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ENVIRONMENT

SHEFFIELD RESOURCES PTY LTD
THUNDERBIRD HAUL ROAD & ACCOMMODATION CAMP
FLORA AND FAUNA ASSESSMENT

Document Status						
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ACRONYMS

BAM Act	*Biosecurity and Agriculture Management Act 2007*
BOM	Bureau of Meteorology
DAFWA	Department of Agriculture and Food Western Australia
DEC	Department of Environment and Conservation (now DPaW)
DoE	The Department of Environment (formerly DSEWPaC)
DPaW	Department of Parks and Wildlife
DSEWPaC	Department of the Sustainability, Environment, Water, Population and Communities (now DotEE)
ESA	Environmentally Sensitive Area
ESCAVI	Executive Steering Committee for Australia Vegetation Information
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
NVIS	National Vegetation Information System
PEC	Priority Ecological Community
TEC	Threatened Ecological Community
TPFL	Threatened and Priority Flora Database
TPList	Threatened and Priority Flora List
WA	Western Australia
WAHERB	Western Australian Herbarium
WAOL	Western Australian Organism List
WC Act	*Wildlife Conservation Act 1950*
WONS	Weeds of National Significance

EXECUTIVE SUMMARY

Sheffield Resources Limited (Sheffield) is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway for their Thunderbird project. Sheffield previously commissioned *ecologia* Environment (*ecologia*) to conduct flora and vegetation, vertebrate, SRE invertebrate and subterranean fauna assessments for their Thunderbird project.

To service the Thunderbird project, a proposed haul road and accommodation camp (study area) has been identified by Sheffield. Sheffield commissioned *ecologia* to undertake a Level 2 flora and vegetation and Level 1 and targeted fauna assessment of the study area.

The flora, vegetation and fauna assessment was carried out in accordance with EPA Guidance and encompassed both desktop and field assessments. The flora and vegetation assessment was carried out in accordance with a Level 2 survey and the fauna assessment was carried out in accordance with a Level 1 survey. The survey was conducted by a suitably qualified and experienced botanist and zoologist over five days from 11 to 15 May 2015.

Flora

A total of 16 quadrats (50 x 50 m) were sampled at the study area to determine the flora and vegetation characteristics of the study area. Quadrat locations were selected using a combination of aerial photography, topographic features, land systems, field observations and accessibility to represent the diversity of vegetation and habitats present. Significant flora taxa identified during the database searches were targeted by using aerial imagery to identify suitable habitat as well as the locations of previous records.

A total of 162 vascular plant taxa (including species, infraspecific taxa, and phrase name taxa) were recorded at the study area, representing 97 genera and 41 families. This includes two Priority Flora species: *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3) and four introduced species: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*.

Communities

A search of Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) within and adjacent to the study area was undertaken as part of the literature review. Two Priority 3 PECs were recorded within 60 km of the study area: “Vegetation assemblages of Lolly Well Springs wetland complex” and “Assemblages of Disaster Bay organic mound springs”. Niether of these two PECs occur within the study area. The study area does not intersect with any conservation areas or reserves. A search of DER’s online Native Vegetation Viewer was undertaken to determine the locations of any ESAs within the study area. No ESAs occur at the study area.

Fauna

Vertebrate fauna was sampled via active searches (including bird surveys), camera trapping and bat echolocation recordings via SongMeter2 devices. Targeted searches for potential conservation significant fauna identified during the literature review were carried out according to appropriate species specific survey methodology.

The literature review identified a total of 383 fauna species with the potential to occur in the study area. This includes 32 native and six introduced mammal species, 249 bird species, 82 reptiles and 14 amphibians. Included in the species recorded in the literature review are a total of 69 conservation significant vertebrate fauna species have the potential to occur in the study area, comprising six mammal species, 59 bird species, and four reptile species.

The field survey recorded a total of 79 fauna species from both direct sightings and secondary evidence such as scats and calls, comprised of 13 mammal, 63 bird and three reptile species. Three

broad habitat types were identified within the study area; pindan shrubland, sandstone range and footslopes and savannah woodland. Four conservation significant fauna species were recorded: Greater Bilby (EPBC Act Vulnerable); Rainbow Bee-eater (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement); Common Greenshank (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement) and Australian Bustard (DPaW Priority 4).

The Greater Bilby was only recorded from the haul road sections within the current Thunderbird study area. It is unlikely to occur within the remainder of the haul road study area, due to the narrow linear corridor and lack of dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat and sandy soil substrate. Locations where Greater Bilby was recorded are likely to be part of a resident breeding population. However the occupancy of these areas will be determined by fire history and therefore will continue to change temporally.

Of the 69 conservation significant fauna that may potentially occur within the study area, a total of 46 species were assessed as low likelihood, 16 species as medium likelihood and seven species recoded as high likelihood or recorded during current survey. Conservation significant fauna species recorded or assessed as high likelihood of occurrence were; Greater Bilby (*Macrotis lagotis*), Lakeland Downs Mouse (Short-tailed Mouse) (*Leggadina lakedownensis*), Rainbow Bee-eater (*Merops ornatus*), Fork-tailed Swift (*Apus pacificus*), Common Greenshank (*Tringa nebularia*), Australian Bustard (*Ardeotis australis*) and Dampier Peninsula Goanna (*Varanus sparnus*).

1 INTRODUCTION

1.1 PROJECT BACKGROUND

Sheffield Resources Limited (Sheffield) is a rapidly emerging Western Australian mineral sands company, also with significant nickel, talc and iron assets, all located within the state of Western Australia. Sheffield is undertaking biological surveys at an early stage to aid their project pathway for their Thunderbird project.

Sheffield has previously commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna survey of its Thunderbird Project, located 70 kilometres west of Derby on the Dampier Peninsula. Level 2 assessments were completed in 2014.

In order to service the Thunderbird project, proposed haul road otions and an accommodation camp (study area) has been identified by Sheffield. Sheffield commissioned *ecologia* to undertake a Level 2 flora and vegetation and Level 1 and targeted fauna assessment of the haul road and accommodation camp study area. Sections of the proposed haul road and the entire accommodation camp are within the previously surveyed Thunderbird project study area. The study area totals an area of 538.4 ha inside the existing Thunderbird study area, with 810.9 ha outside the existing Thunderbird study area (1,349.3 ha total). A location map of the study area is shown in Figure 1.1.

