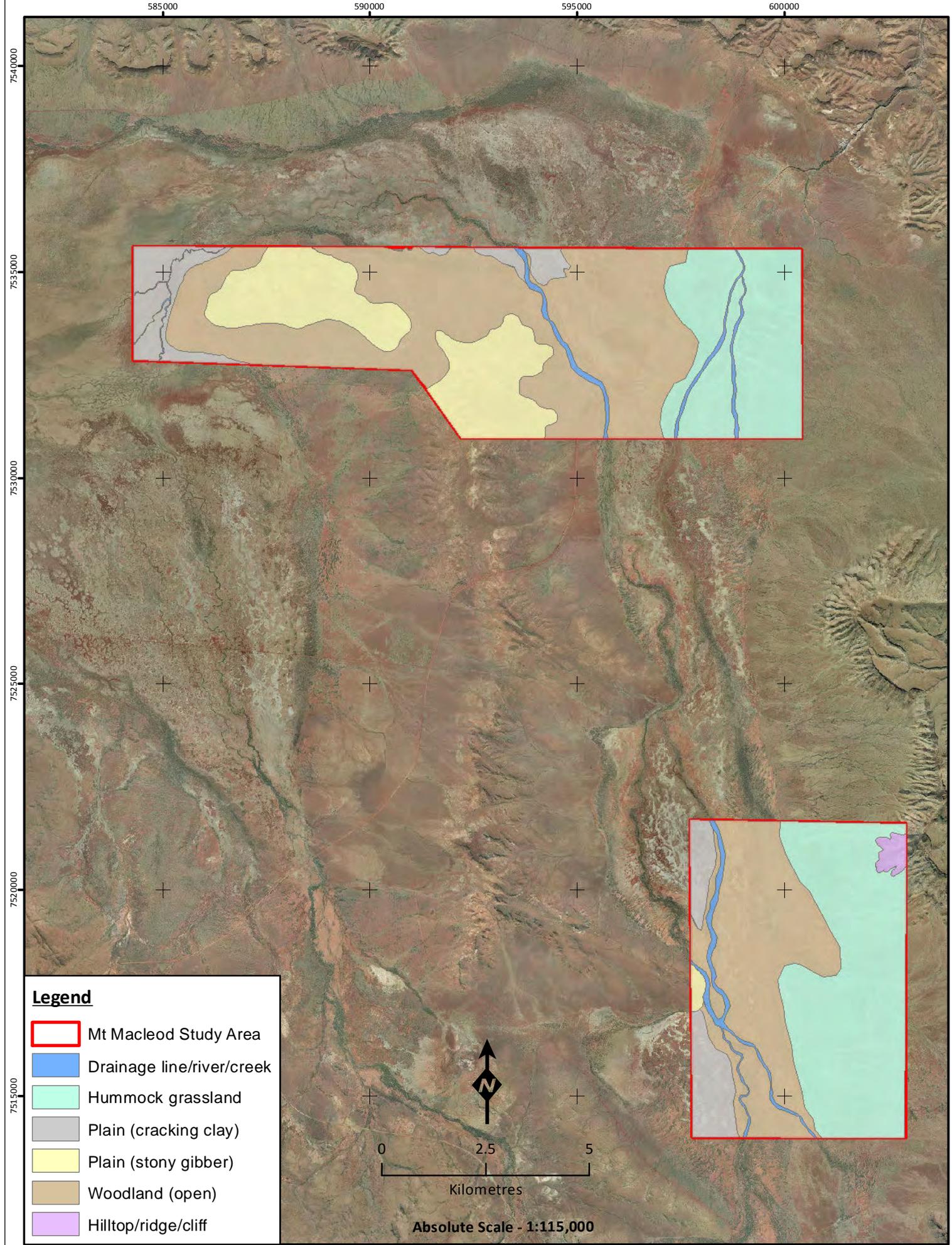
Fauna Habitat	Area inside Study area (ha)	Percentage of Total Study area (%)	Area within 20 km of study area (ha)	Percentage within 20 km of study area (%)
Woodland (open)	4,486.7	44.3	11,895.9	4.6
Hummock grassland	3,191.9	31.5	4,678.4	1.8
Plain (stony gibber)	1,326.9	13.1	190,272.0	73.0
Plain (cracking clay)	838.8	8.3	24,762.1	9.5
Drainage line/river/creek	235.1	2.3	2,967.6	1.1
Hilltop/ridge/cliff	59.8	0.6	26,163.3	10.0
Total	10,139.3	100	260,739.3	100

Woodland (open) and hummock grassland were the most common fauna habitat types identified in the study area, encompassing 75.7% of the total study area. The remaining four habitat types – plain (stony gibber), hilltop/ridge/cliff, plain (cracking clay) and drainage line/river/creek made up the remaining 24.3%. All habitat types are widespread in the surrounding region (within 20 km of the study area) (Table 4.2). The stony gibber plain is the most common habitat type with 73.0% of the local region, followed by the hilltop/ridge/cliff habitat (10.0%) and the cracking clay habitat (9.5%). The remaining habitat types – open woodland, hummock grassland and drainage line/river/creek combined occupy 7.5% of the area within 20 km of the study area (Table 4.2, Figure 4.2). Of these, the cracking clay habitat is an important habitat type due to its potential to support conservation significant species, such as the Short-tailed Mouse (*Leggadina lakedownensis*; DPaW P4) within the study area.

When survey effort is assessed against the habitats within the study area, (Table 4.3), all fauna habitats within the study area were adequately surveyed.

Table 4.3 – Combined Survey effort (Level 2 and targeted survey) per fauna habitat type

Habitat type	Pit Traps (trap nights)	Funnels (trap nights)	Elliott's (trap nights)	Cages (trap nights)	Bird Survey (min)	Diurnal Opp. Search (min)	Bat Recording (hrs)	Nocturnal Opp. Search (min)	Camera Trapping (min)
Woodland (open)	140	280	140	28	240	240	36	0	0
Hummock grassland	140	280	140	28	270	0	12	0	0
Plain (stony gibber)	70	140	70	14	120	120	12	150	0
Hilltop/ridge/cliff	0	0	0	417	0	3,430	144	0	702
Plain (cracking clay)	70	140	70	14	120	0	12	80	0
Drainage line/river/creek	140	280	140	28	270	240	48	290	103
Total	560	1,120	560	529	1,020	4,030	264	520	805



Legend

- Mt Macleod Study Area
- Drainage line/river/creek
- Hummock grassland
- Plain (cracking clay)
- Plain (stony gibber)
- Woodland (open)
- Hilltop/ridge/cliff

Absolute Scale - 1:115,000

Figure:4.1
Project ID: 1514

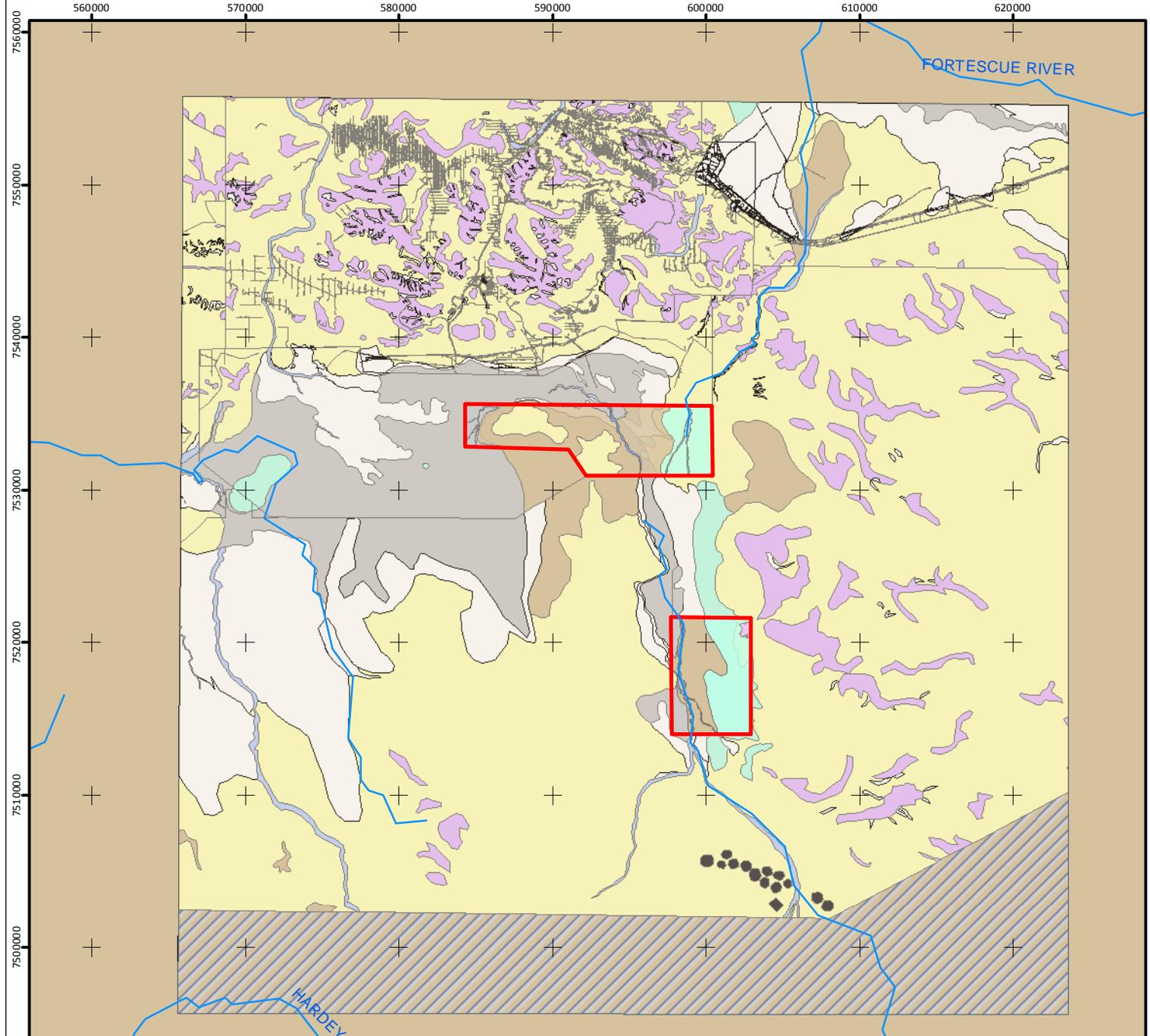
Drawn: CK & AH
Date: 15/12/14

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: CK029



Fauna habitat mapping

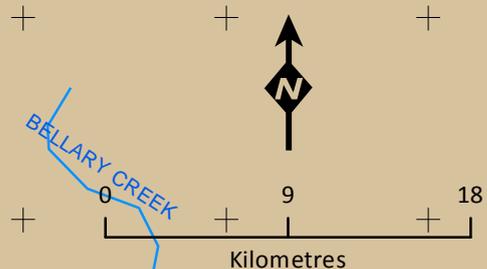


Legend

- River
- Mt Macleod Study Area

Habitat types

- Drainage line/river/creek
- Hilltops/ridges/plateaux
- Hummock grassland
- Plain (cracking clay)
- Plain (stony gibber)
- Woodland (open eucalypt)
- Cleared area/Agriculture
- other habitats
- not mapped



Absolute Scale - 1:375,000



Regional fauna habitat mapping

<p>Figure:4.2 Project ID: 1514</p>	<p>Drawn: AH Date: 11/12/14</p>
<p><small>Coordinate System Name: GDA 1994 MGA Zone 50 Projection: Transverse Mercator Datum: GDA 1994</small></p>	
<p><small>Unique Map ID: CK029</small></p>	
<p>A4</p>	

4.1.1 Woodland (open)

Woodland (open) habitat is the dominant habitat type within the study area, covering 44.3 % (4,486.7 ha) of the total study area (Table 4.2). This habitat type consists of moderately dense *Eucalyptus* spp. and *Acacia aneura* trees over *Acacia* spp. shrubs and tussock grasslands on loam or clay soils containing pebbles (Figure 4.3). Wood litter is usually sparse to moderately dense. Leaf litter can build up over time in denser areas which have not been subject to fire, such as the acacia thickets. The open woodland habitat occurs in both the Mt Macleod North and Mt Macleod South study areas (Figure 4.1) but can also be found outside the study area covering 4.6% of the regional area (Table 4.2). The habitat condition was assessed to be very good to excellent with little impacts (Table 3.4).



Figure 4.3 – Woodland over grassland plain habitat recorded from the study area

4.1.2 Hummock Grassland

The hummock grassland plains habitat is the second largest habitat type of the study area, a total of 3,191.9 ha (31.6%) (Table 4.2). It is less common within 20 km of the study area, covering 4,678.4 ha (1.8% of the regional area); however small areas of this habitat type may be found within the plain (stony gibber) in addition to the extent mapped due to the similarity of the landform and vegetation composition between the two habitat types (Figure 4.4, Figure 4.5). The vegetation of the hummock grassland habitat is characterised by isolated trees of *Eucalyptus leucophloia* subsp. *leucophloia* and *Acacia aneura* over sparse to medium dense *Acacia/Senna* spp. shrubs over *Triodia wiseana* hummock grassland (Figure 4.4). These often undulating plains consist of firm red fine clay-sands with numerous loose rocks. The amount of leaf litter and woody debris is usually low within these habitats. Hummock grassland are located to the eastern margins of both Mt Macleod North and Mt Macleod South, and represent the footslopes of large hills and ranges to the east of the study area (Figure 4.1). Based on the categories listed in Table 3.4 the condition of the hummock grassland was assessed to be excellent due to very little disturbance, mainly clearance in the form of tracks.



Figure 4.4 – Hummock grassland plain habitat recorded from the study area

4.1.3 Plain (stony gibber) – includes rocky hillslopes

The stony gibber plain is a relatively large habitat within the study area, comprising 13.1 % (1,326.9 ha) of the total area and includes rocky hillslopes (Table 4.2). This habitat is the most elevated of the six habitat types within areas of hillslopes, and is mainly found in the western half of the study area (Figure 4.1). This habitat type consists of an open shrubland of *Acacia aneura*, *A. pruinocarpa*, *A. binevosa* and *Senna glutinosa* over *Triodia wiseana* hummock grassland on a continuous layer of bedrock and scattered pebbles and stones (Figure 4.5). Wood litter and leaf litter is generally sparse in this habitat. The stony gibber plain occupies the large majority of the region with 190,272.0 ha (73.0 %) covering the area within 20 km of the study area (Figure 4.2). This habitat was in very good to excellent condition during the current survey with few signs of recent fires and some clearance in the form of vehicle tracks (Table 3.4).



Figure 4.5 – Plain (stony gibber) recorded from the study area

4.1.4 Plain (cracking clay)

The plain (cracking clay) occupies approximately 838.8 ha (8.3%) within the Mt Macleod study area (Table 4.2). This habitat type is located in the northern and far western areas of Mt Macleod North and in the eastern margins of Mt Macleod South (Figure 4.1). It was also recorded from 24,762.1 ha (9.5%) within 20 km of the study area (Table 4.2). The cracking clay is a habitat type which contains little to no overstorey and is often dominated by one or two tussock grass species. The vegetation is described as isolated shrubs of *Sida spinosa* and/or *Vachellia farnesiana* located amongst dense tussock grassland dominated by *Chrysopogon fallax*, *Themeda* sp. Hamersley Station and/or *Astrebla pectinata* grass species. The soils are firm cracking clays that contain many cracks and crevices. Rocks/stones/pebbles, leaf litter and woody debris are almost entirely lacking from this habitat type (Figure 4.6). During the current survey, the cracking clay was in good condition based on the criteria listed in Table 3.4. Slight grazing of cattle and some clearance in form of tracks was noted.



Figure 4.6 – Cracking clay grassland habitat recorded from the study area

4.1.5 Drainage line/river/creek

The drainage line/river/creek habitat type comprises 2.3% (235.1 ha) of the study area and is the smallest habitat represented within the Mt Macleod study area (Table 4.2). The drainage line/river/creek habitat consists of features that are distinct from other habitats. This habitat type is represented by two creeklines which run continuous, north-to-south through both Mt Macleod North and Mt Macleod South (Figure 4.1). This habitat type was also recorded from 2,967.6 ha (1.1%) within 20 km of the study area (Table 4.2, Figure 4.2). The banks of the drainage line/river/creek are defined as an open woodland of *Acacia citronviridis* and *Eucalyptus victrix* over a dense tussock grassland which is dominated by *Cenchrus ciliaris* and therefore degraded in many areas. The bed of the drainage line/river/creek consists of river stones and gravel with sections and banks consisting of moist clay-loam topsoil and built up debris. During the survey there were sections of water which have the potential to support a large number of fauna species. These areas contain a moderate amount of leaf litter and woody debris (Figure 4.7). The drainage line/river/creek habitat type within the study area was of poor to good habitat condition due to some signs of fire, as well as grazing and tracks by cattle, in particular in the vicinity of water pools (Table 3.4).



Figure 4.7 – Drainage line/river/creek habitat recorded from the study area

4.1.6 Hilltop/ridge/cliff

The hilltop/ridge/cliff habitat of the study area consists of the hillslopes and boulders leading up to the ridges. The habitat type is very restricted within the study area and comprises 0.6 % (59.8 ha) of the total study area (Table 4.2, Figure 4.1). This habitat is the most elevated of the six habitat types, and is represented in the north-east section of Mt Macleod South (Figure 4.1). It is more common in the regional area (within 20 km of the study area) and occupies 26,163.3 ha (10.0%) of the local region (Table 4.2). This habitat type consists of an open shrubland of *Acacia aneura*, *A. pruinocarpa*, *A. binevosa* and *Senna glutinosa* over *Triodia wiseana* hummock grassland on a continuous layer of bedrock with scattered pebbles and stones (Figure 4.8). Wood litter and leaf litter is generally sparse in this habitat, accumulating around the base of shrubs and larger rocks. It contains large rock boulders and crevices that have the potential to provide shelter for a range of fauna species. The habitat condition is very good to excellent based on the criteria listed in Table 3.4.



Figure 4.8 – Hillslope habitat recorded from the study area

4.2 FAUNA HABITAT ANALYSIS

Five of the six fauna habitats within the study area were sampled with systematic trapping sites during the current Level 2 survey. The hilltop/ridges/cliffs habitat was not suitable for pitfall trapping due to very hard substrate and the incline of the Hillslope. However, it was targeted using cage traps during the targeted survey. Of the eight systematic Level 2 trap sites, four were expended in the two largest habitat types (woodland (open), and hummock grassland) during the Level 2 survey, while extensive trapping effort occurred in hilltop/ridge/cliff habitat during the targeted survey. The smaller cracking clay plain, drainage line/river/creek and stony gibber plain habitats were sampled sufficiently during the Level 2 survey.

A one-way ANOSIM test and MDS plot of the trapping sites within the different habitat types was completed for data collected systematically for both birds and trapped terrestrial fauna. The results from these statistical analyses indicate there are some differences between the faunal assemblages in the different habitat types for the birds or trapped terrestrial fauna. MDS plots for the analyses are shown in Figure 4.9.

The one-way ANOSIM test when comparing trapped terrestrial fauna against the different habitat types determined an R-value of 0.09315 (R-value ranges from -1 to 1, with 1 indicating that the groups are dissimilar and -1 indicating that the groups are similar) and a p-value of 0.0836 (p-value of <0.05 indicating a significant difference). The R-value close to 0 and a relatively low p-value from this analysis suggest that only a slight differences between habitat types exist, and that the data collected are sufficient to make this analysis. The MDS plot for trapped terrestrial fauna data provides a visual illustration of the habitat data, showing some fauna habitats (such as woodland (open) and hummock grassland) are distinct from one another, but also that overlap exists for some habitat types (Figure 4.9). The stress value of 0.0928 for this test indicates good fit of the scaling to the matrix, confirming differences in some habitat types when comparing trapped terrestrial fauna data.

Statistical analysis of the avifauna recorded showed a greater difference between habitat types and avifauna recorded than the terrestrial trapped fauna. The one-way ANOSIM test determined an R-value of 0.1875 and a p-value of 0.0131. This indicates that differences between the avifauna habitats exist. The p-value of 0.0131 suggests sufficient data was obtained to complete the analysis. The MDS plot reflects the results from the ANOSIM. Visually, it appears bird species recorded from the cracking clay grassland habitat type are distinct from the remaining four habitat types, while considerable overlap exists between woodland (open), drainage line/river/creek, hummock grassland, and stony gibber plain habitat types (Figure 4.9). A stress value of 0.2102 for this test indicates good fit of the scaling to the matrix.