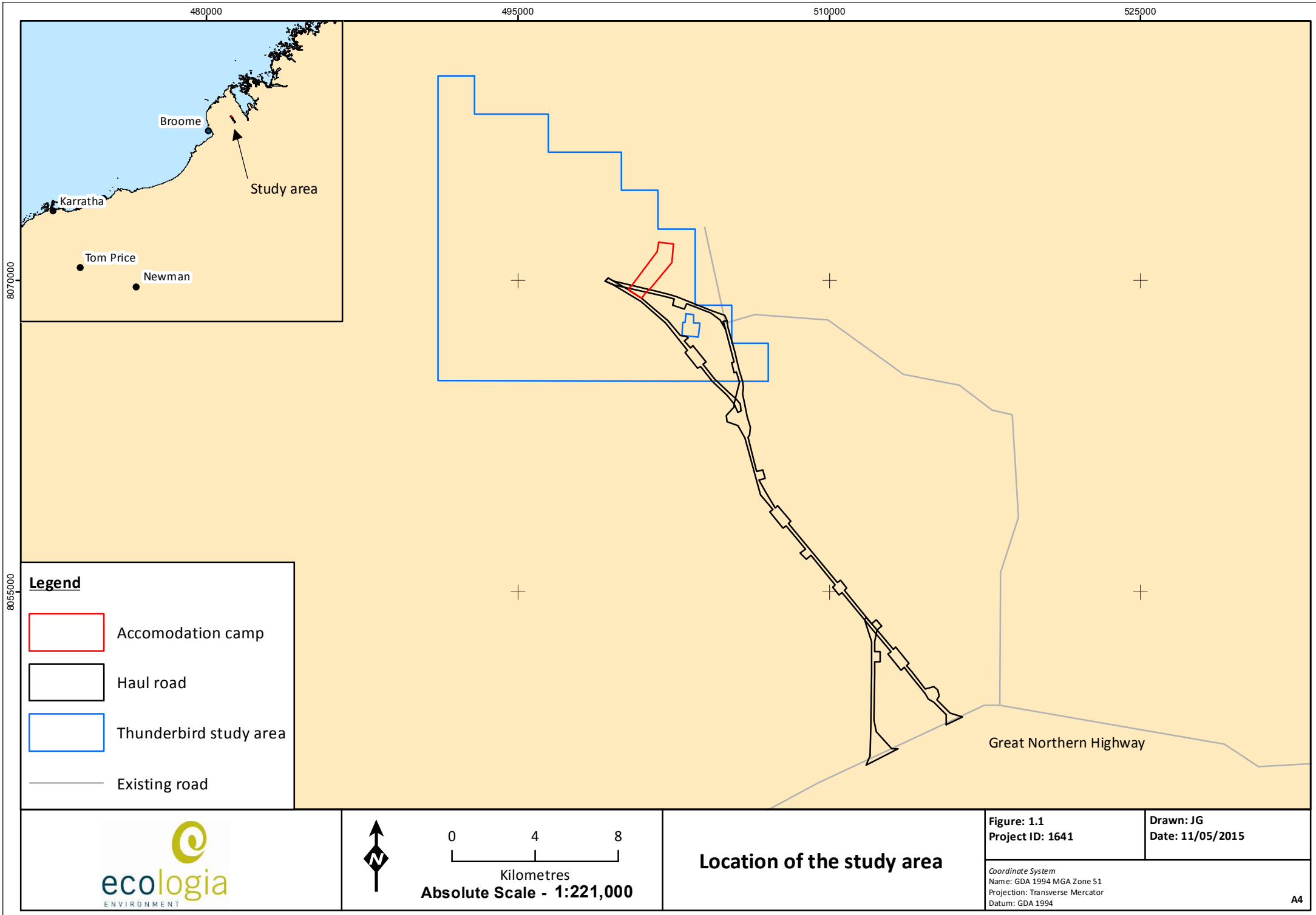
1.2 LEGISLATIVE FRAMEWORK

Commonwealth and State legislation applicable to the conservation of native flora and fauna in Western Australia (WA) includes, but is not limited to, the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Western Australian *Wildlife Conservation Act 1950* (WC Act) and the *Environment Protection Act 1986* (EP Act). Section 4a of the EP Act requires that developments take into account the following principles applicable to native flora and fauna:

- **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 Principles 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; and
- **The Principle of the Conservation of Biological Diversity and Ecological Integrity:** Conservation of biological diversity and ecological integrity should be a fundamental consideration of development projects.

The EPBC Act was developed to provide for the protection of the environment, particularly 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 (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 the principle of ecologically sustainable development; that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations.

The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under the WC Act, all native flora and fauna are protected in WA; however, the Minister may, via a notice published in the Government Gazette, declare a list of flora and fauna identified as likely to become extinct, or as rare, or otherwise in need of special protection. The current listing was gazetted on 2 December 2014.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Tom Price
Newman
Great Northern Highway
Legend
Accomodation camp
Haul road
Thunderbird study area
Existing road
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Absolute Scale - 1:221,000
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ENVIRONMENT
Location of the study area
Figure: 1.1
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

1.3 SURVEY OBJECTIVES

The Environmental Protection Authority's (EPA) objectives with regard to the management of native flora, fauna and vegetation are to:

- Avoid adverse impacts on biological diversity comprising the different plants and animals and the ecosystems they form, at the levels of genetic, species and ecosystem diversity;
- Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities;
- Protect Threatened Flora and Fauna consistent with the provisions of the WC Act; and
- Protect other flora and fauna species of conservation significance.

The primary objective of this flora, fauna and vegetation assessment is to provide sufficient information to the EPA to assess the impact of the proposed development on the vegetation, flora and fauna communities of the study area, thereby ensuring that the EPA objectives will be upheld.

1.4 SIGNIFICANT FLORA

Significant flora as described in EPA Guidance Statement 51 (EPA 2004a) includes Threatened and Priority Flora as well as range extensions, keystone species, relic species, potential new species, restricted subspecies, varieties or naturally occurring hybrids, local endemics or poorly reserved species. These are described below.

1.4.1 Threatened Flora

***Environment Protection and Biodiversity Conservation Act,* 1999 (Commonwealth of Australia)**

At a Commonwealth level, Threatened Flora are protected under the EPBC Act, which lists species that are considered Critically Endangered, Endangered, Conservation Dependant, Extinct, or Extinct in the Wild (Appendix A).

***Wildlife Conservation Act, 1950* (Western Australia)**

Flora taxa which have been adequately searched for and are deemed to either be rare, in danger of extinction, or otherwise in need of special protection in the wild, are gazetted as Threatened (Declared Rare) Flora under the WC Act. Threatened Flora are further categorised according to their level of threat using the International Union for Conservation of Nature (IUCN) Red List criteria:

- Critically Endangered: considered to be facing an extremely high risk of extinction in the wild;
- Endangered: considered to be facing a very high risk of extinction in the wild; and
- Vulnerable: considered to be facing a high risk of extinction in the wild.

Threatened Flora taxa are legally protected and their removal or impact to their surroundings cannot be conducted without Ministerial approval, obtained specifically on each occasion for each population (Appendix A).

1.4.2 Priority Flora

The Department of Parks and Wildlife (DPaW) maintains a list of Priority Flora, which are considered poorly known, uncommon or under threat but for which there is insufficient justification, based on known distribution and population sizes, listing as Threatened under the WC Act. Priority Flora taxa are assigned to one of five priority categories (Appendix A).

1.4.3 Range Extensions

Taxa that are outside of their known distribution are identified as range extensions. The distribution and range extensions have been subdivided into three categories:

- Bioregional Extension: indicates the taxon has not been previously recorded in the Interim Biogeographic Regionalisation for Australia (IBRA) Bioregion;
- Range Extension: indicates the records are at least 100 km from the boundary of the known distribution based on herbarium lodged records; and
- Bridging Record: indicates records between known populations, but at least 100 km from the nearest population.

1.4.4 Introduced Flora

Weeds of National Significance (WONS)

At a national level there are 32 weeds listed as Weeds of National Significance (WONS). *The Commonwealth National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance* (2012b) describes broad goals and objectives to manage these weeds.

Declared Pests (Weeds)

The *Biosecurity and Agriculture Management Act 2007* (BAM Act) (Department of Agriculture and Food Western Australia (DAFWA) 2007) seeks to prevent serious animal and plant pests and diseases from entering the State and becoming established, and to minimise the spread and impact of any that are already present. The BAM Act (and associated regulations) replaces the *Agriculture and Related Resources Protection Act 1976* (and associated regulations). The BAM regulations were enacted on 1 May 2013, placing organisms into four categories:

- Permitted organism (listed under Section 11): permitted in WA subject to regulations;
- Prohibited organism (listed under Section 12): prohibited in WA subject to regulations (i.e. is a Declared Pest for the whole of State);
- Permitted organism: permit required (under regulation 73): must not be imported unless in accordance with an import permit ; and
- Permitted organism: Declared Pest (under Section 22): can apply to part of or the whole of the State.

The current Western Australian Organism List (WAOL) was published on 1 May 2013 (DAFWA 2013) and lists organisms in each of these categories. Unlisted organisms must not be imported (unless in accordance with an import permit and regulations). The BAM Act further categorises Declared Pests in one of three control categories; C1 Exclusion, C2 Eradication and C3 Management (Table 1.1).

Table 1.1 – Control categories for Declared Pests (Weeds)

Declared plant category	Description
C1 - Exclusion	Pests assigned to this category are not established in WA and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2 - Eradication	Pests assigned to this category are present in WA in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3 - Management	Pests assigned to this category are established in WA but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Environmental Weeds

A second and much more extensive categorisation of weeds has been developed by the DPaW in the State Environmental Weed Strategy (The Department of Conservation and Land Management

(CALM) 1999). Species considered to adversely affect the communities they invade are evaluated based on the following criteria:

- Invasiveness: ability to invade bushland in good to excellent condition or ability to invade waterways (scored as yes or no);
- Distribution: wide current or potential distribution including consideration of known history of widespread distribution elsewhere in the world (scored as yes or no); and
- Environmental impacts: ability to change the structure, composition and function of ecosystems. In particular an ability to form a monoculture in a vegetation community (scored as yes or no).

Weeds listed as Environmental Weeds are ranked into four categories using the above criteria and the scoring system:

- High: a species which scores yes to all three of the above criteria. A rating of high indicates a species that should be prioritised for control and/or research;
- Moderate: a species which scores yes for two of the above criteria. A rating of moderate indicates a species which should be monitored. Control or research should be directed to it if funds are available;
- Mild: a species which scores yes to one of the criteria. A mild rating indicates monitoring or control if appropriate; and
- Low: a species which does not score yes for any of the criteria. A low rating indicates a low requirement for monitoring.

1.5 SIGNIFICANT VEGETATION AND COMMUNITIES

1.5.1 Threatened and Priority Ecological Communities

Nationally Listed Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (Department of Environment and Conservation (DEC) 2010) . At a national level, flora and Threatened Ecological Communities (TEC) are protected under the Commonwealth EPBC Act. An ecological community may be categorised into one of three sub-categories:

- Critically Endangered: if it is facing an extremely high risk of extinction in the wild in the immediate future;
- Endangered: if it is not critically endangered and is facing a very high risk of extinction in the wild in the near future and
- Vulnerable: if it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

State Listed Threatened Ecological Communities

DPaW also maintains a list of state listed TECs which are further categorised into three subcategories, much like those of the EPBC Act. Within the Western Australian classification, an ecological community will be listed as Vulnerable "when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future".

State Listed Priority Ecological Communities

DPaW maintains a list of Priority Ecological Communities (PEC). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined.

1.5.2 Conservation Estate

The National Reserve System is a network of protected areas managed for conservation under international guidelines. The objective of placing areas of bushland into the Conservation Estate is to achieve and maintain a comprehensive, adequate and representative reserve system for Western Australia. Areas vested in the Conservation Estate are managed by the Conservation Commission.

1.5.3 Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are areas that require special protection due to aspects such as landscape, wildlife of historical value. ESAs are declared under the *Environmental Protection (Clearing of Native Vegetation) Regulation 2004*.

1.6 SIGNIFICANT FAUNA

1.6.1 Threatened Fauna

Species of fauna are defined as Threatened where their populations are under threat, require protection or are protected under an international agreement between federal governments. Threats of extinction to fauna species are recognised at a Commonwealth level and are categorised according to the EPBC Act, administered by the Department of Environment (DoE). Categories of Threatened species are summarised in Appendix A.

DPaW recognises these threats of extinction and consequently applies regulations towards population and species protection. Schedule 1 Threatened fauna are further ranked by DPaW according to their threat using IUCN Red List criteria. Threatened fauna species are protected under the WC Act and the categories are defined in Appendix A.

1.6.2 Priority Fauna

Priority fauna not listed as Threatened (Scheduled) under the WC Act, but are poorly known or poorly represented in the conservation estate are regarded as priority and attention is given to their conservation by DPaW. The five classifications of Priority fauna are listed in Appendix A.

1.6.3 Migratory Fauna

Migratory species are matters of Commonwealth environmental significance under the EPBC Act. Recognised migratory species include any native species identified in an international agreement approved by the Minister and those listed under:

- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention);
- The China-Australia Migratory Bird Agreement (CAMBA); and
- The Japan-Australia Migratory Bird Agreement (JAMBA).

2 METHODOLOGY

The flora, vegetation and fauna assessment was carried out in accordance with EPA Guidance and encompassed both desktop and field assessments. The flora and vegetation assessment was carried out in accordance with a Level 2 survey and the fauna assessment was carried out in accordance with a Level 1 survey.