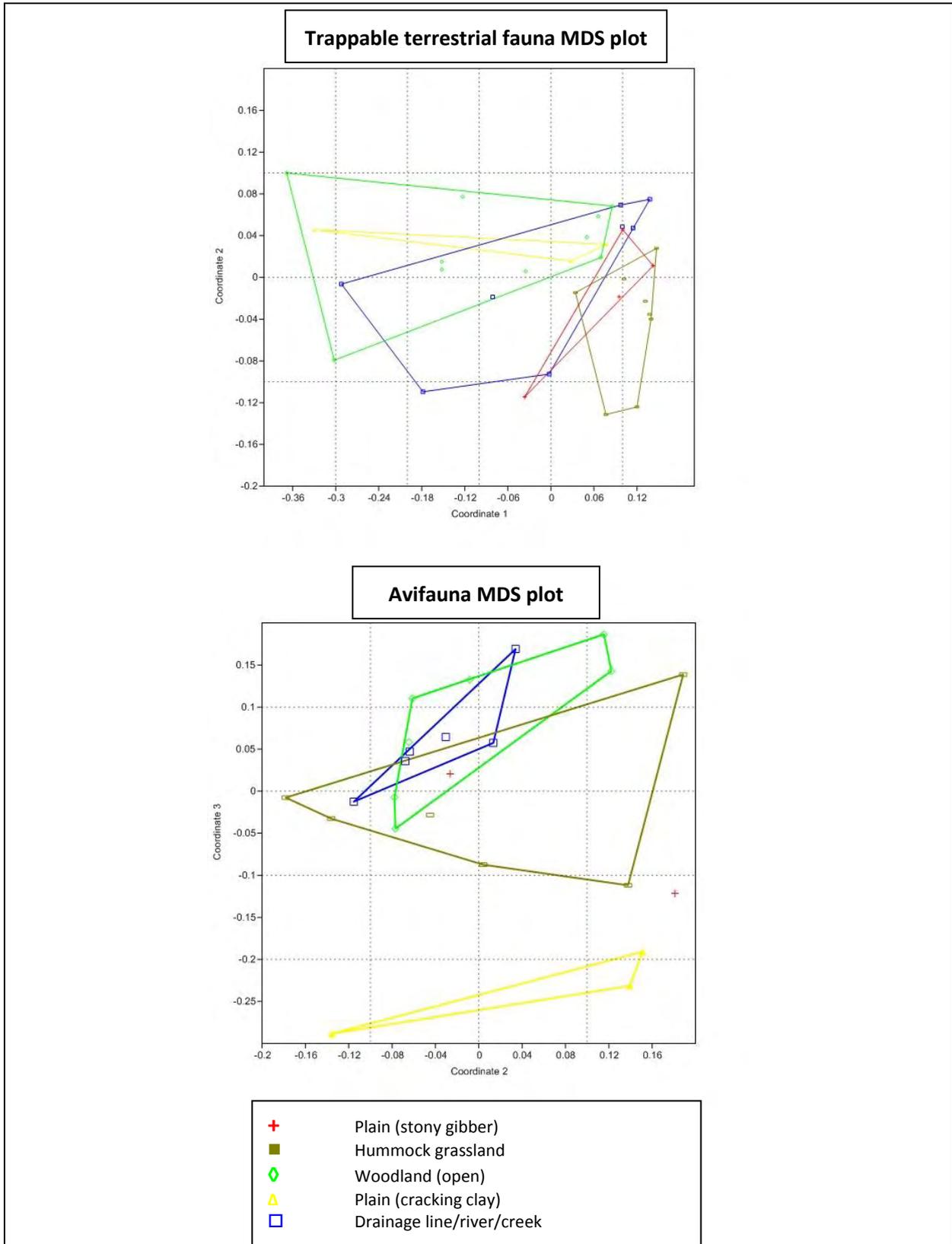


Figure 4.9 – Trappable terrestrial fauna and avifauna MDS plots

4.3 FAUNA ASSEMBLAGE

During the survey a total of 18 native and one introduced mammal, 63 bird, 28 reptile and two amphibian species were recorded (Appendix E). A further two species of mammal and one reptile were recorded by secondary evidence only (scats and tracks). Of all species recorded, four species are of conservation significance, the Short-tailed Mouse, Western Pebble-mound Mouse, Australian Bustard and Rainbow Bee-eater. A site-by-species matrix of the results of the survey is provided in Appendix E.

4.3.1 Mammals

The 18 native mammal species recorded consist of one tachyglossid (Echidna), four dasyurids (small, carnivorous marsupials), six rodents, one macropod (kangaroos and wallabies) and six microbats. The smaller mammals were captured in pitfall and funnel traps at systematic trapping sites, whilst the macropods were observed during opportunistic searches. Bat species were identified from calls recorded on SM2BAT systems.

The most abundant mammal species recorded during the Level 2 survey was the Striped-faced Dunnart (*Sminthopsis macroura*), which was captured on 44 occasions at seven trapping sites. The bats Gould's Wattled Bat *Chalinolobus gouldii* (14 sites) and Finlayson's Cave Bat (*Vespadelus finlaysoni*) (nine sites) were the most widespread bat species recorded. The introduced House Mouse (*Mus musculus*) was trapped at four sites.

One mammal species of conservation significance was recorded during the Level 2 fauna assessment, the Short-tailed Mouse (DPaW Priority 4). The species was captured on seven occasions from five separate sites. Western Pebble-mound Mouse mounds (*Pseudomys chapmani*; DPaW Priority 4) were recorded within the study area at eight locations including one mound likely to be active (Figure 4.10, Table 4.4).

During the targeted survey, the Common Rock-rat (*Zyomys argurus*) was captured on 45 occasions. No other mammal species were trapped during the targeted survey.

4.3.2 Birds

In total, 63 native bird species were recorded during systematic and opportunistic searches. The more abundant species included the Zebra Finch (*Taeniopygia guttata*) (307), Crested Pigeon (*Ocyphaps lophotes*) (99), Brown Honeyeater (*Lichmera indistincta*) (56), Weebill (*Smicronis brevirostris*) (56), Galah (*Eolophus roseicapilla*) (55) and Rufous Whistler (*Pachycephala rufiventris*) (50).

Two species of conservation significant birds were recorded within the study area: nine Rainbow Bee-eater (*Merops ornatus*) from four locations (MMS1, MMS2, MMS6 and opportunistic)(EPBC Act Migratory, WC Act Schedule 3) and one Australian Bustard (*Ardeotis australis*; DPaW Priority 4) from one location (MMS2).

4.3.3 Herpetofauna

A total of 28 reptile species and two amphibian species were recorded during the survey. The reptile assemblage comprised one turtle, five agamids (dragons), four geckos, two pygopods, ten scincids (skinks), and six elapids (front-fanged venomous snakes). In addition, the remains of an unidentifiable *Delma* sp. (legless lizard) was recorded. The most common species were *Ctenotus robustus* (53), *Amphibolurus longirostris* (20) and *Ctenotus patherinus* (16). The two species of amphibians trapped included *Litoria rubella* and *Cyclorana maini*.

One species of conservation significance, Ganes blindsnake (*Ramphotyphlops ganei*; DPaW P1) was recorded during this and the first phase of the survey (Rapallo 2011). However, the record during this survey is located 4 km north of the study area (Figure 4.10).

4.3.4 Fish

All waterholes present at the time of the current survey were surveyed and no species of fish were recorded from the Mt Macleod study area.

4.3.5 Endemic species and species of biological significance

No species endemic to the Pilbara IBRA region were recorded during the survey. It is expected that Pilbara endemics such as *Varanus bushi* and *Varanus caudolineatus* may occur within the woodlands of the study area and *Varanus pilbarensis* within the hillslope habitat.

Four species with a restricted distribution were recorded, including the Little Red Kaluta, Pilbara Ningaui, Southern Pilbara Tree Dragon (*Diporiphora valens*) and the skink *Ctenotus duricola*. Only a small percentage of the distributional areas of these species extend beyond the Pilbara IBRA region boundary.

4.4 CONSERVATION SIGNIFICANT FAUNA

Based on database searches and the results of previous biological surveys in the surrounding region, nine mammals, 10 birds and four reptiles of conservation significance could potentially occur in the study area (Appendix C). Three species of conservation significance were recorded during the survey, and these records are summarised in Table 4.4 and displayed in Figure 4.10. Additionally, secondary evidence (a potentially active mound) of the Western Pebble-mound Mouse was recorded.

Sixteen species were assessed as having a medium to high likelihood of occurrence, with the remaining 18 species assessed as having a low likelihood. Species with medium to high likelihood of occurrence are described in greater detail in Section 5.2.

Table 4.4 – Conservation significant fauna recorded during the survey

Species	Location			Count
	Easting	Northing	Site	
This survey				
Mammals				
Short-tailed Mouse (<i>Leggadina lakedownensis</i>)	584639	7534712	MMS1	2 records
	584600	7534794	MMS1	2 record
	594127	7534175	MMS2	1 record
	594171	7534109	MMS2	1 record
	596519	7532387	MMS3	1 record
Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>)	601895	7521185	Opportunistic	Inactive mound
	602495	7520108	Opportunistic	Inactive mound
	593495	7533529	Opportunistic	Inactive mound
	602408	7519855	Opportunistic	Inactive mound
	602096	7519792	Opportunistic	Inactive mound
	597927	7517815	Opportunistic	Inactive mound
	602329	7519973	Opportunistic	Inactive mound
	602107	7519789	Opportunistic	Inactive mound

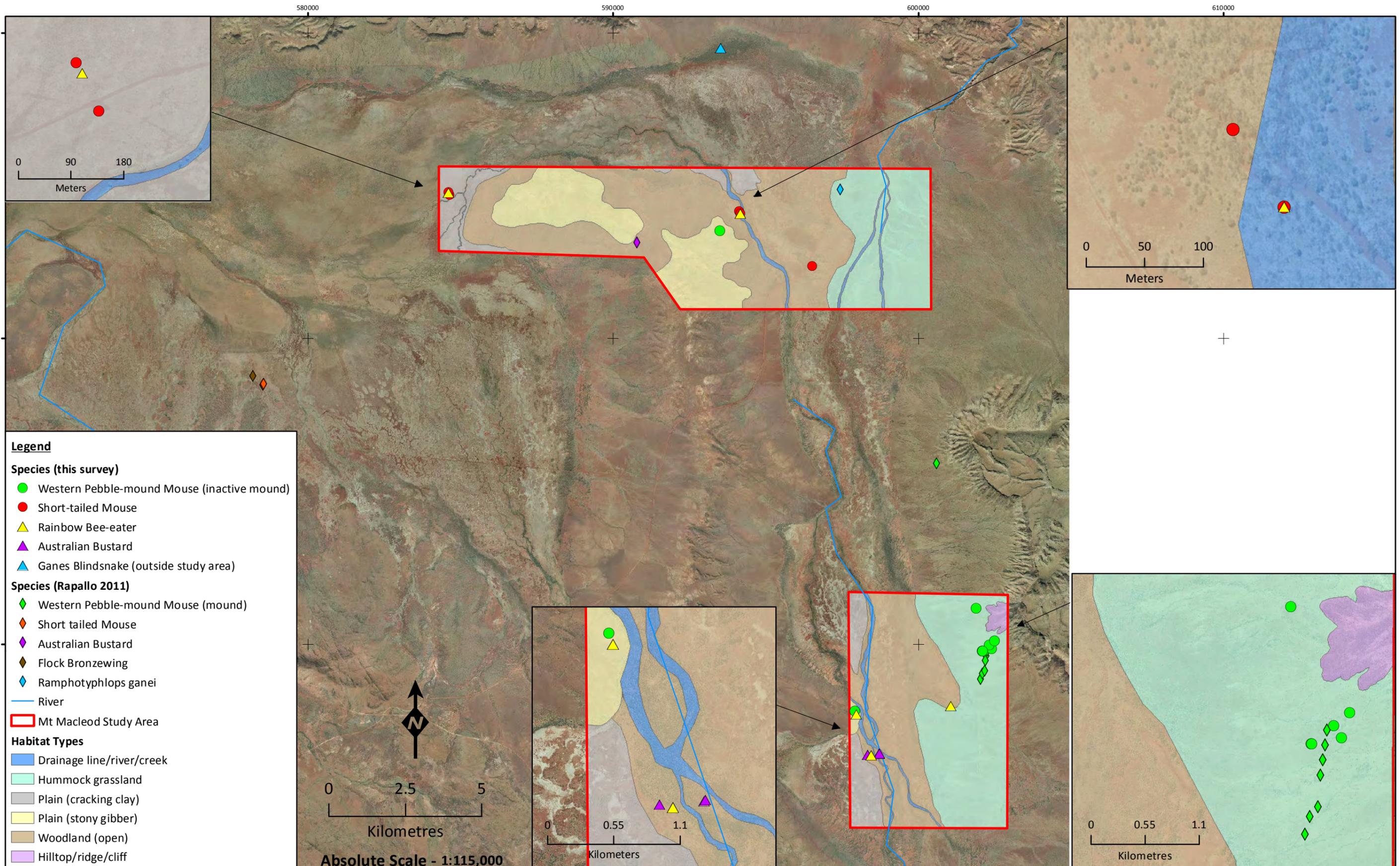
Species	Location			Count
	Easting	Northing	Site	
Birds				
Australian Bustard (<i>Ardeotis australis</i>)	598345	7516392	MMS7	1 record
	598715	7516420	Opp sighting	2 individuals
	598727	7516431	Opp sighting	3 individuals
Rainbow Bee-eater (<i>Merops ornatus</i>)	598459	7516367	MMS7	2 records
	584610	7534777	MMS1	1 individual
	594171	7534109	MMS2	1 individual
	597963	7517723	opp	1 individual
	601063	7517996	opp	1 individual
Reptiles				
Gane's Blindsnake (<i>Ramphotyphlops ganei</i>)	593519	7539508	Opp (outside study area)	1 individual
Rapallo (2011)				
Western Pebble-mound Mouse (<i>Pseudomys chapmani</i>)	600600*	7525915*	Opportunistic	Inactive mound
	602260*	7519929*	Opportunistic	Inactive mound
	602039*	7518873*	Opportunistic	Inactive mound
	602087*	7519052*	Opportunistic	Inactive mound
	602170*	7519148*	Opportunistic	Inactive mound
	602218*	7519631*	Opportunistic	Inactive mound
	602194*	7519470*	Outside the study area	Inactive mound
	602242*	7519780*	Outside the study area	Inactive mound
Birds				
Australian Bustard (<i>Ardeotis australis</i>)	590782	7533136	SHET2	2 individuals
Reptiles				
Gane's Blindsnake (<i>Ramphotyphlops ganei</i>)	597446	7534872	MGS4	1 individual

Zone 50 K; Datum GDA 94

*Estimated coordinates only (map reading)

¹ Individuals = animals seen at the same time and, therefore, numbers are confirmed.

Records = some individuals may have been observed multiple times.



- Legend**
- Species (this survey)**
- Western Pebble-mound Mouse (inactive mound)
 - Short-tailed Mouse
 - ▲ Rainbow Bee-eater
 - ▲ Australian Bustard
 - ▲ Ganes Blindsnake (outside study area)
- Species (Rapallo 2011)**
- ◆ Western Pebble-mound Mouse (mound)
 - ◆ Short-tailed Mouse
 - ◆ Australian Bustard
 - ◆ Flock Bronzewing
 - ◆ Ramphotyphlops ganei
- River
- ▭ Mt Macleod Study Area
- Habitat Types**
- Drainage line/river/creek
 - Hummock grassland
 - Plain (cracking clay)
 - Plain (stony gibber)
 - Woodland (open)
 - Hilltop/ridge/cliff

0 2.5 5
Kilometres
Absolute Scale - 1:115,000

0 0.55 1.1
Kilometers

0 0.55 1.1
Kilometers

0 0.55 1.1
Kilometers



Location of conservation significant fauna recorded

Figure: 4.10
Project ID: 1514

Drawn: AH
Date: 11/12/2014

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: MD'A001

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4.5 SURVEY ADEQUACY

Systematically obtained data (trapping results for terrestrial fauna and set-time survey for birds, excluding opportunistic data) was analysed for survey adequacy. Mammal, reptile and amphibian trapping data were combined for analysis as 'terrestrial fauna', as these fauna groups were sampled using the same methods. The results of trapping during the targeted conservation significant fauna assessment were not included in these analyses due to the different trapping methodology.

Analysis of the terrestrial vertebrate trapping data produced a reasonably smooth SAC, nearing the asymptotic plateau (Figure 4.11). Extrapolation of the Michaelis-Menten (MM) curve suggests that 71.3% of the theoretical total number of terrestrial fauna able to be trapped had been captured at the completion of the 56 trap nights of the Level 2 vertebrate fauna survey (Table 4.5). These results indicate that additional trapping could detect approximately 12 additional species.

Species accumulation curve (SAC) analysis of the avifauna set-time survey dataset also produced a typical SAC, almost reaching the asymptotic plateau (Figure 4.12). Used as a stopping rule, the MM estimator indicated that at the completion of the systematic bird surveys (34 set-time surveys) the survey was to 84.6% sufficient. The MM estimator generated the highest theoretical maximum of 67 species (Table 4.5), suggesting further survey effort could identify approximately ten additional species.

Parametric analysis of systematically obtained survey data for birds and terrestrial faunal groups revealed that survey effort was adequate. Table 4.5 provides a summary of the theoretical maximum number of species using seven different methods of estimating richness. The Michaelis-Menten (MM) equation provides the most accurate representation of the potential species number. This is compared against the actual number of species observed, with any inconsistencies smoothed by an algorithm (Mao Tau) which simulates an infinite number of randomisations of the sample order.

Table 4.5 – Mean estimates of total species richness

Richness Estimators	Total Richness Estimate	
	Terrestrial Vertebrates	Birds
ACE	39.29	60.32
ICE	46.24	62.81
Chao-1	36.6	59.14
Jack-1	43.77	66.6
Jack-2	50.62	66.1
Bootstrap	36.8	62.34
Michaelis-Menten	43.46	67.39
Species Observed	31	57

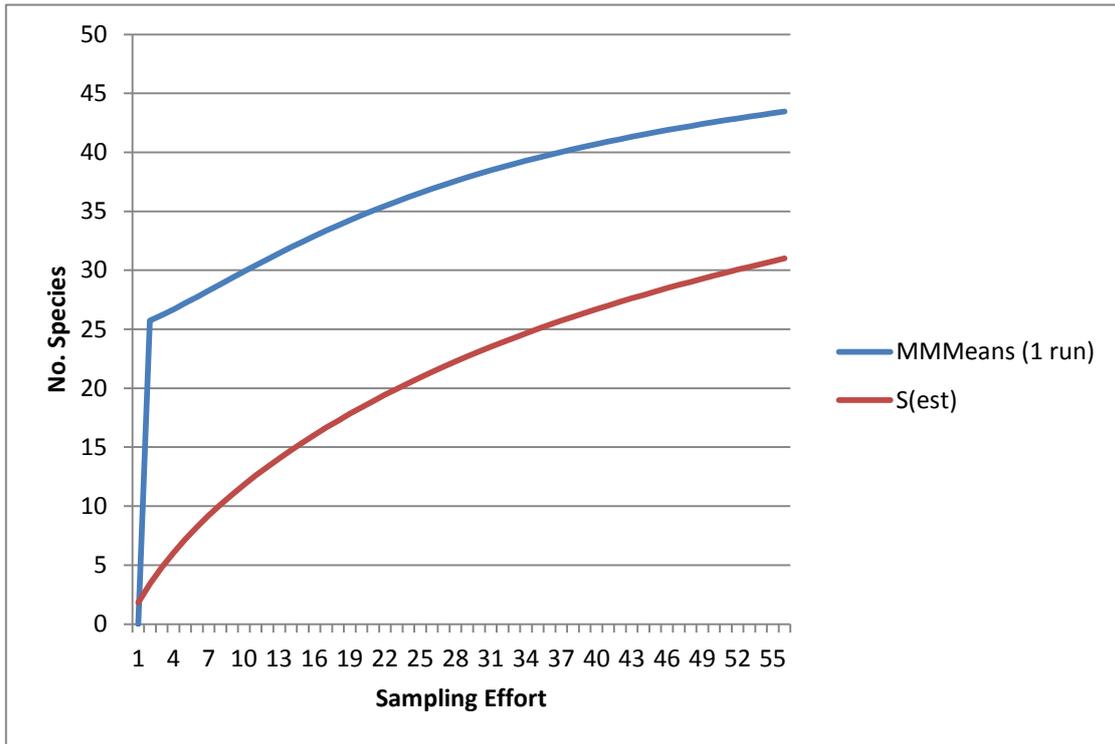


Figure 4.11 – Species accumulation curve for trapped terrestrial vertebrates

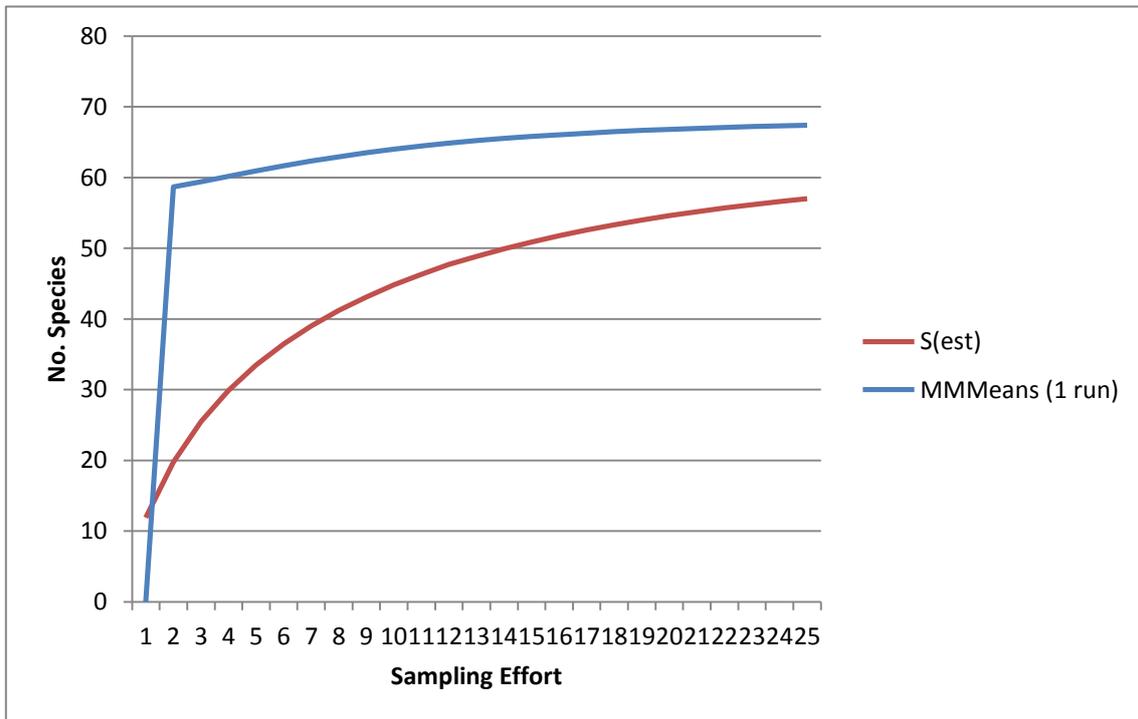


Figure 4.12 – Species accumulation curve for avifauna

4.6 SURVEY LIMITATIONS AND CONSTRAINTS

Limitations of the current survey are summarised in Table 4.6. No significant limitations were experienced during the surveys. Given the few limitations encountered, survey effort was adequate.