2.1 GUIDING PRINCIPLES

This survey was undertaken as part of the Environmental Impact Assessment process in WA and is required to address the following government legislation:

- EPA Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a);
- EPA Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2002a); and
- EPA Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002b).

Specifically providing:

- A review of background information (including literature and database searches);
- An inventory of flora and fauna species observed at the study area;
- An inventory and a map of species of biological and conservation significance recorded or likely to occur within the study area and surrounds;
- An inventory and a map of introduced flora species recorded at the study area;
- An inventory of vegetation types and flora and fauna species occurring at the study area, incorporating recent published and unpublished records;
- A map and detailed description of vegetation types (to National Vegetation Information Systems (NVIS) Level V: Association) occurring in the study area and an assessment of which vegetation units potentially represent TEC or PECs;
- A map and detailed description of fauna habitats at the study area;
- A map of the vegetation condition and discussion on the type of disturbances encountered;
- An appraisal of the current knowledge base for the area, including a review of previous surveys conducted in the area relevant to the current study; and
- A review of regional and biogeographical significance, including the conservation status of species recorded at the study area.

2.2 SURVEY TIMING

The field component of the flora and fauna assessment was conducted by one botanist and one zoologist over five days between the 11 to 15 May 2015. A survey effort equivalent to 10 person days was expended.

2.3 STUDY TEAM AND LICENCES

The flora and fauna assessment described in this document was planned, coordinated and executed by those summarised and under the following licences listed in Table 2.1.

Table 2.1 – Study team and licences

Project Staff			
Name	**Qualification**	**Role**	**Project role**
Matthew Macdonald	PhD	Principal Ecologist	Project management, field survey and reporting
Bruce Greatwich	BSc.	Senior Zoologist	Field survey and reporting
Melissa Hay	BSc. (Hons)	Senior Botanist	Reporting and vegetation mapping
John Graff	BSc. (Hons)	Zoologist	Reporting
Palitha Jayasekara	PhD	Botanist/Taxonomist	Flora identifications
Shaun Grein			
Licences			
The flora, fauna and vegetation assessment described in this report was conducted under the authorisation of the following licences issued by DPaW:			
Name	**Licence Number**	**Licence**	
Matthew Macdonald	SL011413	Licence to take flora for scientific purposes	
Bruce Greatwich	SF010318	Regulation 17 licence	

2.4 DATABASE SEARCHES

2.4.1 Flora

Using a shapefile of the study area, searches of the following databases were undertaken to determine species and communities of significance recorded in the vicinity of the study area:

- DoE EPBC Act Protected Matters Database flora searches (buffer 40 km);
- Department of Parks and Wildlife (DPaW), Threatened and Priority Flora Database (TPFL) (Search reference 15-0313FL) with a 50 km buffer around the Sheffield Thunderbird study area;
- DPaW Threatened and Priority Flora List (TPList) (Search reference 15-0313FL) with a 50 km buffer around the Sheffield Thunderbird study area;
- DPaW Western Australian Herbarium Specimen Database (WAHERB) (Search reference 15-0313FL) with a 50 km buffer around the Sheffield Thunderbird study area; and
- DPaW Threatened and Priority Ecological Communities Database with a 50 km buffer around the Sheffield Thunderbird study area.

2.4.2 Fauna

Three databases were consulted in the preparation of potential fauna lists (Table 2.2). The online database NatureMap (DPaW 2015a) encompasses several datasets, including the Western Australian Museum, the DPaW Threatened Fauna database and the DPaW Survey Return database. The results from 14 previous vertebrate fauna surveys within 100 km of the study area were also consulted.

Table 2.2 – Fauna databases searched

Database	Custodian	Search Details
NatureMap (includes DPaW Threatened Fauna Database)	DPaW	Search co-ordinates: 17° 34' 03" S, 123° 04' 44" S Buffer (radius): 40 km Date accessed: 08/05/2015
EPBC Act Protected Matters Search Tool	DoE	Search co-ordinates: 17° 34' 03" S, 123° 04' 44" S Buffer (radius): 40 km Date accessed: 08/05/2015
Birdata	BirdLife Australia	Records within the one degree grid square containing the point 17° 34' 03" S, 123° 04' 44" S Date accessed: 08/05/2015

Table 2.3 – Previous vertebrate fauna survey reports within 100 km of the study area

Survey location and author(s)	Distance from study area (km)	Comments
ecologia internal database	0 – 85	Two Level 1 and three single phase Level 2 surveys
Thunderbird Project Terrestrial and Subterranean Fauna Assessment (*ecologia* 2014b)	0	Two phase Level 2 survey
Perpendicular Head-North Head, Packer Island, Gourdon Bay and Coulomb-Quondong Vertebrate Fauna Assessment (ENV 2008)	70	Single phase Level 2 survey
James Price Point Terrestrial Fauna Survey (Biota 2009)	85	Single phase Level 2 survey
James Price Point Browse LNG Precinct Targeted Terrestrial Fauna Survey (Biota 2010)	85	Single phase Level 2 survey
Supplementary Terrestrial Fauna and Habitat Assessment (AECOM 2010)	85	Single phase Level 1 survey
Browse LNG Precinct Access Road: Targeted Fauna Survey – Greater Bilby (AECOM 2011)	85	Targeted Greater Bilby survey
Monitoring Yellow Sea Migrants in Australia (MYSMA) (Rogers *et al.* 2009)	85 - 435	Targeted shorebird survey
Assessment of Birds Utilising Habitat within the Vine Thickets and Woodlands of James Price Point (Bamford 2011)	85	Targeted bird survey
Browse Project Greater Bilby Survey of the James Price Point Area - Summary Report (ENV 2011)	85	Targeted Greater Bilby survey

2.5 FLORA AND VEGETATION ASSESSMENT

A single phase Level 2 flora and vegetation assessment was conducted at the study area to gather data allowing for vegetation mapping and undertake floristic analysis of the entire study area. Methodologies were formulated based on the legislative framework listed in Section 1.2.

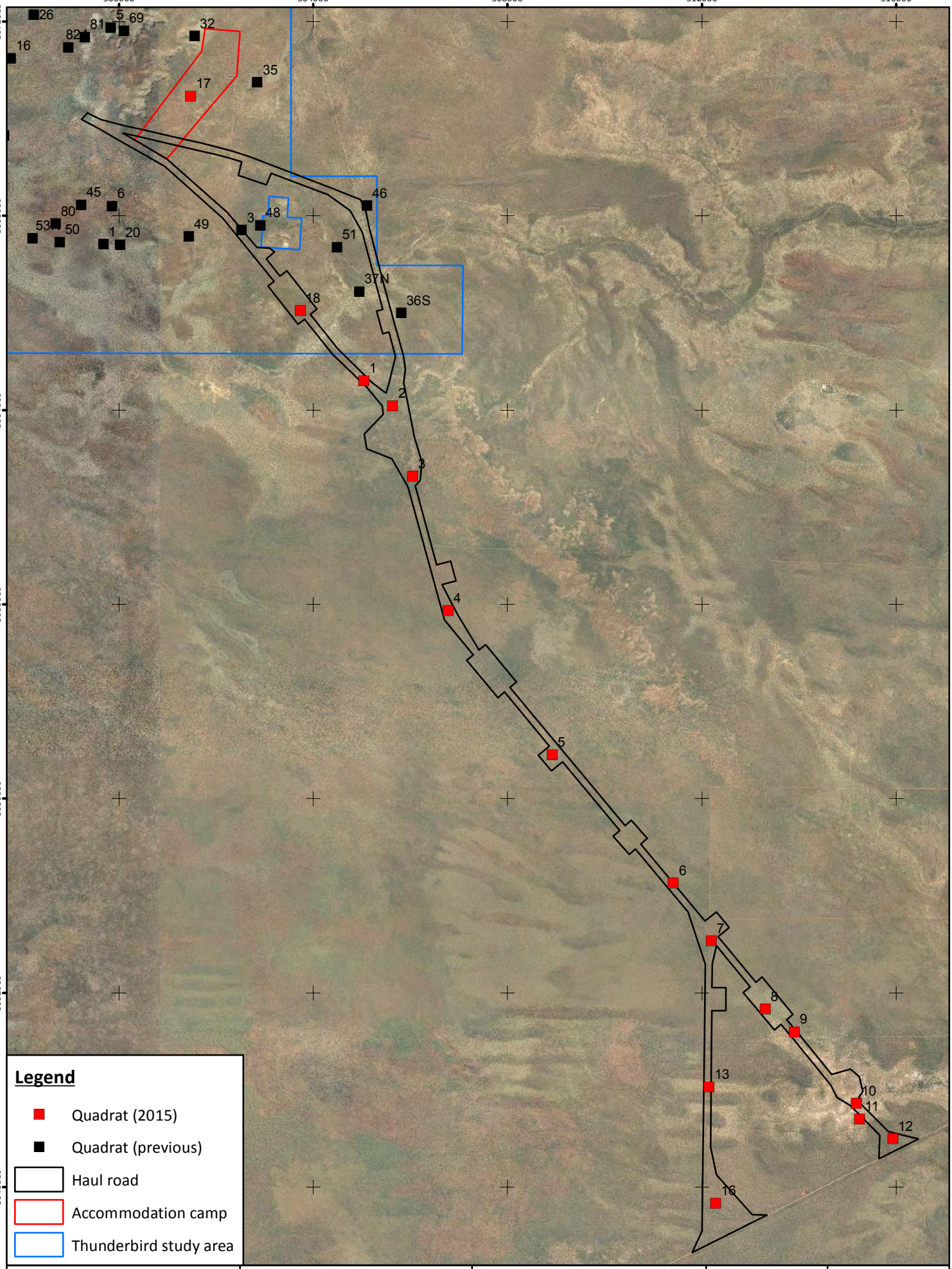
2.5.1 Quadrats

A total of 16 quadrats were sampled at the study area (Figure 2.1). Quadrat locations were selected using a combination of aerial photography, topographic features, land systems, field observations and accessibility to represent the diversity of vegetation and habitats present.

All quadrats were 50 x 50 m (2,500 m^2) in dimension. The following paramters were recorded from each quadrat:

- All observed flora species and the average height, percentage cover and observable presence/absence of fruit/flowers for each;
- Vegetation structure (National Vegetation Information System (NVIS), Section 2.5.4);
- Vegetation condition scale of Trudgen (1991), which is based on the criteria in Table 2.4;

- Estimated time since fire;
- GPS co-ordinate for the north-west corner;
- Digital photograph of the quadrat, taken from the north-west corner facing south-east;
- The landform element that the quadrat occupies;
- The presence of rock outcrops (type and abundance);
- Soil type (colour, profile, field texture and surface type); and
- Position, slope and aspect.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Quadrat (2015)
Quadrat (previous)
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Accommodation camp
Thunderbird study area
ecologia
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Absolute Scale - 1:100,000
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Flora quadrats completed
Figure: 2.1
Project ID: 1641
Drawn: BG
Date: 7/5/15
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

2.5.2 Targeted Significant and Additional Flora Searches

Significant flora identified during the database searches were targeted by interpreting aerial imagery to identify suitable habitat (listed for each taxon in Table 4.2) as well as the locations of previous records. The targeted flora searches involved a series of transects which were traversed on foot to locate flora of conservation significance, introduced flora and to provide opportunistic collections of taxa not recorded within the quadrats. Previous records of significant flora were also visited where possible.

2.5.3 Taxonomy

Nomenclature of the species recorded follow the protocols of the West Australian Herbarium (Western Australian Herbarium 1998-2015). An atypical form of *Triodia schinzii*, informally recognised as *Triodia schinzii* (Broome variant) is reported as *Triodia schinzii* - all specimens of this taxon from this project are referrable to *Triodia schinzii* (Broome variant).

2.5.4 Vegetation Mapping

Vegetation mapping is the delineation of plant communities based on distinctive characteristics that these communities share such as the vegetation structure, dominant species and species composition.

Vegetation units are described based on the NVIS methodology (ESCAVI 2003). They are described to the broad floristic formation (level III) and the association (level V) with the dominant growth form, height and crown cover for three species are described for three strata levels (upper, middle and ground).

2.5.5 Vegetation Condition Mapping

The vegetation condition at the study area was mapped using the average condition of the quadrats that were conducted in each vegetation unit. Condition is assessed based on criteria listed in Table 2.4 as described by Trudgen (1991).

Table 2.4 – Vegetation condition assessment

Vegetation Condition	Criteria
Pristine	Pristine or nearly so, no obvious sign of disturbance.
Excellent	Vegetation structure intact; disturbance affecting individual species; weeds are non-aggressive species.
Very good	Vegetation structure altered; obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires; the presence of some more aggressive weeds; dieback; logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires; the presence of some very aggressive weeds at high density; partial clearing; dieback and grazing.
Degraded or Poor	Very few values remaining.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as “parkland cleared” with the flora comprising weed or crop species with isolated native trees or shrubs.

2.5.6 Statistical Analysis

Quadrat data was used to produce a dendrogram of dissimilarity in floristic composition among quadrats. The dendrogram was divided into groups which correspond to the vegetation units. A combination of aerial photography, the vegetation unit grouping and ground truthing was used to interpret the vegetation patterns of the study area and formed the basis of the vegetation mapping.