Table 4.6 – Summary of survey limitations

Constraint	Relevant (yes/no)	Comment
Competency/experience of the consultant carrying out the survey.	No	All key members of the survey team are experienced in Pilbara fauna identification and fauna surveys.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	All faunal groups were adequately sampled
Proportion of fauna identified, recorded and/or collected.	No	The majority of fauna species expected to occur within the study area were recorded, as indicated by SACs (Figure 4.11, Figure 4.12). All captured species were identified in the field and released.
Sources of information (previously available information as distinct from new data).	No	Thirty-one fauna surveys have been conducted within 100 km of the study area. Data from these surveys was included to provide a regional context.
The proportion of the task achieved and further work which might be needed.	No	A two phase Level 2 vertebrate fauna assessment was completed. There are also a large number of surveys that have been conducted in the surrounding area. Due to this large number of previous surveys it is unlikely that there are any additional species within the study area that have not been identified in this report.
Timing/weather/season/cycle.	Minor	The Level 2 fauna assessment was conducted shortly after the peak activity time for reptiles species within the Pilbara region. This has resulted in a moderate capture rate, however the majority of species were recorded as shown by the species accumulation curves (section 4.5)
Disturbances which affected results of the survey (e.g. fire, flood, accidental human intervention).	No	No major disturbances were experienced during the survey.
Intensity (in retrospect was the intensity adequate).	No	The survey intensity was adequate, all habitat types were surveyed systematically or opportunistically and most of the species expected to occur were recorded.
Completeness (e.g. was relevant area fully surveyed).	No	The hilltop/ridge/cliffs habitat in the north-east of the Mt Macleod South study area was not suitable for trapping during the Level 2 survey due to access restrictions. However, this area was thoroughly surveyed during opportunistic and targeted searches and during cage trapping during the targeted survey. Therefore, the study area was comprehensively surveyed.
Resources (e.g. degree of expertise available in animal identification to taxon level).	No	All zoologists are suitably qualified and experienced in identification of Pilbara fauna and Pilbara fauna habitats. There were no resource issues encountered.
Remoteness and/or access problems.	No	All habitats within the study area were surveyed.
Availability of contextual (e.g. biogeographic) information on the region).	No	Sufficient contextual information was available on the Pilbara region and the study area.
Efficacy of sampling methods (i.e. any groups not sampled by survey methods).	No	Survey methods were suitable to record all terrestrial vertebrate fauna groups distributed in the study area.

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5 DISCUSSION

5.1 FAUNA HABITATS

Habitat types potentially suitable for EPBC Act listed conservation significant fauna (Northern Quoll, Pilbara Leaf-nosed Bat and Pilbara Olive Python) were identified within the study area and areas for each species mapped Figure 5.2 - Figure 5.4. Detailed descriptions of the suitability of potential habitats identified for each species within the study area and extent of these is summarised in Table 5.1 below.

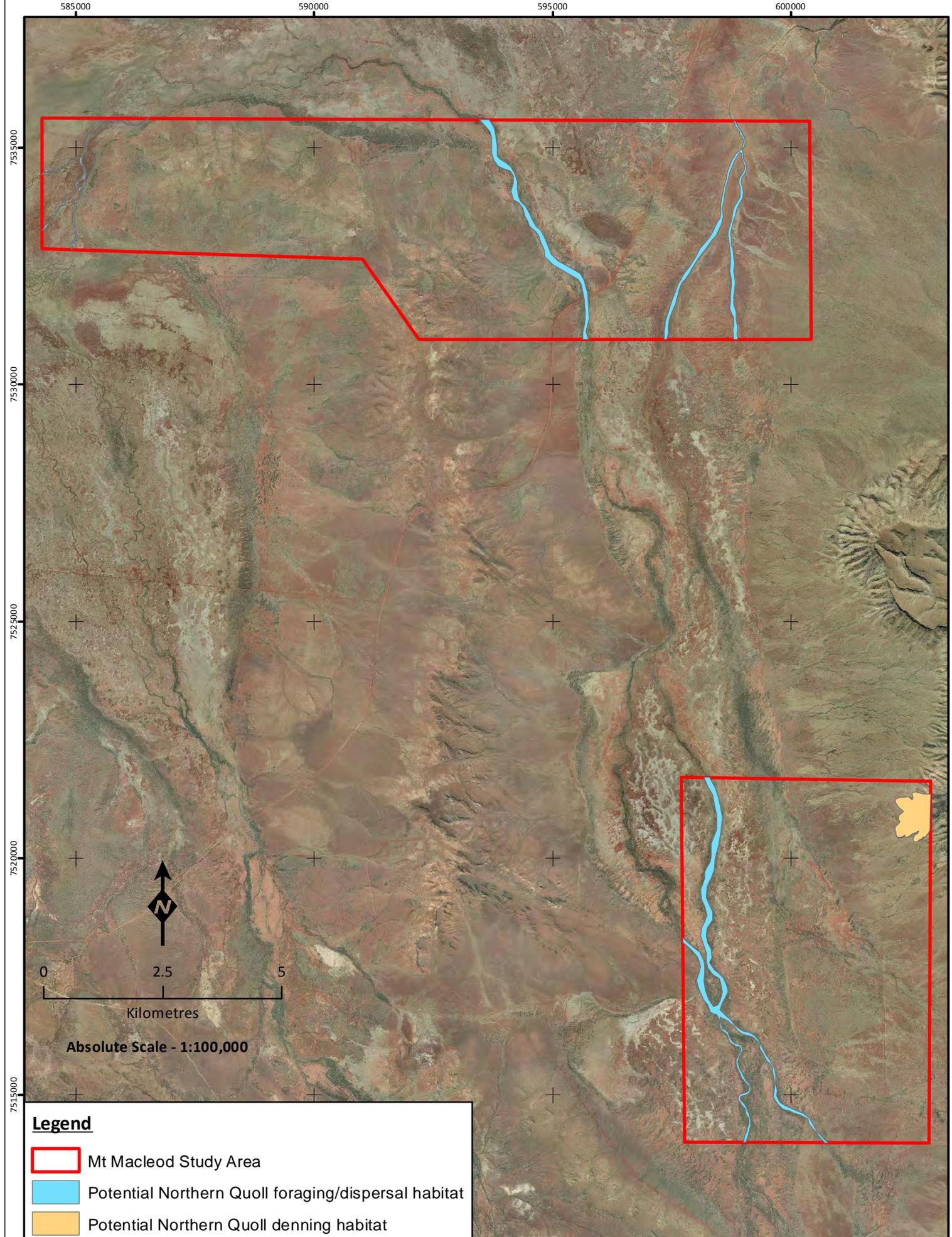
Potential denning habitat for Northern Quolls and Pilbara Leaf-nosed Bats was only recorded from one location in the north-east corner of the Mt Macleod South study area (Figure 5.1, Figure 5.2). The area comprises of rocky boulder piles within the hilltop/ridge/cliff habitat which occupies 59.8 ha (0.6%). Potential foraging and dispersal habitat for Northern Quolls in the form of drainage lines/river/creeks was recorded from 235.14 ha (2.3%) within the study area and potential foraging habitat for the Pilbara Leaf-nosed Bat occupied 295.02 ha (2.9%) of the study area. The Pilbara Leaf-nosed Bat foraging habitat comprises of drainage line/river/creek habitat and the rocky boulders in the north-east of the study area (Figure 5.1, Figure 5.2). Potential habitat for Pilbara Olive Pythons was recorded from the hilltop/ridge/cliff and drainage lines/river/creek habitat which occupies 295.02 ha (2.9%) of the study area. However, not the entire extent of this habitat type is considered to be critical for the species and only patches along the drainage line may be critical for the species.



Figure 5.1 – Potential habitat for Northern Quoll and Pilbara Olive Python recorded

Table 5.1 – Summary of potential habitats for EPBC Act listed fauna within the study area

Species	Fauna Habitat	Area inside study area (ha)	Percentage of Total study area (%)
Northern Quoll	Potential denning habitat. Areas of rocky habitat in the study area that may contain suitable den sites, preferably near a water source.	59.88	0.6
	Foraging/dispersal habitat. Well-vegetated and/or rocky areas used for foraging/hunting, often associated with a creekline or river system, as well as habitat traversed by the species when moving from potential denning areas to suitable foraging areas and when seeking mates during the breeding season (includes footslopes and plains).	235.14	2.3
Pilbara Leaf-nosed Bat	Potential roosting habitat. Areas of rocky gorges and gullies in the study area that may contain suitable caves for roosting.	0	0
	Foraging habitat. Habitat over which the species may fly while foraging, preferably well-vegetated areas, often associated with water and open valleys, which attract a higher number of insects.	295.02	2.9
Pilbara Olive Python	Potential critical habitat. Areas which may contain escarpments, gorges, preferably with rock crevices and outcrops near water holes, which attract prey species.	295.02	2.9



Legend

- Mt Macleod Study Area
- Potential Northern Quoll foraging/dispersal habitat
- Potential Northern Quoll denning habitat



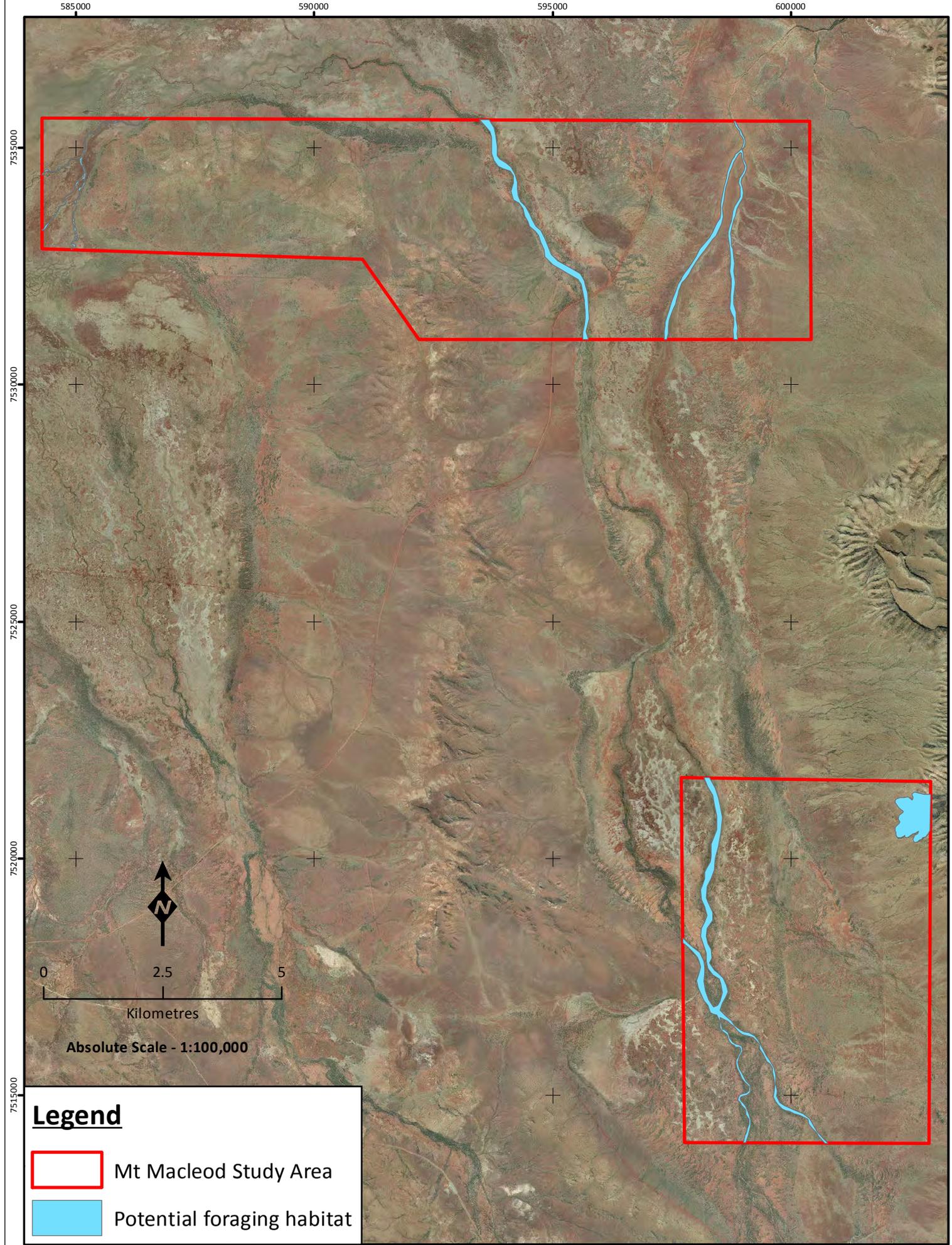
Northern Quoll habitat within the Mt Macleod study area

Figure: 5.2
Project ID: 1514

Drawn: AH
Date: 12/12/14

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: AH482



Legend

- Mt Macleod Study Area
- Potential foraging habitat



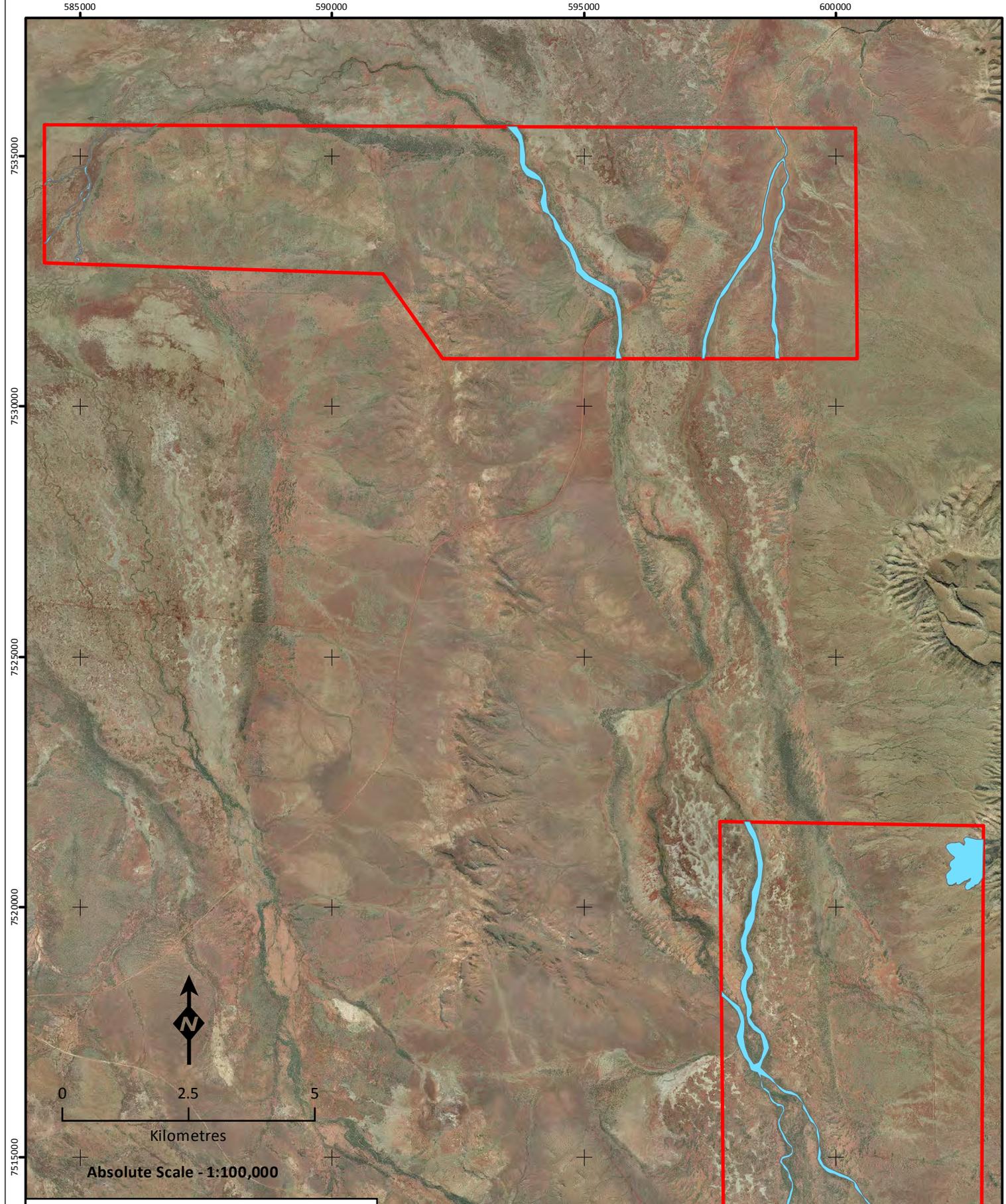
**Pilbara Leaf-nosed Bat
habitat within the Mt Macleod study area**

Figure: 5.3
Project ID: 1514

Drawn: AH
Date: 12/12/14

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: AH482



Legend

- Mt Macleod Study Area
- Potential foraging/dispersal habitat



Pilbara Olive Python habitat within the Mt Macleod study area

Figure: 5.4
Project ID: 1514

Drawn: AH
Date: 29/08/2013

Coordinate System
Name: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID: AH482

5.1.1 Woodland (open)

The habitat condition of the open woodland habitat was assessed to be very good to excellent with little impacts by fire and feral herbivores. In addition, the clearance was limited to small vehicle tracks. This habitat type is also the most common habitat type within the study area whereas it is usually recorded from smaller area in study areas within the Pilbara bioregion (*ecologia* 2013d, 2014a; Ecoscape 2010c, 2012a, b, c, 2013).

The mammal species inhabiting the woodland over grassland habitat are generalist species that occur throughout the majority of the Pilbara. Common species recorded within this habitat type include the Stripe-faced Dunnart, Desert Mouse (*Pseudomys desertor*) and Sandy Inland Mouse (*Pseudomys hermannsburgensis*) which forage and shelter within the large amounts of woody debris and grass.

The avifauna of the woodland is usually most diverse after significant rainfall when acacia shrubs and trees are flowering, increasing feeding resources for birds (Johnstone and Storr 2004). In particular, honeyeater species such as the Singing Honeyeater (*Lichenostomus virescens*), Brown Honeyeater and in good conditions, Black Honeyeater (*Sugomel nigrum*) and White-fronted Honeyeater (*Phylidonyris albifrons*) can be commonly found in this habitat (Morcombe 2000; Simpson and Day 2010, *ecologia* internal database). Other species such as the Crested Bellbird (*Oreica gutturalis*), Grey-crowned Babbler (*Pomatostomus temporalis*), Chestnut-rumped Thornbill (*Acanthiza uropygialis*) and Willie Wagtail (*Rhipidura leucophrys*) are less reliant on rainfall events and occupy such habitat year-round.