Multivariate floristic analysis provides an objective means of defining vegetation units and provides insight into the hierarchical relationship between communities based on the degree of similarity in species composition and abundance.

Multivariate analysis was conducted using the site by species matrix from quadrats completed by *ecologia* during the 2015 field survey and data previously collected in 2012 (*ecologia* 2012) and 2014 (*ecologia* 2014a). Cluster analysis used cover-weighted site by species matrix with Spearman rank correlation (SYSTAT 12). The data from the species by site matrix was manipulated for analysis in the following ways:

- Taxa of the same genus, but with not fully identified species, varieties or subspecies were grouped or removed from the analysis; and
- Annual taxa were removed (except *Sorghum timorense*, which was combined with the perennial *Sorghum plumosum* for the statistical analysis.

2.6 VERTEBRATE FAUNA ASSESSMENT

Prior to the development of survey methods, a review was undertaken of the factors likely to influence survey design and intensity (EPA (2004c), Table 2.5). Based on this review, a Level 1 fauna survey in accordance with EPA Guidance Statement 56 (EPA 2004b) was considered to be appropriate, incorporating a desktop assessment and Level 1 field survey.

Table 2.5 – Factors likely to influence survey design

Factor	Comment
Bioregion – level of existing survey-knowledge of the region and associated ability to predict accurately	*ecologia* has previously completed a two-phase Level 2 survey of the adjacent Thunderbird study area. A number of previous surveys have been completed on the Dampier Peninsula.
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 represent any rare or unique characteristics.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present	Not applicable to a Level 1 survey of this nature; survey was largely habitat-based assessment and targeted conservation significant fauna assessment.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves)	Total of 10 previous surveys of the Dampier Peninsula incorporated in to literature review plus relevant databases providing good existing knowledge.
Number of different habitats or degree of similarity between habitats within a study area	The survey was undertaken to determine the different habitat types present in the study area.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods)	No climatic constraints were experienced.
Sensitivity of the environment to the proposed activities	No ESAs at the study area.
Size, shape and location of the proposed activities	The haul road study area largely consists of widening existing roads, therefore limiting potential impacts and therefore a Level 1 survey was deemed adequate.
Scale and impact of the proposal	As above, impact will largely be restricted to development of existing roads, therefore minimising potential impacts.

2.6.1 Potential conservation significant fauna likelihood of occurrence assessment

An assessment of likelihood of occurrence for conservation significant fauna recorded during the desktop assessment 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 or biologically significant fauna species potentially occurring in the study area was assigned a likelihood of occurrence based on the four categories described in Table 2.6. The likelihood of occurrence is then further categorised in to most likely potential habitat usage of the species within the study area (Table 2.7)

Table 2.6 – Criteria used to assess likelihood of occurrence of conservation significant fauna

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

Table 2.7 – Criteria used to assess likely habitat usage of conservation significant fauna

Likely status	Criteria
Resident – Breeding	Species is resident within the study area and has been recorded or is likely to breed within the study area.
Resident – Non-breeding	Species is resident within the study area but is unlikely to breed within the study area.
Migratory visitor	Migratory species which regularly occurs within the study area during appropriate times of the year.
Transient visitor	Species occurs infrequently in the study area, and is unlikely to be resident. Utilises the study area on a temporary basis only.
Nomadic visitor	Species occurs within the study area during favourable environmental conditions, may include breeding.

The level of available information for each species was also taken into consideration so that species were not allocated a low likelihood of occurring due to insufficient survey information or cryptic behaviours and ecology, in accordance with the precautionary principle.

2.6.2 Sampling methods

The survey methods adopted by *ecologia* are aligned with EPA Guidance Statement No. 56, Position Statement No. 3 (EPA 2002a) and *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA and DEC 2010). A variety of opportunistic survey methods were undertaken.

Diurnal active searching

Active searches for mammal and reptile species were completed throughout the study area. Search techniques included checking beneath the bark of dead trees, investigating old logs, stumps and dead free-standing trees, raking leaf litter, investigating burrows and over-turning logs and stones. Tracks, diggings, scats, burrows and nests were also recorded where possible. Bird species were also recorded during active searches. Bird point counts were conducted at water points.

Camera trapping

A total of four motion sensor cameras were set up throughout the study area. Cameras were baited with universal bait mix in an attempt to lure animals to the area, or placed in areas to target

conservation significant fauna. Reconyx HC500 Hyperfire motion cameras were used. All cameras are triggered by movement using highly sensitive passive infra-red motion sensors that function both during the day and at night.

Figure 2.2 – Camera trap set up in study area

Bat echolocation call recordings

Two nights of recordings were made via a Song Meter 2 (SM2Bat) device. Bat echolocation calls were recorded and then subsequently analysed via SongScope.