The herpetofauna of the woodland habitat comprises species such as the Mulga Snake (*Pseudechis australis*) and *Ctenotus robustus* and the Western Netted Dragon (*Ctenophorus reticulatus*) (Bush and Maryan 2011; Storr *et al.* 1999; Wilson and Swan 2013, *ecologia* internal database). The woodland (open) habitat has the potential to inhabit species that prefer mulga woodlands such as the two monitor lizards *Varanus bushi* and *Varanus caudolineatus*, and the Mulga Dragon (*Caimanops amphiboluroides*) (Wilson and Swan 2013).

The woodland (open) habitat is a widespread habitat within the study area and occurs throughout the Pilbara bioregion and arid zone; as such, the fauna assemblage of this habitat consists of many common and widespread species. The Australian Bustard and the Short-tailed Mouse are the only conservation significant species recorded from this habitat in this survey. However, both species were also recorded from other habitats within the study area and in particular the Short-tailed Mouse is thought to prefer the cracking clay habitat types (*ecologia* internal database, *ecologia* 2012a, 2013d; van Dyck and Strahan 2008). Therefore it is not reliant on the open woodland habitat type.

5.1.2 Hummock Grassland

The very good to excellent condition of the hummock grassland was due to very little impact by feral species, only few tracks and no recent fire history was recorded. As stated in section 4.1, the hummock grassland was recorded and mapped within the region (Table 4.2, Figure 4.2) and previous surveys in the local region (*ecologia* 2014a) and is not unique to the study area.

The mammal species of the hummock grasslands comprise a variety of generalists such as the Little Red Kaluta (*Dasykaluta rosamondae*), Pilbara Ningauai (*Ningauai timealeyi*), Desert Mouse and the Striped-face Dunnart. All mammal species caught within this habitat type were caught in other habitats of the study area, with exception to the Delicate Mouse (*Pseudomys delicatulus*), which was only recorded once during this survey but has been recorded during previous surveys within the region (Biota 2011; *ecologia* 2012c).

The avifauna of this habitat type is of relatively low diversity due to the low density of trees and shrubs. Bird species that can be found in this habitat include generalists such as Zebra Finch, Willie Wagtail, Galah, Weebill and Diamond Dove (*Geopelia cuneata*) (Morcombe 2000; Simpson and Day 2010, ecologia internal database). Areas of the hummock grassland that support dense shrubs attract a relatively large number of bird species such as Brown Honeyeater, Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), Masked Woodswallow (*Artamus personatus*), Black-faced Woodswallow (*Artamus cinereus*) and Variegated Fairy-wren (*Malurus lamberti*). Birds of prey utilise the open vegetation for hunting and Brown Falcon (*Falco berigora*), Spotted Harrier (*Circus assimilis*) and Whistling Kite (*Haliastur sphenurus*) were often recorded foraging above the hummock grassland plains (Morcombe 2000; Simpson and Day 2010, ecologia internal database).

The herpetofauna of the hummock grassland plains comprises a list of generalists that shelter within spinifex clumps, including the skinks *Ctenotus saxatilis* and *C. pantherinus*, Ring-tailed Dragon (*Ctenophorus caudicinctus*), Spiny-tailed Monitor (*Varanus acanthurus*), Sand-plain Gecko (*Lucasium stenodactylum*).

Hummock grassland plains are also preferred habitat for the Australian Bustard (Johnstone and Storr 1998; Morcombe 2000; Simpson and Day 2010, ecologia internal database).

5.1.3 Plain (stony gibber) – includes rocky hillslopes

The stony gibber plain is a widespread habitat type which often covers large sections of study areas in the Pilbara bioregion (ecologia 2010, 2011a, b, 2013a, 2014a; Ecoscape 2010a, c, 2012a, b, c, d, e). It occupies 190,272.0 ha (73.0 %) of the area within 20 km of the study area. The condition of this habitat is most likely to be impacted by fires as the vegetation is usually moderately dense with spinifex clumps catching fire easily. The stony gibber plain habitat type was in very good condition during the survey with few signs of recent fires and grazing by cattle.

The mammals of this habitat typically comprise the Striped-face Dunnart and Sandy Inland Mouse (van Dyck and Strahan 2008). These species usually shelter under spinifex clumps and shrubs.

The avifauna of the plain (stony gibber) habitat is of usually moderate variety and includes a number of generalists, such as the Zebra Finch, Crested Pigeon and the Spinifexbird (*Eremiornis carteri*) (Morcombe 2000; Simpson and Day 2010, ecologia internal database). The areas containing sparse trees and shrubs support bird species such as the Brown Honeyeater, Weebill and Western Gerygone (*Gerygone fusca*) (Johnstone and Storr 2004). Most birds inhabiting this habitat type are foraging and living within or between spinifex clumps. Raptors such as the Wedge-tailed Eagle (*Aquila audax*) and Brown Falcon are commonly recorded flying over and foraging within these habitats (Morcombe 2000; Simpson and Day 2010, ecologia internal database).

The herpetofauna of this habitat includes common species that are found amongst the spinifex hummocks. Species which commonly inhabit this habitat type include Fat-tailed Gecko (*Diplodactylus conspicillatus*), *Heteronotia binoei* and Pygmy Python (*Antaresia perthensis*) (Wilson and Swan 2013).

The Western Pebble-mound Mouse prefers hillslopes where spinifex clumps on rocky pebbles dominate the landscape; this species was recorded through secondary evidence within this habitat (Dunlop and Pound 1981; van Dyck and Strahan 2008).

5.1.4 Hilltop/ridge/cliff

This habitat type was very limited covering 0.6% of the study area. However, the hilltop/ridge/cliffs are regularly recorded in the region (ecologia 2010, 2011a, b, 2012a, b, c, d, 2013a, 2014a). Impacts on this habitat type are usually very low due to the inaccessibility of these elevated areas by cattle and other feral herbivores. However, fires can sometimes be seen clearing the hilltops. During the survey, this habitat type was in very good to excellent condition.

Typical mammals of this habitat comprise of the Rothschild's Rock-wallaby (*Petrogale rothschildi*) and the Common Rock-rat (*Zyomys argurus*) (van Dyck and Strahan 2008). These species shelter in rock cracks, crevices and small caves and overhangs. The small rock shelters and cracks of this habitat type also have the ability to support cave structures which provide roosting habitat for a variety of bat species such as the Finlayson's Cave Bat (Churchill 2008).

Some reptile species are specialised for this habitat type such as the skinks *Morethia ruficundus*, Pilbara Rock Monitor (*Varanus pilbarensis*), Velvet Gecko (*Oedura marmorata*) and the Desert Cave Gecko (*Heteronotia spelea*) (Wilson and Swan 2013). The avifauna of this elevated habitat type is usually sparse with and share affinities with the plain (stony gibber) fauna assemblages. Grey-headed Honeyeater is usually common, and the Pilbara race *whitei* of Striated Grasswren is largely restricted to these areas. Other species characteristic to this habitat include Little Woodswallow, Spinifex Pigeon, Painted Finch, Striated Pardalote and Weebill (Morcombe 2000; Simpson and Day 2010, ecologia internal database).

The hilltop/ridge/cliff habitat, while common in the region is limited within the study area. The habitat has the potential features to support the EPBC Act listed Northern Quoll (potential denning habitat) and the conservation significant Long-tailed Dunnart (*Sminthopsis longicaudata*) (Burbidge *et al.* 2008; DSEWPaC 2013b; Holmes and Miller 2005). However, the current targeted and Level 2 surveys did not record any evidence of these species.

5.1.5 Plain (cracking clay)

The cracking clay habitat is a widespread habitat type in the area surrounding the study area (Table 4.2, Figure 4.2), dominating the east of the local region (20 km within the study area) and is well recorded in the vicinity of the Fortescue Marsh (ecologia 2014a). The cracking clay plain was in good condition due to grazing and ground disturbance by cattle and some cleared vehicle tracks. No signs of recent fires were observed; however it is not known if the habitat condition and the impacts upon it impacted the fauna assemblage on a significant level.

The mammal diversity within this habitat is generally low. Mammal species captured from this habitat include the Short-tailed Mouse, Planigale (*Planigale* sp.) and Striped-face Dunnart while the Red Kangaroo (*Macropus rufus*) may be observed here opportunistically (Menkhorst and Knight 2011; Moro and Kutt 2008). Small mammals inhabiting this habitat, shelter within the cracks of the substrate and at the bases of the tussock grasses.

Avifauna diversity within cracking clay is limited to a relatively small number which specialise in this less common and relatively homogenous habitat. Specialist avifauna that can be found in this habitat includes the Brown Songlark (*Cincloramphus cruralis*) and Horsfield's Bushlark (*Mirafra javanica*) in addition to the Australasian Pipit (*Anthus novaeseelandiae*), Rufous Songlark (*Cincloramphus mathewsi*) and Black Shouldered Kite (*Elanus axillaris*) (Morcombe 2000; Simpson and Day 2010, ecologia internal database).

Herpetofauna diversity within this habitat is somewhat limited in comparison to other habitat within the study area. This is largely due to homogeneity of the habitat and the lack of microhabitats which it supports. Species which do occur within this habitat include the *Ctenotus robustus* and Gecko's such as *Gehyra variegata*, *Typanocryptis cephalus* and the Pilbara endemic *Diplodactylus savagei* which shelter within the cracking substrate (Wilson and Swan 2013).

The cracking clay is a habitat that supports a small diversity of relatively habitat specific species such as the Short-tailed Mouse (*Leggadina lakedownensis*, DPaW P4), the gecko *Diplodactylus savagei* and the Pebble Dragon *Typanocryptis cephalus* (ecologia internal database, ecologia 2012a, 2013d; van Dyck and Strahan 2008; Wilson and Swan 2013). The cracking clay habitat is also likely to provide supporting habitat for the conservation significant species Australian Bustard (*Ardeotis australis*;

DPaW P4) and Flock Bronzewing (*Phaps histrionica*; DPaW P4) (Johnstone and Storr 1998, 2004). During the current survey, the Short-tailed Mouse and the Australian Bustard were recorded from the cracking clay habitat.

5.1.6 Drainage line/river/creek

The drainage line/river/creek habitat is the smallest habitat type within the study area. Drainage lines/rivers/creeks are often well-vegetated and may contain small puddles of water and for this reason are used as corridors by many species (which may usually occupy other habitats) moving through the landscape. In addition, the drainage lines extend outside the study area, connecting the northern and southern Mt Macleod study area and areas to the north (Figure 4.2).

The diversity of mammals and avifauna found in this habitat is usually relatively high and reflects the preference of many species for trees and/or remnant water, including microbats such as the Little Broad-nosed Bat (*Scotorepens greyii*), Yellow-bellied Sheathtail Bat (*Saccolaimus falviventris*) which commonly forage between the trees and above the water pools (Churchill 2008; van Dyck and Strahan 2008). Several pigeon and honeyeater species such as the White-plumed Honeyeaters (*Lichenostomus penicillatus*), Brown Honeyeater, Crested Pigeon and Singing Honeyeater are commonly found in this habitat (Morcombe 2000; Simpson and Day 2010, ecologia internal database).

The herpetofauna of the drainage line habitat consists of species that prefer dense vegetation and associated leaf litter. These include skinks such as *Carlia munda* and *Ctenotus robustus* and other species such as the Long-nosed Dragon (*Amphibolurus longirostris*), Rosen's Snake (*Suta fasciata*) and legless lizards (Wilson and Swan 2013).

Two conservation significant species were recorded from within this habitat type, the Australian Bustard and the Rainbow Bee-eater. In addition, one record of the Short-tailed Mouse was recorded from the fringe of this habitat type, however, it is not known to prefer the drainage line habitat (Menkhorst and Knight 2011; Moro and Kutt 2008). The drainage line/river/creek habitat may also provide suitable habitat for the Bush-stone Curlew (*Burhinus grallarius*) (Johnstone and Storr 1998; Simpson and Day 2010) and represent potential foraging habitat for the EPBC listed Pilbara Leaf-nosed Bat (Armstrong 2008; DEWHA 2008b; DSEWPaC 2013c) and potential foraging/dispersal habitat for the Northern Quoll (Cook 2010; DSEWPaC 2013b; Holmes and Miller 2005; Oakwood 2000, 2008), although the species were not recorded during this survey.

5.2 CONSERVATION SIGNIFICANT FAUNA

Based on database searches and the results of previous biological surveys in the surrounding region, nine mammal, 20 bird, four reptile and one fish of conservation significance could potentially occur in the study area. Of these, one species of mammal, 10 species of bird and one species of fish are unlikely to occur within the study area and therefore these species are excluded from the assessment. Information regarding conservation significant species are summarised below in Table 5.2. Species of conservation significance with a high to medium likelihood of occurrence are reviewed in greater detail below.

Table 5.2 – Conservation significant fauna occurring or potentially occurring in the study area

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPAW			
Mammals						
Northern Quoll <i>Dasyurus hallucatus</i>	EN	S1	EN	In the Pilbara, most common on dissected rocky escarpments, but also found in eucalypt forest and woodland. Typically rocky areas with suitable denning sites and access to surface water (Holmes and Miller 2005; Oakwood 2008)..	Species not recorded within study area. Scats and individual Northern Quolls have been recorded 14 km and 18 km north of the study area (DPaW 2014). Monitoring programs at the Solomon Mine confirmed the ongoing presence of the species 17 km north of the study area (<i>ecologia</i> 2014b, c)	MEDIUM The Northern Quoll has been recorded repeatedly within 17 km of the study area. Within the study area, very limited rocky habitats are present, and no evidence was recorded during the surveys. However, based on suitable habitat and a viable population present within 20 km of the study area individuals may occasionally travel or forage in the study area and therefore the Northern Quoll is expected to have a moderate likelihood to occasionally forage or travel through the study area.
Greater Bilby <i>Macrotis lagotis</i>	VU	S1	VU	Variety of habitats on soft soil including spinifex hummock grassland, acacia shrubland, open woodland and cracking clays (Johnson 2008)..	Listed in table as DEWPaC states 'potential habitat'. The species occurs within the Pilbara region but not recorded within 100 km of the study area (DPaW 2014).	LOW Not known from the Hamersley Range despite widespread fauna surveys. Limited habitat (soft soils) present within the study area.
Pilbara Leaf-nosed Bat <i>Rhinonicteris aurantia</i> (Pilbara form)	VU	S1	VU	Roost in caves with high humidity (95%) and temperature (32 °C). Forage along waterbodies with fringing vegetation (Armstrong 2008)	Species not recorded within the study area. There are four NatureMap records taken since 2011, located ~15 km northwest of the study area (DPaW 2014).	MEDIUM No suitable dry roosting habitat exists within the study area. However, due to the close proximity of recent records, this species has a medium likelihood of occurring within the study area during foraging activities along drainage lines. The drainage lines may also provide some wet season roost habitat.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPAW			
Spectacled Hare-wallaby <i>Lagorchestes conspicillatus leichardti</i>			P3	Grasslands, open forests, open woodlands and tall shrublands; shelter during the day under tussocks of <i>Triodia</i> spp (Burbidge and Johnson 2008).	Species not recorded within the study area. Several records between 1966 and 1979 within 100 km of the study area (DPaW 2014).	LOW Not recorded within 100 km of the study area since 1979. Limited suitable habitat occurs.
Long-tailed Dunnart <i>Sminthopsis longicaudata</i>			P4	Rocky, hilly areas vegetated with spinifex; occasionally open areas with a stony, rocky mantle (Burbidge <i>et al.</i> 2008).	Species not recorded within the study area. Ten records within 100 km of the study area, including two records within 20 km to the study area (DPaW 2014).	MEDIUM Some suitable habitat occurs within the hilltop/ridge/cliff habitat of the study area. Based on the presence of nearby recent records, this species has a medium likelihood of occurrence.
Ghost Bat <i>Macroderma gigas</i>			P4	Roost in caves, rockpiles and abandoned mines. Will travel 2 km from roost to hunt (Armstrong and Anstee 2000a; Richards <i>et al.</i> 2008).	Nineteen records within 100 km of the study area, including a record from 2013 within 10 km to the study area (DPaW 2014; <i>ecologia</i> 2013d). Remains recorded from a barb wire fence 2km south of the study area during the targeted assessment.	MEDIUM (FORAGING) No suitable roosting habitat exists within the study area. Based on the presence of nearby recent records, this species has a medium likelihood to occurring within the study area during foraging activities along drainage lines.
Short-tailed Mouse <i>Leggadina lakedownensis</i>			P4	Spinifex and tussock grassland on cracking clays. Also acacia shrubland, samphire, woodlands, and stony ranges (Moro and Kutt 2008).	Recorded at five locations during the survey. Previously recorded within the study area (Rapallo 2011). More than 20 records within 100 km of the study area, including a record approximately 20 km south-west (DPaW 2014).	RECORDED This species was recorded at five locations within the Mt Macleod study area. Suitable habitat exists in the cracking clay.
Western Pebble-mound Mouse <i>Pseudomys chapmani</i>			P4	Footslopes of rocky ranges and rocky hills where the ground has continuous small pebbles and vegetated by spinifex (Start 2008).	Recorded in the study area via secondary evidence. Previously recorded in the study area via secondary evidence (Rapallo 2011). Numerous records within 100 km of the study area (DPaW 2014).	RECORDED (via secondary evidence) An active mound was recorded during the survey. Suitable habitat occurs in the stony gibber plain habitat throughout the study area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPAW			
Birds						
Night Parrot <i>Pezoporus occidentalis</i>	EN	S1	CR	Mostly ground-dwelling; spinifex grasslands or samphire and chenopod shrublands near waterbodies (Johnstone and Storr 1998; Simpson and Day 2010).	Species not recorded within the study area. Not previously recorded within 100 km of study area (DPaW 2014). The nearest confirmed record is located ~140 km to the east of the study area at Minga Well, Fortescue Marsh (Davis and Metcalf 2008).	LOW Only one recent record located within Western Australia Marsh (Davis and Metcalf 2008). No records within 100 km of the study area.
Fork-tailed Swift <i>Apus pacificus</i>	M	S3		Nomadic, almost entirely aerial lifestyle over a variety of habitats; associated with storm fronts (Johnstone and Storr 1998; Simpson and Day 2010).	Species not recorded within the study area. The nearest record is located ~ 15 km north of the study area (DPaW 2014). Recorded at three locations in 2011 during Fortescue's Central Pilbara project and Solomon Project (<i>ecologia</i> 2010, 2011a) with the closest record from 20 km north-west of the study area.	MEDIUM The species has recently been recorded during nearby surveys. The species may occur within the study area as an irregular summer migrant.
Rainbow Bee-eater <i>Merops ornatus</i>	M	S3		Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water (Johnstone and Storr 1998; Simpson and Day 2010).	Previously recorded in the study area in 2011 (Rapallo 2011). Numerous records within 100 km of the study area (DPaW 2014).	RECORDED The Rainbow Bee-eater was recorded at five locations within the study area. The drainage line habitat provides suitable foraging and breeding habitat for the species.
Barn Swallow <i>Hirundo rustica</i>	M	S3		Open agricultural areas and urban areas; wetlands, including sewage and saltwork ponds, river pools and tidal creeks (Morcombe 2000; Simpson and Day 2010).	Listed in table as DEWPaC states 'potential habitat'. Species rarely recorded within the region. There are no records within 200 km of the study area.	LOW There are no records of the species within 200 km of the study area. The species is rarely recorded within the Pilbara region.
Grey Falcon <i>Falco hypoleucos</i>		S1	VU	Lightly wooded coastal and riverine plains (Johnstone and Storr 1998; Simpson and Day 2010).	Species not recorded within the study area. Recorded three times within 100 km of the study area, including a record within 20 km east of the study area (DPaW 2013).	MEDIUM The species has been recorded recently adjacent to Mt Macleod North. Limited foraging habitat exists throughout the drainage line of the study area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPAW			
Peregrine Falcon <i>Falco peregrinus</i>		S4	Other	Widespread; coastal cliffs, riverine gorges and wooded watercourses (Johnstone and Storr 1998; Simpson and Day 2010)..	Species not recorded within the study area. The nearest record is located ~12 km to the north of the study area from 2012 (DPaW 2014). There are two 2011 records of the species from Fortescue's Central Pilbara project located to the west of the study area (<i>ecologia</i> 2011a).	MEDIUM Species recently recorded outside the study area. Suitable foraging habitat exists within the plain(stony gibber) and drainage line habitat of the study area.
Flock Bronzewing <i>Phaps histrionica</i>			P4	Sparsely wooded plains near water. Nomadic visitor to areas of suitable habitat (grasslands and cracking clay grasslands for foraging) (Johnstone and Storr 2004; Simpson and Day 2010)	The species has previously been recorded within the Mt Macleod North study area (Rapallo 2011). The nearest NatureMap record is located ~115 km to the northeast of the study area (DPaW 2014).	HIGH The species has previously been recorded within the study area. The cracking clay grasslands of the study area provide suitable foraging habitat and potential breeding habitat for the species. The species is however not a regular occurring species of the Hamersley Ranges (Johnstone and Storr 1998)
Australian Bustard <i>Ardeotis australis</i>			P4	Open grasslands, chenopod flats and low heathland (Johnstone and Storr 1998; Simpson and Day 2010)..	The species was recorded at numerous locations within the Mt Macleod study area. There are numerous NatureMap records within the surrounding area (DPaW 2014) and 20 DPaW (2013) records within 50 km of the study area.	RECORDED The species was recorded at three locations throughout the study area. The cracking clay grassland, hummock grassland and woodland habitat within the study area provide suitable habitat for the species.
Bush Stone-curlew <i>Burhinus grallarius</i>			P4	Lightly wooded country next to daytime shelter of thickets or long grass (Johnstone and Storr 1998; Simpson and Day 2010).	Species not recorded within the study area. The nearest NatureMap record is located ~15 km to the east of the study area from 2012 (DPaW 2014). There are four records of the species within 50 km of the study area (DPaW 2013).	MEDIUM Suitable habitat exists through the drainage line and woodland habitats of the study area. The species has been recorded recently within 50 km of the study area.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPAW			
Star Finch (western) <i>Neochmia ruficauda subclaescens</i>			P4	Vegetation around watercourses, particularly thick reed beds (Johnstone and Storr 2004; Simpson and Day 2010)..	Species not recorded within the study area. The nearest record is located ~35 km east of the study area (DPaW 2014). The species was recorded from Fortescue's Stingray study area located ~20 km to the west of the Mt Macleod study area (<i>ecologia</i> 2013d).	LOW Species has been recorded within the region however limited habitat occurs within the study area, as there are no permanent water pools.
Reptiles						
Pilbara Olive Python <i>Liasis olivaceus barroni</i>	VU	S1	VU	Watercourses and areas of permanent water in rocky gorges, escarpments and gullies (Bush and Maryan 2011; Pearson 2003; Wilson and Swan 2013)..	Species not recorded within the study area. The nearest NatureMap record is located ~6 km to the northwest of the study area from 2013 at Hamersley Gorge and 11 km north of the study area (DPaW 2014) (<i>ecologia</i> 2013c). There are seven DPaW (2013) records within 50 km of the study area.	MEDIUM The species has been well documented within the surrounding area. The study area provides limited habitat within the hilltop/ridge/cliff and drainage line habitat.
Pilbara Barking Gecko <i>Underwoodisaurus seorsus</i>			P1	Rocky areas of the Hamersley Ranges, typically found on the top of hills and occasionally on lower slopes (Doughty and Oliver 2011).	Species not recorded within the study area. Nearest NatureMap record located ~15 km to the north of the study area from 2008 (DPaW 2014). The species was also recorded from Fortescue's Central Pilbara Project and Firetail Mining Area (<i>ecologia</i> 2011a; Ecoscape 2010c).	LOW The species has recently been recorded from the Hamersley region within close proximity <20 km to the study area. No suitable habitat occurs within the study area.
Gane's blindsnake <i>Ramphotyphlops ganei</i>			P1	Variety of habitats; thought to prefer moist gorges (Wilson and Swan 2013)..	Recorded within the study area in 2011 (Rapallo 2011). Species previously recorded within the Mt Macleod North study area (Rapallo 2011). Five records located within 20 km of the study area (DPaW 2014). Recorded from Fortescue's Central Pilbara Project (<i>ecologia</i> 2011a).	Recorded Recorded in 2011 and one individual recorded during this survey from 4 km north of the study area. Five recent records are located within close proximity to the study area. The plain(stony gibber) and drainage line habitat potentially provide suitable habitat for the species.