Figure 2.3 – SM2Bat device set up in study area

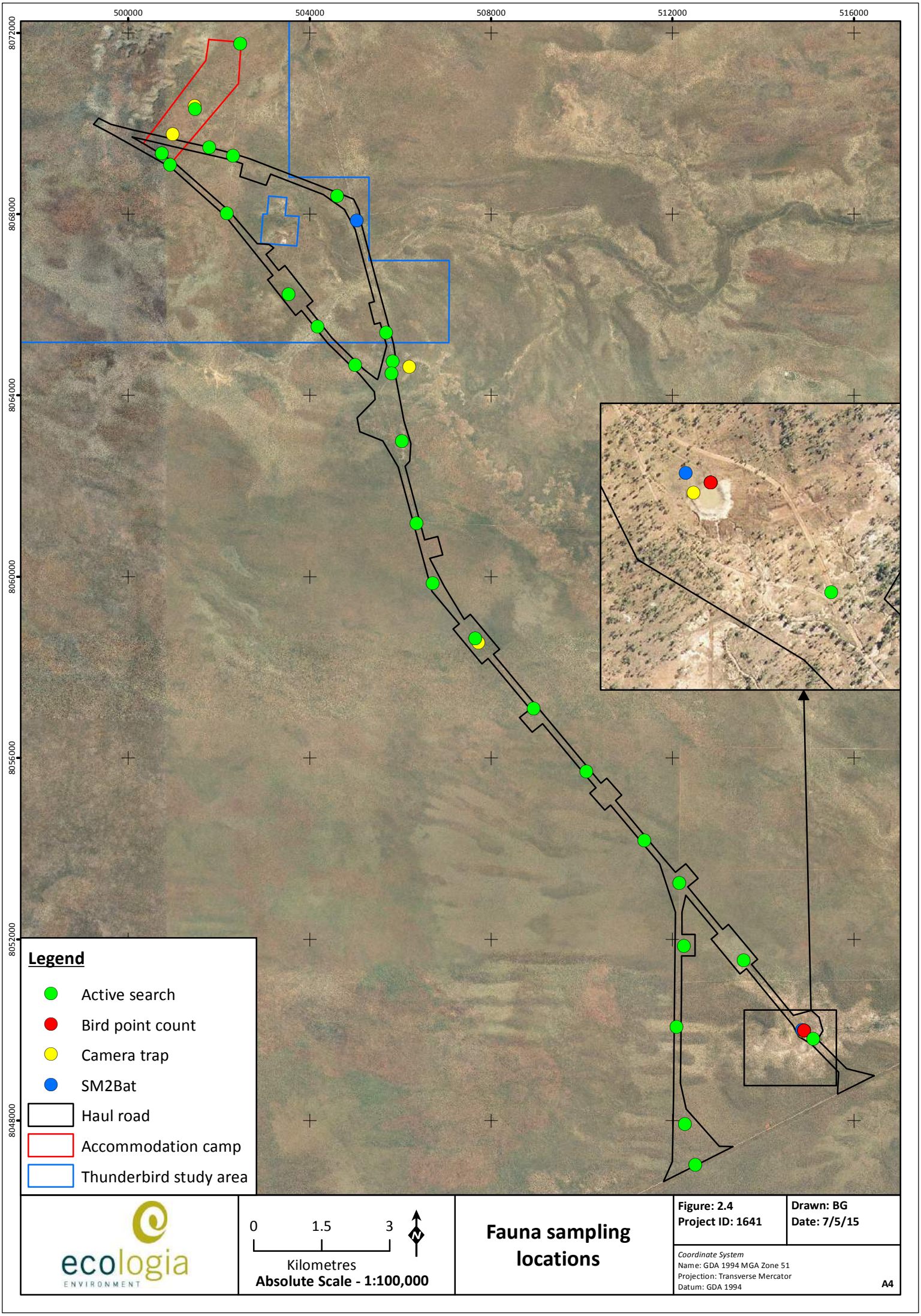
2.6.3 Sampling sites

Vertebrate fauna sampling sites are shown in Table 2.8 and mapped in Figure 2.4.

Table 2.8 – Fauna sampling locations

Site	Easting	Northing
Camera trap 1	514872	8049964
Camera trap 2	506192	8064632
Camera trap 3	507719	8058546
Camera trap 4	514901	8049981
Camera trap 5	500978	8069759
Camera trap 6	501456	8070386
SM2 1	514859	8049997
SM2 2	505036	8067859
Bird point count 1	514901	8049981
Bird point count 2	504295	8072673
Diurnal active search 1	505687	8065383
Diurnal active search 2	505003	8064661
Diurnal active search 3	515105	8049795
Diurnal active search 4	512148	8053238
Diurnal active search 5	505829	8064742
Diurnal active search 6	506037	8062986
Diurnal active search 7	505805	8064486
Diurnal active search 8	506712	8059846
Diurnal active search 9	506356	8061172
Diurnal active search 10	507652	8058640
Diurnal active search 11	510099	8055699
Diurnal active search 12	502470	8071752
Diurnal active search 13	504605	8068400
Diurnal active search 14	508941	8057088
Diurnal active search 15	502308	8069288
Diurnal active search 16	513569	8051532
Diurnal active search 17	511372	8054171
Diurnal active search 18	512506	8047022
Diurnal active search 19	504174	8065510
Diurnal active search 20	503536	8066226
Diurnal active search 21	502171	8068020
Diurnal active search 22	500922	8069082
Diurnal active search 23	512249	8051851
Diurnal active search 24	512273	8047917
Diurnal active search 25	512086	8050058
Diurnal active search 26	501471	8070313
Diurnal active search 27	501781	8069467
Diurnal active search 28	500737	8069336

Datum: GDA 1994 MGA Zone 51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Camera trap
SM2Bat
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Accommodation camp
Thunderbird study area
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Absolute Scale - 1:100,000
Fauna sampling locations
Figure: 2.4
Project ID: 1641
Drawn: BG
Date: 7/5/15
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
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2.6.4 Targeted conservation significant fauna surveying

Prior to the commencement of the field survey, the preferred habitat of conservation significant species potentially occurring in the study area was determined. These habitats were identified and then targeted during the field survey. In particular, targeted surveys for species assessed as having a high likelihood of occurrence or were previously recorded during the Thunderbird project Level 2 assessment were conducted. These species consisting of Greater Bilby, Gouldian Finch, Rainbow Bee-eater, Australian Bustard, Dampierland Burrowing Snake and *Lerista separanda.*

Greater Bilby (*Macrotis lagotis*) (EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable)

The survey methodology undertaken for Greater Bilby was in accordance with recommended guidelines (DSEWPaC 2011). Areas that represented suitable habitat were searched on foot by completing transects searching for secondary evidence (diggings, tracks and scats). Where active secondary evidence was observed, the area was searched intensely for burrows. Two active burrows were monitored for one night with motion cameras (Figure 2.5).

Figure 2.5 – Motion camera set up on active Greater Bilby burrow

Gouldian Finch (*Erythrura gouldiae*) (EPBC Act Endangered, DPaW Priority 4)

Survey methodology for Gouldian Finch was in accordance with recommended guidelines (DSEWPaC 2010). Bird surveys were conducted throughout the study area in conjunction with active searches. Bird point counts were made at water points in the study area in an attempt to recorded individuals coming in to drink. In addition, two motion cameras were established on the water's edge for three days in an attempt to record individuals coming in to drink (Figure 2.2).

Rainbow Bee-eater (*Merops ornatus*) (EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement)

Survey methodology for Gouldian Finch was in accordance with recommended guidelines (DSEWPaC 2010). Bird surveys were conducted throughout the study area in conjunction with active searches. Opportunistic recordings were made when individuals were encountered.

Australian Bustard (*Ardeotis australis*) (DPaW Priority 4)

Bird surveys were conducted throughout the study area in conjunction with active searches. Opportunistic recordings were made when individuals were encountered. Secondary evidence in the form of tracks were searched for and recorded when encountered.

Dampierland Burrowing Snake (*Simoselaps minimus*) and *Lerista separanda* (DPaW Priority 2)

As both species inhabit fossorial habitats, they were searched for in conjunction. Species were searched for during diurnal active searches, by raking leaf litter and searching under logs and wood litter.

2.6.5 Fauna habitat mapping

A fauna habitat type broadly describes an area of habitat that is distinguishable in its vegetation and land features from its surroundings, and is likely to support a different fauna assemblage to that found in other fauna habitat types. Particular attention is also paid to the likelihood that certain species are present which tend to be found only in that specific habitat type. Fauna habitat types were identified, described and mapped using the following existing information:

- IBRA subregions;
- Aerial photography; and
- Beard vegetation associations (Shepherd *et al.* 2001).