Species	Conservation Significance			Habitat	Previous Records	Likelihood of Occurrence
	EPBC Act	WC Act	DPAW			
Lined Soil-crevice Skink <i>Notoscincus butleri</i>			P4	Associated with stony/rocky, spinifex-dominated areas near creek and river margins, but also found on plains (Wilson and Swan 2013)..	Species not recorded within the study area. The species was recorded at multiple locations during surveys at Fortescue’s Central Pilbara Project, located ~20 km to the west (<i>ecologia</i> 2011a). The nearest NatureMap record is located ~15 km to the northwest of the study area (DPaW 2014).	MEDIUM The species has recently been recorded within close proximity to the study area. Limited habitat is located in the plain (stony gibber) and hummock grassland habitat of the study area.

5.2.1 Mammals

Northern Quoll (*Dasyurus hallucatus*)

Conservation Status: EPBC Act Endangered, WC Act Schedule 1 (Endangered).

Distribution and Habitat: The Northern Quoll formerly occurred across northern Australia, from the Pilbara region in Western Australia to south-eastern Queensland. A 75% reduction of available habitat occurred during the 20th century, so that the species is now restricted to the Pilbara and northern Kimberley in Western Australia, and a few discrete populations across the Northern Territory and eastern Queensland (Braithwaite and Griffiths 1994). Northern Quolls are most common on dissected rocky escarpments, but are also found in eucalypt forest and woodland (Oakwood 2008). They are both arboreal and terrestrial and use a variety of den sites, including rock crevices, tree hollows, logs, termite mounds and goanna burrows (Oakwood 2008).

Ecology: Northern Quolls are the smallest of the Australian quolls. Northern Quolls are nocturnal and opportunistic omnivores feeding primarily on small vertebrates, large insects and soft fruits. Breeding tends to occur near creeklines, where individuals go to drink when water is available (Oakwood 2008).

The most common cause of adult Northern Quoll mortality is predation by dingoes, feral cats, snakes, owls and kites (Maxwell *et al.* 1996; Oakwood 2008). Other causes of mortality include predation by domestic dogs, motor vehicle strikes and pesticide poisoning. The level of predation is increased through the removal of groundcover by fire.

Likelihood of Occurrence: Medium. The Northern Quoll has been documented within 20 km of the study area (*ecologia* 2013b). The hillslope habitat located to the northeast of Mt Macleod provides suitable denning (hilltop/ridge/cliffs) and foraging habitat (drainage line/river/creek) for the species. No evidence of the species was recorded during the Level 2 fauna assessment or the targeted survey

Pilbara Leaf-nosed Bat (*Rhinonictis aurantia* (Pilbara form))

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

Distribution and Habitat: The Pilbara Leaf-nosed Bat is the Pilbara form of the Orange Leaf-nosed Bat (*Rhinonictis aurantia*). While it is considered a separate form, formal reclassification has been hampered by the small sample size of the Pilbara population (Armstrong 2008).

Recent evidence suggests two main stronghold areas for the Pilbara Leaf-nosed Bat; in the western Pilbara and north of Marble Bar (Armstrong 2008). In the western Pilbara, they roost in caves formed in gorges that dissect siliceous sedimentary geology. They are most often observed in flight over waterholes in gorges, although they are rare even in the Hamersley Ranges where this habitat is common (Armstrong 2008). The Pilbara Leaf-nosed Bat roosts in disused mines and areas of high relief with gorges and watercourses (Armstrong 2001). They are unlikely to occur in the shallow 'breakaway' caves that occur along mesas and strike ridges.

Ecology: At dusk, Pilbara Leaf-nosed Bats emerge from their roosting sites to forage in gorges, small gullies and large watercourses for insects (van Dyck and Strahan 2008). They are susceptible to disturbance and will abandon roost caves if disturbed. Colonies in mines in the eastern Pilbara are subject to several pressures, including human visitation, and the collapse and flooding of disused mines (Armstrong 2008; DEWHA 2008b).

Likelihood of Occurrence: Medium. The study area does not provide any suitable dry roosting habitat for the species although foraging habitat may exist within the drainage line habitat. The species has been recorded recently during nearby surveys (*ecologia* 2011a, 2012c, 2013b, e). As the species has

not been recorded during the Level 2 and targeted survey it is expected that the Pilbara Leaf-nosed Bat does not forage within the area frequently and is therefore not reliant on habitats present within the study area.

Long-tailed Dunnart (*Sminthopsis longicaudata*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: Long-tailed Dunnarts are mostly found in rocky country in the western arid zone and occasionally in open country with a gravel/stony mantle. Although rarely encountered, in Western Australia they occur in the Pilbara, Murchison, north-eastern Goldfields, Ashburton and Gibson Desert regions (Burbidge *et al.* 2008).

Ecology: The Long-tailed Dunnart is a small, carnivorous marsupial, distinguished from other *Sminthopsis* species by the length of its brush-tipped tail; more than twice the head-body length (Burbidge *et al.* 2008). The species feeds on arthropods such as beetles, ants, spiders, cockroaches, centipedes, grasshoppers and larvae (Burbidge *et al.* 2008). Its long tail is muscular at the base, allowing it to be held in a variety of positions, probably acting as a balancer; this, along with striated foot pads, suggest it is adapted to climbing (Burbidge *et al.* 2008).

Threatening processes have not yet been identified as only little is known about this species. Threats could include inappropriate fire regimes and habitat modification as a result of the activities of introduced herbivores such as Horses and Cows, invasion by Buffel Grass and predation by feral cats and foxes (Pavey 2006).

Likelihood of Occurrence: Medium. There are five recent records of the Long-tailed Dunnart located within 50 km of the study area (DPaW 2013; *ecologia* 2011a, 2013e). The stony gibber plain and hilltop/ridge/cliff habitat which potentially provides suitable habitat for the species were surveyed during the Level 2 and targeted survey and no individuals captured.

Ghost Bat (*Macroderma gigas*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: The Ghost Bat has a patchy but widespread distribution across northern Australia. Preferred roosting habitats in the Pilbara include caves beneath bluffs of low, rounded hills composed of Marra Mamba geology, and granite rock piles (Churchill 1998). Ghost Bats have also been known to roost in large colonies within sandstone caves, under boulder piles and in abandoned mines (Churchill 1998). Ghost Bats disperse widely during the non-breeding season but require warm caves with high relative humidity (80%) for rearing their young (Churchill 2008; Toop 1985). These maternity caves are uncommon with only eleven recorded in the Pilbara region (three natural caves and eight mines) (Armstrong and Anstee 2000b).

Ecology: The Ghost Bat is carnivorous and takes prey to an established feeding site to be eaten. These feeding sites are usually a rock overhang or small cave, and are easily recognised by the accumulation of discarded prey parts littering the floor (Richards *et al.* 2008). Foraging occurs in an area of approximately 60 ha, in a radius of approximately 2 km from the bats' roost (Tidemann *et al.* 1985).

Likelihood of Occurrence: Medium (foraging). The Ghost Bat has been documented during many surveys within the region (remains recorded 2km south of Mt Macleod South; 598933e, 7511769n), including the identification of potential non-maternal roosting sites (Coffey 2008; DPaW 2013; *ecologia* 2010, 2011a, 2012c, 2013d). The study area does not provide suitable roosting sites. However, based on regional records the study area and the ability to fly long distances for hunting purposes (Churchill 2008), the species may occasionally use the study area for foraging activities.

Short-tailed Mouse (*Leggadina lakedownensis*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: Populations of this small, elusive rodent are distributed across northern Australia, but records have been sporadic (Moro and Kutt 2008). They occupy a diverse range of habitats from the monsoon tropical coast to semiarid climates, including spinifex and tussock grasslands, samphire and sedgelands, *Acacia* shrublands, tropical eucalypt and *Melaleuca* woodlands and stony ranges (Moro and Kutt 2008). However, Short-tailed Mice are usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro and Kutt 2008).

Ecology: The diet of the Short-tailed Mouse consists primarily of invertebrates, with plants supplementing their water requirements (Moro and Kutt 2008). Populations fluctuate greatly in response to rainfall, sometimes reaching plague proportions. The species is nocturnal and solitary, spending the day in simple, single-chambered burrows (Moro and Kutt 2008).

Likelihood of Occurrence: Recorded. During the current survey there were seven captures of the Short-tailed Mouse from five locations (Figure 4.10). Within the Mt Macleod study area, Short-tailed Mice were recorded from or near cracking clay grasslands habitat. The species was previously recorded from one trap site within cracking clay (CGS) in the Mt Macleod North study area by Rapallo (2011) which is located 6.8 km south-west of the current Mt Macleod study area. The species has been documented within the region with more than ten records within 50 km of the study area. The cracking clay over grasslands and the woodland over grasslands provide suitable habitat for the species (Moro and Kutt 2008).

Western Pebble-mound Mouse (*Pseudomys chapmani*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: The Western Pebble-mound Mouse occurs across central and southern Pilbara and extends into the smaller ranges of the Little Sandy Desert (Start 2008). Abandoned mounds have been found in the Gascoyne and Murchison, indicating a recent decline in distribution. This decline is most likely attributable to foxes and exotic herbivores (Start 2008). However, the species appears relatively secure in its remaining range (Start 2008). The Western Pebble-mound Mouse inhabits gently sloping hills of rocky ranges where the ground is stony and vegetated by spinifex with a sparse overstorey of eucalypts and scattered shrubs of senna, *Acacia* and *Ptilotus* spp (Start 2008).

Ecology: In suitable habitats, pebble mounds of this species can be found in large numbers, although not all of these mounds are active and occupied by Pebble-mound Mice at the same time. The demographic structure of the groups that inhabit the mounds and their patterns of movement around the mounds is still unknown (Anstee 1996; Anstee *et al.* 1997). Mounds can cover an area of 0.5 to 9.0 m², and a single mound can house up to 25 mice (Start 2008). Breeding occurs throughout the year with females producing several litters of four young per year (Start 2008).

Likelihood of Occurrence: High. This species is widespread throughout the region, with captures and active mounds recorded at over 71 locations within 50 km of the study area, including one mound from within the Mt Macleod North study area from 1995 (DPaW 2014). Seven Western Pebble-mound Mouse mounds were recorded within the Mt Macleod South study area during the Rapallo (2011) Mt Macleod vertebrate survey with one additional mound located 4 km north of Mt Macleod South (Figure 4.10). During this survey, seven inactive and one potentially active Western Pebble-mound Mouse mounds were recorded from new locations (Figure 4.10). However, all but one mound were located in close proximity to the mounds recorded in 2011 (Figure 4.10). Based on the species' preference for gentle slopes near rocky ranges with hard spinifex (Start 2008), the stony gibber plain

habitat, hilltop/ridge/cliff habitat and the adjacent hummock grassland of the study area provide suitable habitat for the species.

5.2.2 Birds

Fork-tailed Swift (*Apus pacificus*)

Conservation Status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and Habitat: The Fork-tailed Swift is a small, insectivorous species with a white throat and rump, and a deeply forked tail (Morcombe 2000). Its distribution spans from central Siberia and throughout Asia, breeding in north-east and mid-east Asia, and wintering in Australia and south New Guinea (Johnstone and Storr 1998). It is a relatively common trans-equatorial migrant from October to April throughout mainland Australia (Simpson and Day 2004). In Western Australia the species begins to arrive in the Kimberley in late September, the Pilbara in November and the South-west by mid-December (Johnstone and Storr 1998). In Western Australia the Fork-tailed Swift is considered uncommon to moderately common near the north-west, west and south-east coasts, common in the Kimberley and rare or scarce elsewhere (Johnstone and Storr 1998).

Ecology: Fork-tailed swifts are nomadic in response to broad-scale weather pattern changes. They are attracted to thunderstorms where they can be seen in flocks, occasionally of up to 2,000 birds. They rarely land, living almost exclusively in the air and feeding entirely on aerial insects, especially nuptial swarms of beetles, ants, termites and native bees (Simpson and Day 2004).

Likelihood of Occurrence: Medium. Fork-tailed Swifts were not observed during this survey but previous records exist from five locations within 20 km at the nearby Central Pilbara Project and Solomon Project (*ecologia* 2010, 2011a). Due to the transient and highly nomadic lifestyle of this species, there is a medium likelihood it will occasionally fly through the study area.

Rainbow Bee-eater (*Merops ornatus*)

Conservation Status: EPBC Act Migratory, WC Act Schedule 3.

Distribution and Habitat: The Rainbow Bee-eater is scarce to common throughout much of Western Australia, except for the arid interior, preferring lightly wooded, preferably sandy country near water (Johnstone and Storr 1998).

Ecology: In Western Australia the Rainbow Bee-eater can occur as a resident, breeding visitor, post-nuptial nomad, passage migrant or winter visitor. It nests in burrows usually dug at a slight angle on flat ground, sandy banks or cuttings, and often at the margins of roads or tracks (Simpson and Day 2004). Eggs are laid at the end of the metre-long tunnel from August to January (Boland 2004). Rainbow Bee-eaters are most susceptible to predation during breeding, as it spends significantly more time on the ground in this period (Johnstone and Storr 1998).

Likelihood of Occurrence: Recorded. The species was recorded from one location at Mt Macleod South (Figure 4.10). The species is regularly recorded from throughout the region and there are 37 DPaW (2013) records located within 50 km of the study area. Within the study area the species was recorded from the woodland (open) habitat neighbouring a nearby creekline. Based on the habitat requirements for breeding and foraging (Johnstone and Storr 1998), the study area provides suitable breeding and foraging habitat along the drainage lines as there are sandy banks for nesting burrows and large trees for foraging activities.

Grey Falcon (*Falco hypoleucos*)

Conservation Status: WC Act Schedule 1 (Vulnerable).

Distribution and Habitat: Grey Falcons are a rare, nomadic species sparsely distributed across much of arid and semi-arid Australia. In Western Australia, they are restricted to the northern half, occurring in a variety of habitats ranging from wooded drainage systems through to open spinifex plains (Johnstone and Storr 1998; Morcombe 2000; Simpson and Day 2010). However, the current distribution is now thought to be restricted to north of 26 °S (Johnstone and Storr 1998). Because the distribution of this species is scarce over an extremely large area, sightings of this species are very uncommon.

The Grey Falcon occurs in a wide variety of arid habitats, including open woodlands and open acacia shrubland, hummock and tussock grasslands and low shrublands, and may also be seen around swamps and waterholes that attract prey (Ehmann and Watson 2008).

Ecology: Like other falcons, this species preys primarily on birds such as parrots and pigeons, although reptiles and mammals are also taken (Ehmann and Watson 2008). Two to three eggs are laid in winter in the nests of other birds of prey and ravens, typically in tall eucalypt trees near water (Ehmann and Watson 2008; Garnett and Crowley 2000).

Likelihood of Occurrence: Medium. The species has recently been recorded ~15 km to the east of the Mt Macleod study area. Within the Pilbara the species is commonly associated with riparian and other productive oases (Sutton 2010). Given the habitats within the study area it is unlikely that the study area provides breeding habitat for the species. Due to regional records of the species and the habitats present within the study area Grey Falcon may utilise the area, particularly the drainage line habitat as part of its foraging range.

Peregrine Falcon (*Falco peregrinus*)

Conservation Status: WC Act Schedule 4, DPaW Specially Protected Fauna.

Distribution and Habitat: This nomadic or sedentary falcon is widespread in many parts of Australia and some of Australia's continental islands, but absent from most deserts and the Nullarbor Plain. The species is considered to be moderately common in the Stirling Range, uncommon in the Kimberley, Hamersley and Darling Ranges, and rare or scarce elsewhere (Johnstone and Storr 1998). The Peregrine Falcon occurs most commonly near cliffs along coasts, rivers and ranges, and around wooded watercourses and lakes (Johnstone and Storr 1998).

Ecology: Peregrine Falcons feed almost entirely on birds, especially parrots and pigeons. They nest primarily on ledges on cliffs, granite outcrops and in quarries, but may also nest in tree hollows around wetlands. Eggs are predominantly laid in September (Johnstone and Storr 1998; Olsen *et al.* 2006).

Likelihood of Occurrence: Medium. The Peregrine Falcon has been recorded from Fortescue's Central Pilbara Project and within the Solomon Project Area (*ecologia* 2011a, 2013b). While the study area does not provide suitable breeding habitat, the number of nearby records suggests that the species commonly occurs in nearby areas and may utilise the study area, particularly the drainage line habitat as part of its foraging range.

Flock Bronzewing (*Phaps histrionica*)**Conservation Status:** DPaW Priority 4.

Distribution and Habitat: Also known as the Flock Pigeon, the Flock Bronzewing is most common on the black-soil plains of the south-east Kimberley, but is also found in the adjacent north-eastern interior and the coastal and riverine plains between Port Hedland and Carnarvon (Johnstone and Storr 1998). Its preferred habitat is treeless or sparsely wooded plains near water. It is not a frequent visitor to the state, but was recorded in flocks of up to 100,000 individuals in the 1980s and 1990s (Johnstone and Storr 1998).

Ecology: The Flock Bronzewing is gregarious, often feeding and drinking in groups, but is very wary of predators. During the day, the species has been seen resting on the ground in tussock grassland (Ayers *et al.* 1996). Nesting occurs on the ground in the cover of a bush, lower branch, grass tussock or in the dusty, bare ground around bores (Higgins and Davies 1996). It feeds on seeds of grasses and herbaceous plants (NPWS 1999b).

Likelihood of Occurrence: High. The Flock Bronzewing is not commonly recorded within the Hamersely Range (DPaW 2014). The species was recently recorded within the Mt Macleod study area by Rapallo (2011) (Figure 4.10). The Flock Bronzewing is a nomadic species and was recorded utilising the area during a period of above average rainfall. For this reason it is not expected that the Flock Bronzewing is a common visitor to the area. The cracking clay provides suitable habitat for the species within the study area (Johnstone and Storr 1998).

Australian Bustard (*Ardeotis australis*)**Conservation Status:** DPaW Priority 4.

Distribution and Habitat: The Australian Bustard occurs Australia-wide and utilises a number of open habitats, including open or lightly wooded grasslands, chenopod flats, plains and heathlands (Johnstone and Storr 1998).

Ecology: It is a nomadic species, ranging over very large areas, and its abundance varies locally and seasonally from scarce to common, largely dependent on rainfall and food availability. The Australian Bustard has an omnivorous diet, feeding on grasses, seeds, fruit, insects and small vertebrates (Johnstone and Storr 1998).

Although the population size is still substantial, there has been a large historical decline in abundance, particularly south of the tropics, but also across northern Australia (Garnett and Crowley 2000). This is a result of hunting, degradation of its grassland habitat by sheep and rabbits, and predation by foxes and cats (Frith 1976; Garnett and Crowley 2000). Australian Bustards readily desert nests in response to disturbance by humans, sheep or cattle (Garnett and Crowley 2000).

Likelihood of Occurrence: Recorded. The Australian Bustard has been recorded during most surveys within the region (Biota 2009; Coffey 2008; *ecologia* 2010, 2011a, 2012c; Ecoscape 2010b, 2012c, 2013; Rapallo 2011). The species was recorded from three locations throughout the Mt Macleod study area (Figure 4.10). The species is widespread throughout the region is expected to occur in the woodlands over grassland, hummock grassland and cracking clay habitats.

Bush Stone-curlew (*Burhinus grallarius*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: The Bush Stone-curlew occurs across much of Australia, except the arid interior and central south coast, preferring lightly wooded country near thickets or long grass that acts as daytime shelter (Johnstone and Storr 1998). Historically, this species was widely distributed throughout most of WA, but has since declined, particularly in the southern part of the State. Recent estimates indicate an Australian population of 15,000 individuals (Garnett and Crowley 2000). The Bush Stone-curlew inhabits woodlands, dry and open grasslands, and croplands with cover nearby (NPWS 1999a).

Ecology: The species is insectivorous, preying primarily upon beetles, although they will also eat seeds and shoots, frogs, lizards and snakes (Marchant and Higgins 1993). They are usually seen in pairs, although may occasionally flock together during the breeding season (August to January) and are generally nocturnal, being especially active on moonlit nights (NPWS 1999a).

Since Bush Stone-curlews are a ground-dwelling and non-migratory species, they are quite susceptible to local disturbances by humans and to predation by cats and foxes (Frith 1976; Johnstone and Storr 1998). They are most common where land disturbance is minimal, and generally become rare or extinct around human settlements (Johnstone and Storr 1998).

Likelihood of Occurrence: Medium. The species has been recorded during many surveys undertaken within the region (Biota 2005; *ecologia* 2011a, 2012c, 2013e; Ecoscape 2010c). It is expected that the Bush Stone-curlew may occur in the woodland (open) and drainage habitat of the study area.

5.2.3 Reptiles

Pilbara Olive Python (*Liasis olivaceus barroni*)

Conservation Status: EPBC Act Vulnerable, WC Act Schedule 1 (Vulnerable).

Distribution and Habitat: The Pilbara subspecies of the Olive Python only occurs in the ranges of the Pilbara region of Western Australia. It inhabits watercourses and areas of permanent water in rocky gorges and gullies (Pearson 2006).

Ecology: This subspecies is an adept swimmer, often hunting in water, feeding on a variety of vertebrates such as rock wallabies, fruit bats, ducks and pigeons (DEWHA 2008a). Individuals spend the cooler winter months sheltering in caves and rock crevices. In the warmer months the pythons can move widely, usually in close proximity to water and rock outcrops (DEWHA 2008a). In late winter or early spring males will travel large distances to find, and mate with, females.

Population size estimates are difficult due to the Olive Python's cryptic nature and lack of reliable trapping or census techniques (DEWHA 2008a). The main threats to this subspecies come from predation by feral cats and foxes, particularly of juveniles, competition with foxes for food, and destruction of habitat (Pearson 2006).

Likelihood of Occurrence: Medium. Seven DPaW (2013) records for the Pilbara Olive Python are located within 50 km of the study area and the species has been recorded from many surveys within the region, particularly within Fortescue's Solomon Mine Project area (Biota 2009, 2011; *ecologia* 2011a, 2012c, 2013b; Ecoscape 2010c). The species often occupies highly specialised habitat that are not represented within the Mt Macleod study area. Based on the number and locality of nearby records the Pilbara Olive Python has a medium likelihood of occurring in the drainage and stony gibber plain of the study area.

Gane's blindsnake (*Ramphotyphlops ganei*)

Conservation Status: DPaW Priority 1.

Distribution and Habitat: Very little is known about this elusive blind snake due to its fossorial lifestyle. Blind snakes are exclusively insectivorous, and like other members of their genus, *R. ganei* probably burrow into social insect colonies to feed on termites and ants, as well as their eggs and pupae (Wilson and Swan 2010). *R. ganei* has been found within the Pilbara region between Newman and Pannawonica (Wilson and Swan 2010).

Ecology: It has been suggested that *R. ganei* prefer to live in subterranean habitats near moist gullies and gorges (Wilson and Swan 2010), although there is a record from sandy soil vegetated with spinifex (NatureMap). This species is most likely threatened by removal of suitable habitat, and by drilling and/or any other mining activities impacting the subterranean environment.

Likelihood of Occurrence: High. *Ramphotyphlops ganei* was recorded during the first phase in 2011 (Rapallo 2011) within the study area and was recorded approximately 4 km north of the study area during the current survey (Figure 4.10). In addition to this, the species has been documented from three surveys within the region (*ecologia* 2010, 2011a; Rapallo 2011). Suitable habitat for this species exists within the drainage and stony gibber plain habitat of the study area. Due to the close proximity of records and the species having been recorded within the study area previously, this species has a high likelihood of occurrence.

Lined Soil-crevice Skink (*Notoscincus butleri*)

Conservation Status: DPaW Priority 4.

Distribution and Habitat: This small skink has a limited distribution, restricted to the arid north-west near-coastal Pilbara of the Dampier district to Harding River dam (Storr *et al.* 1999; Wilson and Swan 2010). Its habitat is typically spinifex dominated areas near creek and river margins (Wilson and Swan 2013).

Ecology: Very little is known about this species of skink. There are only two species belonging to the *Notoscincus* genus. These species are secretive, but readily bask in sunshine (Wilson and Swan 2013). *Notoscincus butleri* is an egg layer and feeds on invertebrates (Wilson and Swan 2013)

Likelihood of Occurrence: Medium. *Notoscincus butleri* has been recorded in many surveys to the west of the study area, these records make up the most southeast extent of the species distribution (Biota 2005, 2009; Coffey 2008; *ecologia* 2011a, 2012c). The known ecology and habitat requirements of the species are relatively vague however based on literature (Wilson and Swan 2013) and observations from previous surveys (*ecologia* 2011a, 2012a) it seems the species has a preference for spinifex rocky hills and plains near drainage lines. The stony gibber plain and hummock grassland within the study area may therefore provide suitable habitat for this species.

5.3 SURVEY ADEQUACY

Survey effort expended within the study area is summarised in Table 3.6, which shows considerable systematic and opportunistic sampling effort was undertaken. In addition, Table 4.3 shows survey effort was adequate in sampling all fauna habitat types within the study area. To compliment the systematic survey effort, additional time was spent conducting opportunistic, diurnal and nocturnal searches and camera trapping across the survey area.

Analysis of the observed avifauna assemblage recorded during the Level 2 vertebrate fauna assessment suggests the survey recorded a high percentage (85%) of the expected avifaunal assemblages (Table 4.5.) Based on the shape of the SACs generated (Figure 4.12), a plateau has nearly been reached for the systematic avifauna data.

Analysis of the observed terrestrial fauna assemblage recorded during the Level 2 vertebrate fauna assessment suggests the survey recorded a suitably high percentage (71%) of the expected terrestrial fauna assemblage (Table 4.5). A further 12 species may occur in the study area.

The current survey data is also supported by data from recent surveys within parts of the study area by Rapallo (2011), and an additional 30 vertebrate fauna surveys conducted within the region (Appendix C). This large amount of information allows an accurate assessment of the faunal assemblages expected to occur within the study area.

6 CONCLUSION

The main conclusions of the vertebrate fauna assessment are as follows:

- The literature review included several databases and 29 publications were consulted in the preparation of potential fauna (and conservation significant fauna) lists. The database searches and review resulted in a total of 42 native and 11 introduced mammal, 163 bird, 108 reptile, nine amphibian and six fish species potentially occurring in the study area. Of these, 34 species are of conservation significance (nine species of mammal, 20 species of bird, four species of reptile and one species of fish).
- The vertebrate fauna assessment survey methods were consistent with *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment*; Guidance Statement No. 56; Position Statement No. 3; and the EPBC Act Survey Guidelines for Australia’s Threatened Mammals, Reptiles, Bats and Birds, as well as Fortescue Metals Group’s *Terrestrial Vertebrate Fauna Assessment Guidelines*.
- During the current vertebrate fauna assessment, six main fauna habitat types based on vegetation assemblages, land systems aerial photography and geographical features were identified; Woodland (open), Hummock grassland, Hilltop/ridge/cliff, plain (stony gibber), plain(cracking clay) and Drainage line/river/creek.
- All six fauna habitats within the study area were sampled with systematic trapping sites during the current survey Level 2 and targeted survey. A one-way ANOSIM test and MDS plot of the trapping sites within the different habitat types was completed for data collected systematically for both birds and trapped terrestrial fauna. The results from these statistical analyses indicate there are some differences between the faunal assemblages in the different habitat types for the birds or trapped terrestrial fauna.
- Survey effort was adequate in sampling all fauna habitat types within the study area. Analysis of the observed avifauna assemblage recorded during the Level 2 vertebrate fauna assessment suggests the survey recorded a high percentage of the expected avifaunal (85%) and terrestrial trappable fauna (71%) assemblages, based on SACs.
- During the survey a total of 18 native and one introduced mammal, 63 bird, 28 reptile and two amphibian species were recorded.
- Of the species recorded, four are of conservation significance: the Short-tailed Mouse (DPaW P4), Western Pebble-mound Mouse (DPaW P4), Australian Bustard (DPaW P4) and Rainbow Bee-eater (EPBC Migratory, WC Act Schedule 3). In addition to these, one species, Gane’s blindsnake (*Ramphotyphlops ganei*; DPaW P4) was recorded during the first phase of surveying in 2011 within the study area and 4 km outside the study area during the current survey.
- No significant limitations were experienced during the surveys.

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APPENDIX A EXPLANATION OF CONSERVATION CODES

Appendix A1 Definitions of categories under the *Environment Protection and Biodiversity Conservation Act 1999*

Category	Definition
Endangered (EN)	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable (VU)	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Migratory (M)	Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: <ul style="list-style-type: none"> • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range state; • the agreement between the Government of Australian and the Government of the Peoples Republic of China for the Protection of Migratory Birds and their environment (CAMBA); or • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA).

Appendix A2 Definition of Schedules under the *Wildlife Conservation Act 1950*

Schedule	Definition
Schedule 1 (S1)	Fauna which are rare or likely to become extinct, are declared to be fauna that is in need of special protection.
Schedule 2 (S2)	Fauna which are presumed to be extinct, are declared to be fauna that is in need of species protection.
Schedule 3 (S3)	Birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction, are declared to be fauna that is in need of species protection.
Schedule 4 (S4)	Declared to be fauna that is in need of species protection, otherwise than for the reasons mentioned above.

Appendix A3 Definition of DPaW Threatened and Priority Fauna Codes

Threatened	Definition
Critically Endangered (CR)	Considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Considered to be facing a high risk of extinction in the wild.
Priority	Definition
Priority 1 (P1)	<i>Taxa with few, poorly known populations on threatened lands.</i> Taxa which are known from few specimens or sight records from one or a few localities, on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 2 (P2)	<i>Taxa with few, poorly known populations on conservation lands.</i> Taxa which are known from few specimens or sight records from one or a few localities, on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 3 (P3)	<i>Taxa with several, poorly known populations, some on conservation lands.</i> Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
Priority 4 (P4)	<i>Taxa in need of monitoring.</i> Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands.
Priority 5 (P5)	<i>Taxa in need of monitoring.</i> Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

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APPENDIX B DAILY WEATHER DATA DURING SURVEY

Appendix B1 Level 2 Vertebrate Fauna Assessment

Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)
03/05/2012	17.2	34.7	0
04/05/2012	18.5	34.5	0
05/05/2012	18.5	34.9	0
06/05/2012	18.1	35.0	0
07/05/2012	19.5	35.9	0
08/05/2012	22.4	29.2	0
09/05/2012	16.2	29.9	0.2
10/05/2012	14.5	31.4	0
11/05/2012	20.8	27.9	0
12/05/2012	18.8	28.6	0
13/05/2012	14.5	24.0	0

Note: climate data recorded from Wittenoom Aero weather station (005026) (BoM 2012).

Appendix B2 Targeted Conservation Significant Fauna Assessment

Date	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)
16/07/2012	14.6	30.4	0
17/07/2012	14.5	22.7	0
18/07/2012	8.5	21.7	0
19/07/2012	9.0	20.8	0
20/07/2012	10.0	19.5	0
21/07/2012	6.8	19.7	0
22/07/2012	11.1	24.0	0
23/07/2012	13.7	27.0	0
24/07/2012	17.8	28.2	0

Note: climate data recorded from Wittenoom Aero weather station (005026) (BoM 2012).

APPENDIX C REGIONAL FAUNA DATA

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Mammals

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2013)	Stingray (ecologia 2014)	Solomon Hub (ecologia 2014)	Central Pilbara Project: Mine (ecologia 2011)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project - rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hamersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninnox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Eliwana and Flying Fish (Ecoscape 2012)	NatureMap	DPaW Rare Fauna	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW																									
TACHYGLOSSIDAE																													
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna																												
DASYURIDAE																													
<i>Dasykaluta rosamondae</i>	Kaluta																												
<i>Dasyurus hallucatus</i>	Northern Quoll	EN	S1	EN																									
<i>Ningau timealeyi</i>	Pilbara Ningau																												
<i>Planigale sp. (prev. maculata)</i>	Common Planigale																												
<i>Pseudantechinus woolleyae</i>	Woolley's False Antechinus																												
<i>Sminthopsis longicaudata</i>	Long-tailed Dunnart			P4																									
<i>Sminthopsis macroura</i>	Stripe-faced Dunnart																												
<i>Sminthopsis ooldea</i>	Ooldea Dunnart																												
THYLACOMYIDAE																													
<i>Macrotis lagotis</i>	Bilby	VU	S1	VU																									
NOTORYCTIDAE																													
<i>Notoryctes caurinus</i>	Northern Marsupial Mole	EN	S1	EN																									
MACROPODIDAE																													
<i>Lagorchestes conspicillatus leichardti</i>	Spectacled Hare-wallaby			P3																									
<i>Macropus robustus</i>	Euro																												
<i>Macropus rufus</i>	Red Kangaroo																												
<i>Petrogale rothschildi</i>	Rothschild's Rock Wallaby																												
PHALANGERIDAE																													
<i>Trichosurus vulpecula arnhemensis</i>	Northern Brushtail Possum																												
PTEROPODIDAE																													
<i>Pteropus scapulatus</i>	Little Red Flying-fox																												
<i>Pteropus alecto</i>	Black Flying Fox																												
HIPPOSIDERIDAE																													
<i>Rhinonicteris aurantia</i>	Pilbara Leaf-nosed Bat	VU	S1	VU																									
MEGADERMATIDAE																													
<i>Macroderma gigas</i>	Ghost Bat			P4																									
EMBALLONURIDAE																													
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail Bat																												
<i>Taphozous georgianus</i>	Common Sheathtail Bat																												
<i>Taphozous hilli</i>	Hill's Sheathtail Bat																												
VESPERTILIONIDAE																													
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat																												
<i>Chalinolobus morio</i>	Chocolate Wattled Bat																												
<i>Nyctophilus arnhemensis</i>	Arnhem Long-eared Bat																												
<i>Nyctophilus bifax daedalus</i>	Northern Long-eared Bat																												
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat																												
<i>Scotorepens greyii</i>	Little Broad-nosed Bat																												
<i>Vespadelus finlaysoni</i>	Finlayson's Cave Bat																												

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2013)	Stingray (ecologia 2014)	Solomon Hub (ecologia 2014)	Central Pilbara Project: Mine (ecologia 2011)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project - rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hammersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninnox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Eliwana and Flying Fish (Ecoscape 2012)	NatureMap	DPaW Rare Fauna	DSEWPaC Protected Matters Search	This survey	
		EPBC Act	WC Act	DPaW																										
MOLOSSIDAE																														
<i>Chaerophon jobensis</i>	Northern Freetail Bat				•			•	•	•	•	•					•									•				
<i>Mormopterus beccarii</i>	Beccari's Freetail Bat				•			•	•		•	•	•				•									•				
<i>Mormopterus loriae</i>	Little Northern Freetail Bat																			•										
<i>Tadarida australis</i>	White-striped Freetail Bat				•			•									•			•						•				
MURIDAE																														
<i>Leggadina lakedownensis</i>	Northern Short-tailed Mouse			P4	•		•	•																		•	•		•	
<i>Notomys alexis</i>	Spinifex Hopping-mouse					S											•													
<i>Pseudomys chapmani</i>	Western Pebble-mound Mouse			P4	•	•	S	SIA	S	•	S	S	SA				•	•	•	S	•		•	•		•	•		SIA	
<i>Pseudomys delicatulus</i>	Delicate Mouse							•																					•	
<i>Pseudomys desertor</i>	Desert Mouse				•	•	•	•	•	•	•	•	•					•	•	•	•					•			•	
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse				•	•	•	•	•	•	•	•	•				•	•	•	•	•					•				
<i>Zyzomys argurus</i>	Common Rock-rat				•			•	•	•	•	•	•				•	•	•	•	•			•	•				•	
CANIDAE																														
<i>*Canis lupus</i>	Dog/Dingo				•	•	•	S	•	•	•	•				•		•	•							•	•		•	
INTRODUCED MAMMALS																														
<i>*Mus musculus</i>	House Mouse				•		•	•	•	•	•	•					•		•							•			•	
<i>*Rattus rattus</i>	Black Rat																												•	
<i>*Vulpes vulpes</i>	Red Fox																												•	
<i>*Felis catus</i>	Cat				•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•					•	•		•	
<i>*Oryctolagus cuniculus</i>	European Rabbit																												•	
<i>*Equus asinus</i>	Donkey																	•		•	•					•			•	
<i>*Equus caballus</i>	Horse				•				•											•	•					•	•		•	
<i>*Camelus dromedarius</i>	Camel																									•			•	
<i>*Bos taurus</i>	Cow				•	•	•	•	•	•	•	•	•							•	•					•				
<i>*Capra hircus</i>	Goat																												•	

SIA = Secondary evidence (inactive mound)

Birds

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2013)	Stingray (ecologia 2014)	Solomon Hub (ecologia 2014)	Central Pilbara Project: Mine (ecologia 2011)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project - rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hammersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Eilwana and Flying Fish (Ecoscape 2012)	NatureMap	DPaWRare Fauna	DSEWPac Protected Matters Search	Birddata	This survey
		EPBC Act	WC Act	DPaW																										
CASUARIIDAE																														
<i>Dromaius novaehollandiae</i>	Emu				•	•		•	•	•	•			•		•			•	•	•	•				•			•	
PHASIANIDAE																														
<i>Coturnix pectoralis</i>	Stubble Quail				•	•			•				•				•									•				
<i>Coturnix ypsilophora</i>	Brown Quail				•				•		•	•	•													•			•	
ANATIDAE																														
<i>Dendrocygna eytoni</i>	Plumed Whistling-duck				•	•			•																	•			•	
<i>Cygnus atratus</i>	Black Swan															•													•	
<i>Chenonetta jubata</i>	Australian Wood Duck				•				•							•	•		•							•			•	
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck					•										•										•			•	
<i>Anas gracilis</i>	Grey Teal				•	•			•							•			•							•			•	
<i>Anas superciliosa</i>	Pacific Black Duck				•	•			•							•			•							•			•	
<i>Aythya australis</i>	Hardhead															•													•	
PODICIPEDIDAE																														
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe															•										•			•	
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe															•										•			•	
COLUMBIDAE																														
* <i>Columba livia</i>	Rock Dove																											•		
<i>Phaps chalcoptera</i>	Common Bronzewing				•	•	•		•	•	•	•	•			•	•	•	•	•	•	•	•	•	•	•			•	•
<i>Phaps histrionica</i>	Flock Bronzewing					•										•														
<i>Ocyphaps lophotes</i>	Crested Pigeon				•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•			•	•
<i>Geophaps plumifera</i>	Spinifex Pigeon				•	•	•		•	•	•	•	•			•	•	•	•	•	•	•	•	•	•	•			•	•
<i>Geopelia cuneata</i>	Diamond Dove				•	•	•		•	•	•	•	•			•	•	•	•	•	•	•	•	•	•	•			•	•
<i>Geopelia striata</i>	Peaceful Dove				•	•			•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•
PODARGIDAE																														
<i>Podargus strigoides</i>	Tawny Frogmouth				•					•	•	•	•			•										•			•	
EUROSTOPODIDAE																														
<i>Eurostopodus argus</i>	Spotted Nightjar				•	•	•	•	•	•	•	•	•			•				•	•					•			•	
AEGOTHELIDAE																														
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar				•	•			•	•	•	•	•			•				•						•			•	
APODIDAE																														
<i>Apus pacificus</i>	Fork-tailed Swift	M	S3		•				•		•					•										•	•	•		
ANHINGIDAE																														
<i>Anhinga novaehollandiae</i>	Australasian Darter															•													•	
PHALACROCORACIDAE																														
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant															•	•									•			•	
<i>Phalacrocorax carbo</i>	Great Cormorant															•													•	
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant																									•			•	
PELECANIDAE																														
<i>Pelecanus conspicillatus</i>	Australian Pelican															•										•			•	
ARDEIDAE																														

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2013)	Stingray (ecologia 2014)	Solomon Hub (ecologia 2014)	Central Pilbara Project: Mine (ecologia 2011)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project - rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hamersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Elwana and Flying Fish (Ecoscape 2012)	NatureMap	DPaWRare Fauna	DSEWPac Protected Matters Search	Birddata	This survey	
		EPBC Act	WC Act	DPaW																											
<i>Ardea pacifica</i>	White-necked Heron				•	•	•	•	•		•					•				•	•				•			•			
<i>Ardea modesta</i>	Eastern Great Egret	M	S3													•										•	•	•			
<i>Ardea intermedia</i>	Intermediate Egret																								•			•			
<i>Ardea ibis</i>	Cattle Egret	M	S3																							•					
<i>Egretta novaehollandiae</i>	White-faced Heron				•	•	•		•							•				•			•			•		•	•		
<i>Nycticorax caledonicus</i>	Nankeen Night Heron															•										•			•		
THRESKIORNITHIDAE																															
<i>Plegadis falcinellus</i>	Glossy Ibis	M	S3																							•	•	•			
<i>Threskiornis molucca</i>	Australian White Ibis																									•			•		
<i>Threskiornis spinicollis</i>	Straw-necked Ibis				•											•	•									•			•		
<i>Platalea flavipes</i>	Yellow-billed Spoonbill																									•					
ACCIPITRIDAE																															
<i>Pandion cristatus</i>	Eastern Osprey	M														•												•			
<i>Elanus axillaris</i>	Black-shouldered Kite				•	•	•	•	•	•	•	•				•	•	•								•		•	•		
<i>Lophoictinia isura</i>	Square-tailed Kite				•						•															•					
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard															•												•			
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	M	S3								•																•				
<i>Haliastur sphenurus</i>	Whistling Kite				•	•	•	•	•	•		•				•	•	•	•	•	•		•	•		•		•	•		
<i>Milvus migrans</i>	Black Kite				•	•		•								•										•		•			
<i>Accipiter fasciatus</i>	Brown Goshawk				•	•		•	•		•	•	•			•				•					•		•	•			
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk				•	•		•	•		•	•	•			•	•		•						•		•	•			
<i>Circus assimilis</i>	Spotted Harrier				•	•	•	•	•	•						•			•		•				•		•	•			
<i>Circus approximans</i>	Swamp Harrier					•																									
<i>Aquila audax</i>	Wedge-tailed Eagle				•	•	•	•	•	•	•	•				•	•	•			•				•		•	•			
<i>Hieraetus morphnoides</i>	Little Eagle				•			•								•	•	•			•				•		•	•			
FALCONIDAE																															
<i>Falco cenchroides</i>	Nankeen Kestrel				•		•	•	•	•	•	•	•		•	•	•	•	•	•	•		•	•		•		•			
<i>Falco berigora</i>	Brown Falcon				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•		•		•	•	
<i>Falco longipennis</i>	Australian Hobby				•	•		•		•	•			•		•			•		•				•		•	•			
<i>Falco hypoleucos</i>	Grey Falcon			P4						•														•							
<i>Falco peregrinus</i>	Peregrine Falcon		S4		•				•							•									•		•		•		
RALLIDAE																															
<i>Gallirallus philippensis</i>	Buff-banded Rail																												•		
<i>Porzana pusilla</i>	Baillon's Crake																												•		
<i>Porzana fluminea</i>	Australian Spotted Crake				•				•																	•					
<i>Tribonyx ventralis</i>	Black-tailed Native-hen																												•		
<i>Fulica atra</i>	Eurasian Coot																									•			•		
OTIDIDAE																															
<i>Ardeotis australis</i>	Australian Bustard			P4	•	•	•	•	•			•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
BURHINIDAE																															
<i>Burhinus grallarius</i>	Bush Stone-curlew			P4	•			•	•				•			•					•				•		•		•		
RECURVIROSTRIDAE																															
<i>Himantopus himantopus</i>	Black-winged Stilt																									•			•		
CHARADRIIDAE																															

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		EPBC Act	WC Act	DPaW																												
<i>Charadrius veredus</i>	Oriental Plover	M	S3																													
<i>Eseyornis melanops</i>	Black-fronted Dotterel				•				•							•	•			•						•			•			
<i>Vanellus tricolor</i>	Banded Lapwing				•				•	•																•						
SCOLOPACIDAE																																
<i>Gallinago megala</i>	Swinhoe's Snipe	M	S3																													
<i>Actitis hypoleucos</i>	Common Sandpiper	M	S3													•										•	•		•			
TURNICIDAE																																
<i>Turnix velox</i>	Little Button-quail				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•	
GLAREOLIDAE																																
<i>Glareola maldivarum</i>	Oriental Pratincole	M	S3																												•	
<i>Stiltia isabella</i>	Australian Pratincole					•																										
LARIDAE																																
<i>Chlidonias leucopterus</i>	White-winged Black Tern	M	S3																												•	
<i>Thalasseus bergii</i>	Crested Tern																														•	
CACATUIDAE																																
<i>Eolophus roseicapillus</i>	Galah				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
<i>Cacatua sanguinea</i>	Little Corella				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
<i>Nymphicus hollandicus</i>	Cockatiel				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
PSITTACIDAE																																
<i>Barnardius zonarius</i>	Australian Ringneck				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
<i>Melopsittacus undulatus</i>	Budgerigar				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
<i>Neopsephotus bourkii</i>	Bourke's Parrot				•	•			•							•															•	
<i>Pezoporus occidentalis</i>	Night Parrot	EN	S1	CR																											•	
CUCULIDAE																																
<i>Centropus phasianinus</i>	Pheasant Coucal										•	•	•	•										•						•	•	
<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo				•				•	•		•	•			•	•	•	•	•	•	•	•	•	•					•	•	
<i>Chalcites osculans</i>	Black-eared Cuckoo					•										•	•							•						•	•	
<i>Cacomantis pallidus</i>	Pallid Cuckoo				•	•	•		•	•	•	•	•			•	•	•	•	•	•	•	•	•	•					•	•	
STRIGIDAE																																
<i>Ninox connivens</i>	Barking Owl															•														•	•	
<i>Ninox novaeseelandiae</i>	Southern Boobook				•				•	•	•	•	•			•								•						•	•	
TYTONIDAE																																
<i>Tyto javanica</i>	Eastern Barn Owl				•						•					•					•									•	•	
HALCYONIDAE																																
<i>Dacelo leachii</i>	Blue-winged Kookaburra				•	•			•	•	•	•	•			•					•		•	•						•	•	
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher				•	•	•		•	•	•	•	•			•	•	•	•	•	•	•	•	•	•					•	•	
<i>Todiramphus sanctus</i>	Sacred Kingfisher				•				•	•	•	•	•			•				•				•						•	•	
MEROPIDAE																																
<i>Merops ornatus</i>	Rainbow Bee-eater	M	S3		•	•			•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
CLIMACTERIDAE																																
<i>Climacteris melanura</i>	Black-tailed Treecreeper				•	•			•	•						•				•	•	•	•							•	•	
PTILINORHYNCHIDAE																																
<i>Ptilonorhynchus guttatus</i>	Western Bowerbird				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•					•	•	

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		EPBC Act	WC Act	DPaW																											
PACHYCEPHALIDAE																															
<i>Pachycephala rufiventris</i>	Rufous Whistler				•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•				•	•	
<i>Colluricincla harmonica</i>	Grey Shrike-thrush				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Oreoica gutturalis</i>	Crested Bellbird				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
ARTAMIDAE																															
<i>Artamus personatus</i>	Masked Woodswallow				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Artamus cinereus</i>	Black-faced Woodswallow				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Artamus minor</i>	Little Woodswallow				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Cracticus torquatus</i>	Grey Butcherbird				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Cracticus nigrogularis</i>	Pied Butcherbird				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Cracticus tibicen</i>	Australian Magpie				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				•	•	
RHIPIDURIDAE																															
<i>Rhipidura albiscapa</i>	Grey Fantail				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Rhipidura leucophrys</i>	Willie Wagtail				•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•				•	•	
CORVIDAE																															
<i>Corvus bennetti</i>	Little Crow				•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•				•	•	
<i>Corvus orru</i>	Torresian Crow				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				•	•	
MONARCHIDAE																															
<i>Grallina cyanoleuca</i>	Magpie-lark				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				•	•	
PETROICIDAE																															
<i>Microeca fascinans</i>	Jacky Winter																														
<i>Petroica goodenovii</i>	Red-capped Robin				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Melanodryas cucullata</i>	Hooded Robin				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
ALAUDIDAE																															
<i>Mirafrja javanica</i>	Horsfield's Bushlark				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
ACROCEPHALIDAE																															
<i>Acrocephalus australis</i>	Australian Reed-Warbler				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
MEGALURIDAE																															
<i>Cincloramphus mathewsi</i>	Rufous Songlark				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Cincloramphus cruralis</i>	Brown Songlark				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Eremiornis carteri</i>	Spinifexbird				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
HIRUNDINIDAE																															
<i>Cheramoeca leucosterna</i>	White-backed Swallow																														
<i>Hirundo rustica</i>	Barn Swallow	M	S3																												
<i>Hirundo neoxena</i>	Welcome Swallow				•	•	•	•	•	•	•	•	•																		
<i>Petrochelidon ariel</i>	Fairy Martin				•	•	•	•	•	•	•	•	•							S	•	•	•	•							
<i>Petrochelidon nigricans</i>	Tree Martin				•	•	•	•	•	•	•	•	•							•	•	•	•	•							
NECTARINIIDAE																															
<i>Dicaeum hirundinaceum</i>	Mistletoebird				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
ESTRILDIDAE																															
<i>Taeniopygia guttata</i>	Zebra Finch				•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				•	•	
<i>Neochmia ruficauda subclarescens</i>	Star Finch (western)			P4	•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
<i>Emblema pictum</i>	Painted Finch				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•				•	•	
PASSERIDAE																															

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		EPBC Act	WC Act	DPaW																											
* <i>Passer montanus</i>	Eurasian Tree Sparrow																														
MOTACILLIDAE																															
<i>Anthus novaeseelandiae</i>	Australasian Pipit				•	•		•								•				•						•			•		

Reptiles

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2013)	Stingray (ecologia 2014)	Solomon Hub (ecologia 2014)	Central Pilbara Project: Mine (ecologia 2011)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project - rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hammersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Eliwana and Flying Fish (Ecoscape 2012)	NatureMap	DEC Rare Fauna	DSEWPac Protected Matters Search	This survey		
		EPBC Act	WC Act	DPaW																											
CHELUIDAE																															
<i>Chelodina steindachneri</i>	Flat-shelled Turtle																														
AGAMIDAE																															
<i>Amphibolurus longirostris</i>	Long-nosed Dragon				•	•	•	•	•	•	•	•	•				•	•	•	•	•			•					•		
<i>Caimanops amphiboluroides</i>	Mulga Dragon				•	•			•		•					†	•														
<i>Ctenophorus caudicinctus</i>	Ring-tailed Dragon				•	•	•	•	•	•	•	•	•		•	•			•	•	•	•	•	•	•				•		
<i>Ctenophorus isolepis</i>	Central Military Dragon				•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•			•							
<i>Ctenophorus nuchalis</i>	Central Netted Dragon																							•							
<i>Ctenophorus reticulatus</i>	Western Netted Dragon				•	•		•								•									•				•		
<i>Diporiphora valens</i>					•	•			•	•						•	•	•			•								•		
<i>Diporiphora winneckei</i>	Blue-lined Dragon					•																									
<i>Pogona minor</i>	Dwarf Bearded Dragon				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•		•	•	•						
<i>Tympanocryptis cephalus</i>	Pebble Dragon				•	•			•	•														•							
DIPLODACTYLIDAE																															
<i>Crenadactylus ocellatus</i>	Clawless Gecko				•				•		•																				
<i>Diplodactylus conspicillatus</i>	Fat-tailed Gecko				•		•	•	•		•	•				†	•	•		•											
<i>Diplodactylus conspicillatus</i>								•																							
<i>Diplodactylus pulcher</i>						•										†															
<i>Diplodactylus savagei</i>					•	•		•	•		•	•	•			†		•			•										
<i>Lucasium stenodactylum</i>	Sand-plain Gecko				•	•		•	•	•	•	•	•			†	•			•				•	•					•	
<i>Lucasium wombeyi</i>					•	•		•	•		•	•	•			†	•			•				•	•						
<i>Oedura marmorata</i>	Marbled Velvet Gecko				•	•		•	•		•	•	•			†	•	•	•	•			•	•							
<i>Rhynchoedura ornata</i>	Beaked Gecko				•			•	•	•	•	•	•			†	•	•	•	•			•	•							
<i>Strophurus elderi</i>	Jewelled Gecko				•			•	•	•	•	•	•			•	•	•	•	•			•	•							
<i>Strophurus jeanae</i>								•	•		•	•																			
<i>Strophurus strophurus</i>	Western Spiny-tailed Gecko				•			•	•		•	•	•																		
<i>Strophurus wellingtonae</i>					•		S	•	•	•	•	•	•				•	•		•										•	
CARPHODACTYLIDAE																															
<i>Nephurus wheeleri</i>	Banded Knob-tailed Gecko				•	•	S	•	•	•	•	•	•			•				•											
<i>Underwoodisaurus seorsus</i>	Barking Gecko					P1		•	•				•																		
GEKKONIDAE																															
<i>Gehyra pilbara</i>					•		•		•	•	•	•	•			•					•										
<i>Gehyra punctata</i>					•	•		•	•	•	•	•	•			•			•												
<i>Gehyra variegata</i>	Tree Dtella				•	•		•	•	•	•	•	•			•	•	•	•	•											•
<i>Heteronotia binoei</i>	Bynoe's Gecko				•	•	•	•	•	•	•	•	•			•	•	•	•	•			•	•						•	
<i>Heteronotia spelea</i>	Desert Cave Gecko				•			•	•		•	•	•			•								•	•						
PYGOPODIDAE																															
<i>Delma butleri</i>					•				•	•																					•
<i>Delma elegans</i>					•				•	•						•	•														
<i>Delma haroldi</i>									•	•							•														
<i>Delma nasuta</i>					•	•	•	•	•	•	•	•	•			•	•	•	•	•											
<i>Delma pax</i>					•				•	•	•	•	•			†	•	•	•	•											
<i>Delma tincta</i>					•	•			•	•	•	•	•			•	•	•	•	•											
<i>Lialis burtonis</i>	Burton's Snake-lizard				•	•	S	•	•	•	•	•	•			•	•	•	•	•											•

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<i>Pygopus nigriceps</i>	Western Hooded Scaly-foot				•			•	•			•	•			•				•					•						
SCINCIDAE																															
<i>Carlia munda</i>					•	•	•	•	•	•	•	•	•				•	•		•						•				•	
<i>Carlia triacantha</i>					•	•	•	•	•	•	•	•	•			•										•				•	
<i>Cryptoblepharus buchananii</i>					•	◊		•	•			◊				◊	•	◊	◊	◊						◊					
<i>Cryptoblepharus ustulatus</i>					•	◊			•			◊	•			◊	•	◊	◊	◊						◊					
<i>Ctenotus duricola</i>					•	•		•	•	•	•	•	•			•	•	•	•	•	•	•	•			•				•	
<i>Ctenotus grandis</i>					•				•	•	•	•	•						•	•	•					•				•	
<i>Ctenotus hanloni</i>								•																		•					
<i>Ctenotus helenae</i>					•	•		•	•	•	•	•	•			•			•	•	•					•				•	
<i>Ctenotus leonhardii</i>					•				•	•	•	•	•			†										•				•	
<i>Ctenotus pantherinus</i>	Leopard Ctenotus				•	•		•	•	•	•	•	•						•	•	•					•				•	
<i>Ctenotus robustus</i>	Eastern Striped Skink				•		•		•	•	•	•	•													•				•	
<i>Ctenotus rubicundus</i>					•	•	•		•	•	•	•	•						•							•					
<i>Ctenotus rutilans</i>					•			•	•	•	•	•	•													•					
<i>Ctenotus saxatilis</i>	Rock Ctenotus				•	•	•	•	•	•	•	•	•			•			•	•	•					•					
<i>Ctenotus schomburgkii</i>					•	•			•	•	•	•	•			•	•	•								•					
<i>Ctenotus serventyi</i>					•				•	•						•	•	•								•					
<i>Ctenotus severus</i>																†										•					
<i>Ctenotus uber</i>							•	•																		•					
<i>Cyclodomorphus melanops</i>	Spinifex Slender Blue-tongue				•	•	•	•	•	•	•	•	•						•	•	•	•				•				•	
<i>Egernia cygnitos</i>					•	•		•									•									•					
<i>Egernia formosa</i>					•	•			•			•														•					
<i>Egernia pilbarensis</i>					•						•	•									•					•					
<i>Eremiascincus fasciolatus</i>	Narrow-banded Sand-swimmer				•				•		•															•					
<i>Eremiascincus richardsonii</i>	Broad-banded Sand-swimmer				•				•																	•					
<i>Lerista flammicauda</i>					•			•																		•					
<i>Lerista jacksoni</i>	(<i>L. muelleri</i> group)				•				•				•													•					
<i>Lerista muelleri</i>					•	•			•	•	•	•				•										•					
<i>Lerista timida</i>								•																		•					
<i>Lerista verhmens</i>					•						•	•														•					
<i>Lerista zietzi</i>					•				•		•	•	•													•					
<i>Menetia greyii</i>					•			•	•	•	•	•	•			†	•	•	•	•	•					•					
<i>Menetia surda</i>					•	•			•	•	•	•	•			•	•	•	•	•	•					•					
<i>Morethia ruficauda</i>					•	•	•	•	•	•	•	•	•			•										•					
<i>Notoscincus butleri</i>									•		•	•														•					
<i>Notoscincus ornatus</i>					•				•																	•					
<i>Prooblepharus reginae</i>					•				•	•	•	•				•										•					
<i>Tiliqua multifasciata</i>	Centralian Blue-tongue				•	•		•	•	•	•	•	•		•	•	•	•	•	•	•					•					
VARANIDAE																															
<i>Varanus acanthurus</i>	Spiny-tailed Monitor				•	•	•	•	•	•	•	•	•			•	•	•	•	•	•					•					

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2013)	Stingray (ecologia 2014)	Solomon Hub (ecologia 2014)	Central Pilbara Project: Mine (ecologia 2011)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project - rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hamersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Eliwana and Flying Fish (Ecoscape 2012)	NatureMap	DEC Rare Fauna	DSEWPaC Protected Matters Search	This survey
		EPBC Act	WC Act	DPaW																									
<i>Varanus brevicauda</i>	Short-tailed Pygmy Monitor				•	•		•	•	•	•	•			•	•	•			•				•					
<i>Varanus bushi</i>	Pilbara Monitor				•	•		•	•		•	•	•		•		•	•					•		•				
<i>Varanus caudolineatus</i>	Stripe-tailed Monitor				•			•		•						•							•		•				
<i>Varanus eremius</i>	Pygmy Desert Monitor				•	•		•	•		•	•	•								•			•					
<i>Varanus giganteus</i>	Perentie				•	•	S			•	•	•	•		•	•					•				•				
<i>Varanus gilleni</i>	Pygmy Mulga Monitor																								•				
<i>Varanus gouldii</i>	Gould's Monitor				•												•							•					
<i>Varanus panoptes</i>	Yellow-spotted Monitor				•	•		•	•	•	•	•	•				•	•						•					
<i>Varanus hamersleyensis</i>	Pilbara Rock Monitor				•			•	•		•	•					•	•			•			•					
<i>Varanus tristis</i>	Black-headed Monitor				•			•	•	•	•	•	•				•	•	•		•			•					
TYPHLOPIDAE																													
<i>Ramphotyphlops ammodytes</i>					•					•		•												•					
<i>Ramphotyphlops ganei</i>								•	•		•															•			
<i>Ramphotyphlops grypus</i>	Beaked Blind Snake				•	•		•	•	•	•	•	•				•	•	•		•			•					
<i>Ramphotyphlops hamatus</i>																	•	•							•				
<i>Ramphotyphlops pilbarensis</i>	Pilbara Blind Snake				•	•				•		•	•	•							•				•				
<i>Ramphotyphlops waitii</i>																	•								•				
BOIDAE																													
<i>Antaresia perthensis</i>	Pygmy Python				•		•		•		•	•	•				•							•		•			
<i>Antaresia stimsoni</i>	Stimson's Python				•	•	•	•	•	•	•	•	•				•							•		•			
<i>Aspidites melanocephalus</i>	Black-headed Python				•		•		•	•	•	•				†									•				
<i>Liasis olivaceus barroni</i>	Pilbara Olive Python	VU	S1	VU	•		S		•		•		•			•		•					•		•	•	•		
ELAPIDAE																													
<i>Acanthophis pyrrhus</i>	Desert Death Adder																•		•										
<i>Acanthophis wellsi</i>	Pilbara Death Adder				•			•	•		•		•					•							•				
<i>Brachyuropsis approximans</i>	NW Shovel-nosed Snake				•			•	•		•	•	•				•	•	•		•			•					
<i>Demansia psammophis</i>	Yellow-faced Whipsnake				•	•	•	•	•	•	•	•	•				•	•			•				•			•	
<i>Demansia rufescens</i>	Rufous Whipsnake				•	•		•	•	•	•	•	•						•					•		•			
<i>Furina ornata</i>	Moon Snake				•			•	•	•	•	•	•				•	•	•		•			•					
<i>Parasuta monachus</i>	Monk Snake				•			•	•	•	•	•	•				•	•	•		•				•			•	
<i>Pseudechis australis</i>	Mulga Snake				•		S		•	•	•	•	•				•				•				•			•	
<i>Pseudonaja mengdeni</i>	Gwardar				•	•	•	•	•	•	•	•	•				•		•	•					•			•	
<i>Pseudonaja modesta</i>	Ringed Brown Snake				•	•		•	•	•	•	•	•				•	•	•						•			•	
<i>Suta fasciata</i>	Rosen's Snake				•			•	•	•	•	•					•	•	•						•			•	
<i>Suta punctata</i>	Little Spotted Snake				•			•	•								†								•			•	
<i>Vermicella snelli</i>	Pilbara Bandy Bandy				•	•			•		•	•					•	•	•					•		•			

Δ species recorded outside of study area

◊ Due to new taxonomic updates, records of *Cryptoblepharus plagioccephalus* and *C. carnabyi* can be either *C. buchanani* or *C. ustulatus*

Amphibians

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2011)	Stingray (ecologia 2014)	Solomon Hub (ecologia 2014)	Central Pilbara Project: Mine (ecologia 2011)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project – rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hammersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Eliwana and Flying Fish (Ecoscape 2012)	NatureMap	DPaW Rare Fauna	DSEWPaC Protected Matters Search	This survey	
		EPBC Act	WC Act	DPaW																										
HYLIDAE																														
<i>Cyclorana maini</i>	Main's Frog							•	•	•		•				•	•	•		•					•				•	
<i>Cyclorana platycephala</i>	Water-Holding Frog																													
<i>Litoria rubella</i>	Little Red Tree Frog				•	•	•	•	•	•		•	•			•	•			•	•		•						•	
LIMNODYNASTIDAE																														
<i>Platyplectrum spenceri</i>	Centralian Burrowing Frog										•					•	•													
MYOBATRACHIDAE																														
<i>Pseudophryne douglasi</i>	Gorge Toadlet									•						•														
<i>Uperoleia glandulosa</i>	Glandular Toadlet										•	•																		
<i>Uperoleia saxatilis</i>	Northwest Toadlet				•			•	•		•	•																		
BUFONIDAE																														
<i>Bufo marinus</i>	Cane Toad																									•				

Fish

Family and Species	Common name	Conservation Status			ecologia Internal Database	Mt Macleod Level 2 (Rapallo 2011)	Mt Macleod West Level 1 (Ecoscape 2011)	Stingray (ecologia 2014)	Marandoo to Great Northern Hwy (Kendrick 1995)	Solomon Hub (ecologia 2014)	Solomon Project - Kings Area (ecologia 2010)	Solomon Project Area (Coffey 2008)	Firetail mining area (Ecoscape 2010)	Solomon Project – rail re-alignment (Ecoscape 2010)	Solomon Project - rail camps (Ecoscape 2010)	Hammersley Range (Muir 1983)	Marandoo Mine (Biota 2008)	West Turner Section 10 (Biota 2009)	Brockman 2 Detritals Transport Corridor (Mattiske and Ninnox 1990)	Brockman Syncline 4 (Biota 2005)	Northern Transport Corridor (Ninox 1995)	Raven (Ecoscape 2012)	Western Range (Biota 2011)	Eliwana and Flying Fish (Ecoscape 2012)	NatureMap	NatureMap	DPaWRare Fauna	DSEWPaC Protected Matters Search	This survey	
		EPBC Act	WC Act	DPaW																										
CLUPEIDAE																														
<i>Nematalosa erebi</i>	Bony Bream																													
MELANOTAENIIDAE																														
<i>Melanotaenia australis</i>	Western Rainbowfish				•				•			•																		
PLOTOSIDAE																														
<i>Neosilurus hyrtli</i>	Hyrtl's Tandan								•			•																		
TERAPONTIDAE																														
<i>Amniataba percooides</i>	Barred Grunter								•			•																		
<i>Leiopotherapon aheneus</i>	Fortescue Grunter																													
<i>Leiopotherapon unicolor</i>	Spangled Perch				•				•			•																		•

APPENDIX D SITE DESCRIPTIONS

Vegetation and Fauna Habitat Description	Site Photo
<p>Site MM S1 Open <i>Themeda</i> grassland on cracking clays. Soil substrate consists of loose reddish-brown loam-clay with loose calcrete stones. Habitat type: Plain (cracking clay)</p>	
<p>Site MM S2 Mature <i>Eucalyptus</i> and <i>Acacia</i> lined drainage line over dense <i>Cenchrus ciliaris</i> grassland. Soil substrate consists of firm red sand-loam with moderate density of loose river stones. Habitat type: Drainage line/river/creek</p>	

Site MM S3

Mature moderately open *Acacia aneura* over dense *Triodia* grassland. Soil substrate consists of firm reddish-brown loam-clay with extensive pebbles.

Habitat type: Woodland (open)



Site MM S4

Moderately dense *Triodia* hummock grassland plain with moderately dense *Acacia* spp. Soil substrate consists of firm red fine sand with numerous loose rocks.

Habitat type: Hummock grassland



Site MM S5

Moderately dense *Acacia aneura* woodland over *Themeda*. Soil substrate consists of firm reddish-brown clay with some loose rocks.

Habitat type: Woodland (open)



Site MM S6

Open *Acacia pruinocarpa* and *A. binevosa* with *Senna glutinosa* shrubland over *Triodia wiseana* hummock grassland. Soil substrate consists of firm reddish-brown sand-clay with continuous loose pebbles.

Habitat type: Plain (stony gibber)



Site MM S7

Acacia lined drainage line with large pool. Moderately open *Acacia xiphophylla* woodland with open *Acacia aneura* shrubland over open *Cenchrus* grassland. Soil substrate consists of firm reddish-brown clay with moderately dense loose pebbles.

Habitat type: Drainage line/river/creek



Site MM S8

Open *Corymbia deserticola* over open *Acacia ancistrocarpa* shrubland over moderately dense *Triodia pungens* hummock grassland. Soil substrate consists of firm reddish-brown sand-clay with a moderate density of loose pebbles.

Habitat type: Hummock grassland



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APPENDIX E FAUNA SPECIES RECORDED DURING SAMPLING

Appendix F1 Mammals

Family and Species	Common Name	Conservation Status			MM S1	MM S2	MM S3	MM S4	MM S5	MM S6	MM S7	MM S8	Targeted	Opportunistic
		EPBC Act	WC Act	DPaW										
TACHYGLOSSIDAE														
<i>Tachyglossus aculeatus</i>	Echidna													S
DASYURIDAE														
<i>Dasykaluta rosamondae</i>	Kaluta				4		1		1					
<i>Ningui timealeyi</i>	Pilbara Ningui											1		
<i>Planigale sp.</i>	Planigale				2									
<i>Sminthopsis macroura</i>	Stripe-faced Dunnart				12	8	5		7	5	3	2		2
MACROPODIDAE														
<i>Macropus rufus</i>	Red Kangaroo													1
EMBALLONURIDAE														
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheathtail Bat					Low		Low						Low
<i>Taphozous georgianus / hilli</i>	Common/Hill's Sheathtail Bat				Low									
VESPERTILIONIDAE														
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat				Low	Low	Low	Low	Low	Low				Low
<i>Scotorepens greyii</i>	Little Broad-nosed Bat				Low	Low	Low	Low						Low
<i>Vespadelus finlaysoni</i>	Finlayson's Cave Bat				Low	Low	Low	Low	Low	Low				Low
MOLOSSIDAE														
<i>Chaerophon jobensis</i>	Northern Freetail Bat				Low									
MURIDAE														
<i>Leggadina lakedownensis</i>	Short-tailed Mouse			P4		2	1							
<i>Pseudomys chapmani</i>	Western Pebble-mound Mouse			P4										S
<i>Pseudomys delicatulus</i>	Delicate Mouse						1							
<i>Pseudomys desertor</i>	Desert Mouse						5					2		1
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse						2		1	2				
<i>Zyomys argurus</i>	Common Rock-rat					2							45	
INTRODUCED MAMMALS														

Family and Species	Common Name	Conservation Status			MM S1	MM S2	MM S3	MM S4	MM S5	MM S6	MM S7	MM S8	Targeted	Opportunistic
		EPBC Act	WC Act	DPaW										
* <i>Mus musculus</i>	House Mouse						1		1		1	1		

S - secondary evidence recorded (i.e. scat, burrow, mound, feather, remains)

Appendix F2 Birds

Family and Species	Common name	Conservation Status			MMS1	MMS2	MMS3	MMS4	MMS5	MMS6	MMS7	MMS8	Targeted	Opportunistic
		EPBC Act	WC Act	DPaW										
CASUARIIDAE														
<i>Dromaius novaehollandiae</i>	Emu													1
COLUMBIDAE														
<i>Phaps chalcoptera</i>	Common Bronzewing						2							
<i>Ocyphaps lophotes</i>	Crested Pigeon				61		2		28		1			7
<i>Geophaps plumifera</i>	Spinifex Pigeon													2
<i>Geopelia cuneata</i>	Diamond Dove					1				12	5			
EUROSTOPODIDAE														
<i>Eurostopodus argus</i>	Spotted Nightjar													2
ARDEIDAE														
<i>Egretta novaehollandiae</i>	White-faced Heron							5		1				
THRESKIORNITHIDAE														
<i>Threskiornis spinicollis</i>	Straw-necked Ibis													1
ACCIPITRIDAE														
<i>Elanus axillaris</i>	Black-shouldered Kite				1									

Family and Species	Common name	Conservation Status			MMS1	MMS2	MMS3	MMS4	MMS5	MMS6	MMS7	MMS8	Targeted	Opportunistic
		EPBC Act	WC Act	DPa W										
<i>Haliastur spheonurus</i>	Whistling Kite						7	1			2			
<i>Accipiter fasciatus</i>	Brown Goshawk								1		1			
<i>Circus assimilis</i>	Spotted Harrier				2			1						
<i>Aquila audax</i>	Wedge-tailed Eagle						1			2				
FALCONIDAE														
<i>Falco cenchroides</i>	Nankeen Kestrel				1			1						
<i>Falco berigora</i>	Brown Falcon					1				1				
<i>Falco longipennis</i>	Australian Hobby							1						
OTIDIDAE														
<i>Ardeotis australis</i>	Australian Bustard			P4		1								
TURNICIDAE														
<i>Turnix velox</i>	Little Button-quail				2		1							
CACATUIDAE														
<i>Eolophus roseicapillus</i>	Galah				38	1	4			2		6		4
<i>Cacatua sanguinea</i>	Little Corella				2	2	3			3	21			
<i>Nymphicus hollandicus</i>	Cockatiel				18	7	2	2						
PSITTACIDAE														
<i>Barnardius zonarius</i>	Australian Ringneck				7	4	2		4		8			3
<i>Melopsittacus undulatus</i>	Budgerigar					19	1	9	2		6			
<i>Neopsephotus bourkii</i>	Bourke's Parrot										2			
STRIGIDAE														
<i>Ninox novaeseelandiae</i>	Southern Boobook													2
HALCYONIDAE														

Family and Species	Common name	Conservation Status			MMS1	MMS2	MMS3	MMS4	MMS5	MMS6	MMS7	MMS8	Targeted	Opportunistic
		EPBC Act	WC Act	DPa W										
<i>Todiramphus pyrrhopygius</i>	Red-backed Kingfisher									1				
MEROPIDAE														
<i>Merops ornatus</i>	Rainbow Bee-eater	M	S3		1	1				1				6
MALURIDAE														
<i>Malurus lamberti</i>	Variegated Fairy-wren						7		9		4	6		
ACANTHIZIDAE														
<i>Smicronis brevirostris</i>	Weebill					19	7	15	3	5	7			
<i>Gerygone fusca</i>	Western Gerygone					14	4	3	2	1	3	1		2
<i>Acanthiza robustirostris</i>	Slaty-backed Thornbill						6							
<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill					6			3			5		2
PARDALOTIDAE														
<i>Pardalotus rubricatus</i>	Red-browed Pardalote					1			3					
MELIPHAGIDAE														
<i>Lichenostomus virescens</i>	Singing Honeyeater					9	3	1	5			1		2
<i>Lichenostomus keartlandi</i>	Grey-headed Honeyeater								2			1		
<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater									1	3			3
<i>Purnella albifrons</i>	White-fronted Honeyeater													2
<i>Manorina flavigula</i>	Yellow-throated Miner				3			4						
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater				1	10	9	18	3		1			3
<i>Conopophila whitei</i>	Grey Honeyeater					3	2							2
<i>Epthianura tricolor</i>	Crimson Chat					18			4					

Family and Species	Common name	Conservation Status			MMS1	MMS2	MMS3	MMS4	MMS5	MMS6	MMS7	MMS8	Targeted	Opportunistic
		EPBC Act	WC Act	DPa W										
<i>Sugomel niger</i>	Black Honeyeater					1								
<i>Lichmera indistincta</i>	Brown Honeyeater					4	2	4	14	6	17	2		7
<i>Melithreptus gularis</i>	Black-chinned Honeyeater								3					
POMATOSTOMIDAE														
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler								6	2				
CAMPEPHAGIDAE														
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike					4	4	5				2		
<i>Lalage sueurii</i>	White-winged Triller					3			3					
PACHYCEPHALIDAE														
<i>Pachycephala rufiventris</i>	Rufous Whistler					14	10	4	8	2	10	2		
<i>Colluricincla harmonica</i>	Grey Shrike-thrush								2					
<i>Oreoica gutturalis</i>	Crested Bellbird					10	15	8	3			1		2
ARTAMIDAE														
<i>Artamus personatus</i>	Masked Woodswallow						6	3						
<i>Artamus cinereus</i>	Black-faced Woodswallow					16	2	3		3		5		
<i>Cracticus torquatus</i>	Grey Butcherbird						1	7						1
<i>Cracticus nigrogularis</i>	Pied Butcherbird				4	1	2	3				1		
RHIPIDURIDAE														
<i>Rhipidura leucophrys</i>	Willie Wagtail				7	12	7	12		1	1			
CORVIDAE														
<i>Corvus bennetti</i>	Little Crow						8	11						

Family and Species	Common name	Conservation Status			MMS1	MMS2	MMS3	MMS4	MMS5	MMS6	MMS7	MMS8	Targeted	Opportunistic
		EPBC Act	WC Act	DPa W										
<i>Corvus orru</i>	Torresian Crow				6	1	2	1		4				
MONARCHIDAE														
<i>Grallina cyanoleuca</i>	Magpie-lark				1	1	1	6						
PETROICIDAE														
<i>Petroica goodenovii</i>	Red-capped Robin							1						
<i>Melanodryas cucullata</i>	Hooded Robin								3					
MEGALURIDAE														
<i>Eremiornis carteri</i>	Spinifexbird							3		2		4		
NECTARINIIDAE														
<i>Dicaeum hirundinaceum</i>	Mistletoebird					8		1	6		6			
ESTRILDIDAE														
<i>Taeniopygia guttata</i>	Zebra Finch				8	68	43	14	9	12	137	11		5

Appendix F3 Herpetofauna

Family and Species	Common Name	Conservation Status			MM S1	MM S2	MM S3	MM S4	MM S5	MM S6	MM S7	MM S8	Targeted	Opportunistic
		EPBC Act	WC Act	DPaW										
CHELUIDAE														
<i>Chelodina steindachneri</i>	Flat-shelled Turtle									1				
AGAMIDAE														
<i>Amphibolurus longirostris</i>	Long-nosed Dragon					11	2		1	3	3			1
<i>Ctenophorus caudicinctus</i>	Ring-tailed Dragon									1	2			
<i>Ctenophorus nuchalis</i>	Central Netted Dragon													1
<i>Ctenophorus reticulatus</i>	Western Netted Dragon						4		2					
<i>Diporiphora valens</i>								2						
DIPLODACTYLIDAE														
<i>Lucasium stenodactylum</i>	Sand-plain Gecko											1		1
<i>Strophurus wellingtonae</i>							1							
GEKKONIDAE														
<i>Gehyra variegata</i>							4							
<i>Heteronotia binoei</i>	Bynoe's Gecko											2		
PYGOPODIDAE														
<i>Delma butleri</i>														1
<i>Delma sp.</i>					S									
<i>Lialis burtonis</i>	Burton's Snake-lizard													1
SCINCIDAE														
<i>Carlia munda</i>							3					2		
<i>Carlia triacanthor</i>														1
<i>Ctenotus duricola</i>										1				
<i>Ctenotus grandis</i>												1		
<i>Ctenotus helenae</i>												1		

Family and Species	Common Name	Conservation Status			MM S1	MM S2	MM S3	MM S4	MM S5	MM S6	MM S7	MM S8	Targeted	Opportunistic
		EPBC Act	WC Act	DPaW										
<i>Ctenotus pantherinus</i>	Leopard Ctenotus						9		3		4			
<i>Ctenotus robustus</i>	Robust Ctenotus				4	13	24		12					
<i>Ctenotus saxatilis</i>	Rock Ctenotus												1	
<i>Cyclodomorphus melanops</i>	Spinifex Slender Blue-tongue												1	
<i>Proablepharus reginae</i>													1	
ELAPIDAE														
<i>Demansia psammophis</i>	Yellow-faced Whipsnake						2	2			1			
<i>Parasuta monachus</i>	Monk Snake									1				
<i>Pseudechis australis</i>	Mulga Snake						1		1			1		
<i>Pseudonaja modesta</i>	Ringed Brown Snake									1				
<i>Suta fasciata</i>	Rosen's Snake								1			1	1	
<i>Suta punctata</i>	Little Spotted Snake												1	
HYLIDAE														
<i>Cyclorana maini</i>	Main's Frog												1	
<i>Litoria rubella</i>	Little Red Tree Frog												1	

S - secondary evidence recorded (i.e. scat, burrow, mound, feather, remains)

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