During the survey, additional information was also collected to aid in habitat mapping, including:

- Landform;
- Vegetation type and structure; and
- Composition of terrestrial fauna community.

2.6.6 Fauna taxonomy and nomenclature

Nomenclature for mammals, reptiles and amphibians within this report follows the *Western Australian Museum Checklist of the Vertebrates of Western Australia* and birds according to Christidis and Boles (2008). References used for fauna identification are listed in Table 2.9.

Table 2.9 – References used for identification

Fauna group	Reference
Mammals	Menkhorst and Knight (2011), Van Dyck and Strahan (2008)
Bats	Churchill (1998), Menkhorst and Knight (2011)
Birds	Morecombe (2000), Pizzey & Knight (2013)
Reptiles	Wilson and Swan (2010), Cogger (2000)
Amphibians	Tyler and Doughty (2009), Cogger (2000)

2.6.7 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).

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3 EXISTING ENVIRONMENT

3.1 CLIMATE

The study area is situated in the Kimberley region of Western Australia at the south-east edge of the Dampier Peninsula. The area has a dry, hot, tropical climate with two distinct seasons: the 'wet' from around December to March, and the 'dry' for the remainder of the year. Rainfall is highly variable in the region due to the inconsistent nature of the movement and occurrence of thunderstorms and tropical systems. Tropical cyclones can occur as late as April, but are most common in January and February. Rainfall during the cooler months is usually associated with cloud bands originating from tropical waters to the north-west (BoM 2015). The average temperature over summer is over 33 °C, with warm overnight minima of around 26 °C (BoM 2015). Winter temperatures are quite mild, with average maximum and minimum temperatures in July being 26.9 °C and 12.0 °C respectively (BoM 2015).

The nearest Bureau of Meteorology (BoM) weather stations (with full data sets) to the study area are Derby Aero (BoM Station 3032) and Broome Airport (BoM Station 3003). Derby Aero is located 70 km east of the study area with Broome Airport located 95 km to the south-west. These stations were selected as a reference to provide the best indication of the local climatic conditions of the study area (Figure 3.1).

The mean annual rainfall for Broome is 612.0 mm, but highly variable with the majority of the annual rainfall usually falling between January and March (BoM 2015). The mean number of rainfall days (≥1 mm) a year is only 35.1. Generally, the wettest months are January and February, with mean rainfall of 181.6 mm and 178.8 mm respectively. The hottest month is April and the coldest is July, with means of 34.3 °C and 28.8 °C, respectively.

The mean annual rainfall for Derby is 682.9 mm, with the majority of the annual rainfall usually falling between December and March (BoM 2015). The mean number of rainfall days (≥1 mm) per year is 38. January and February are generally the wettest months of the year, recording a mean rainfall of 199.0 mm and 199.6 mm respectively. The hottest month is November and the coldest is June, with mean maximum temperatures of 38.1^{o}C and 30.4^{o}C, respectively.

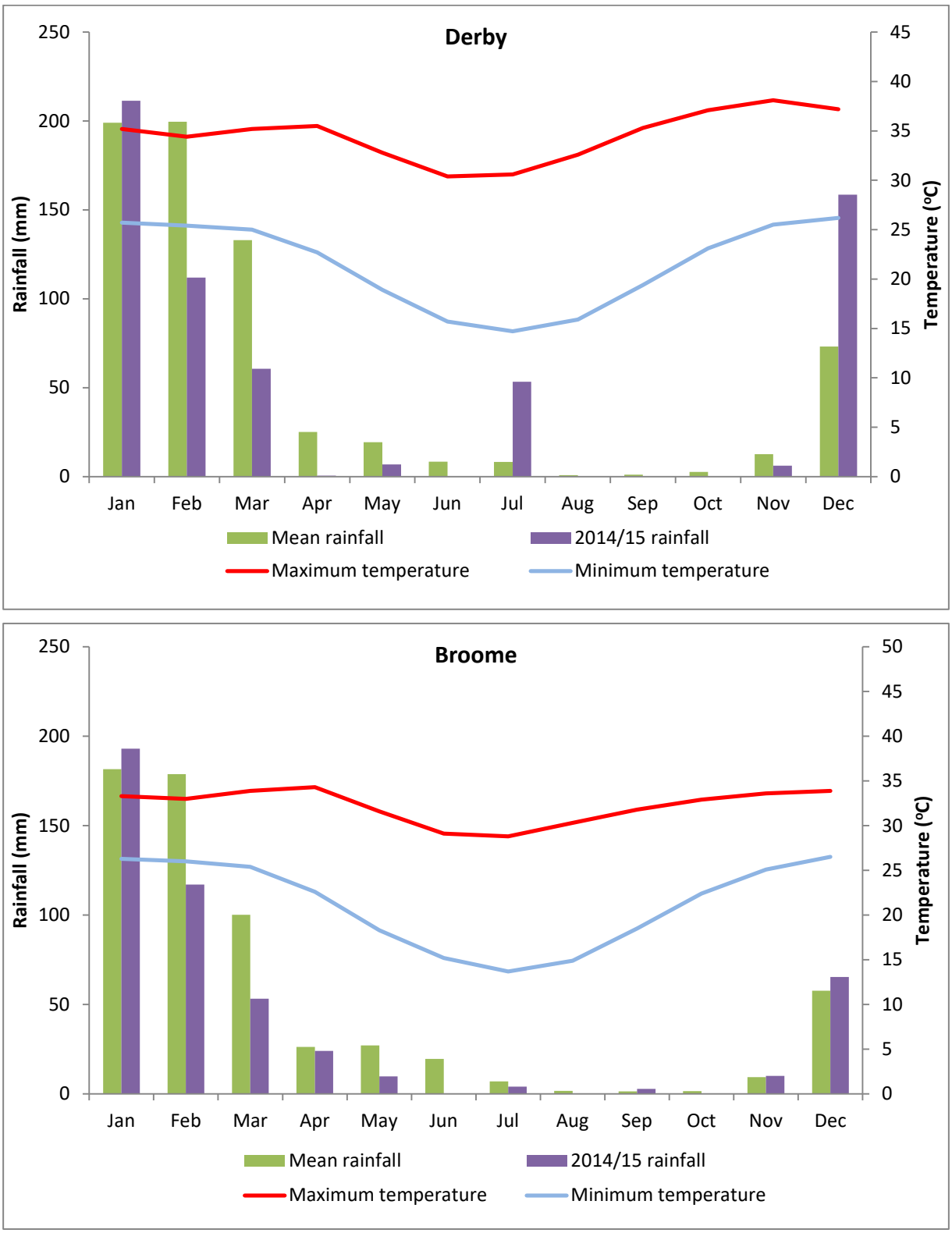
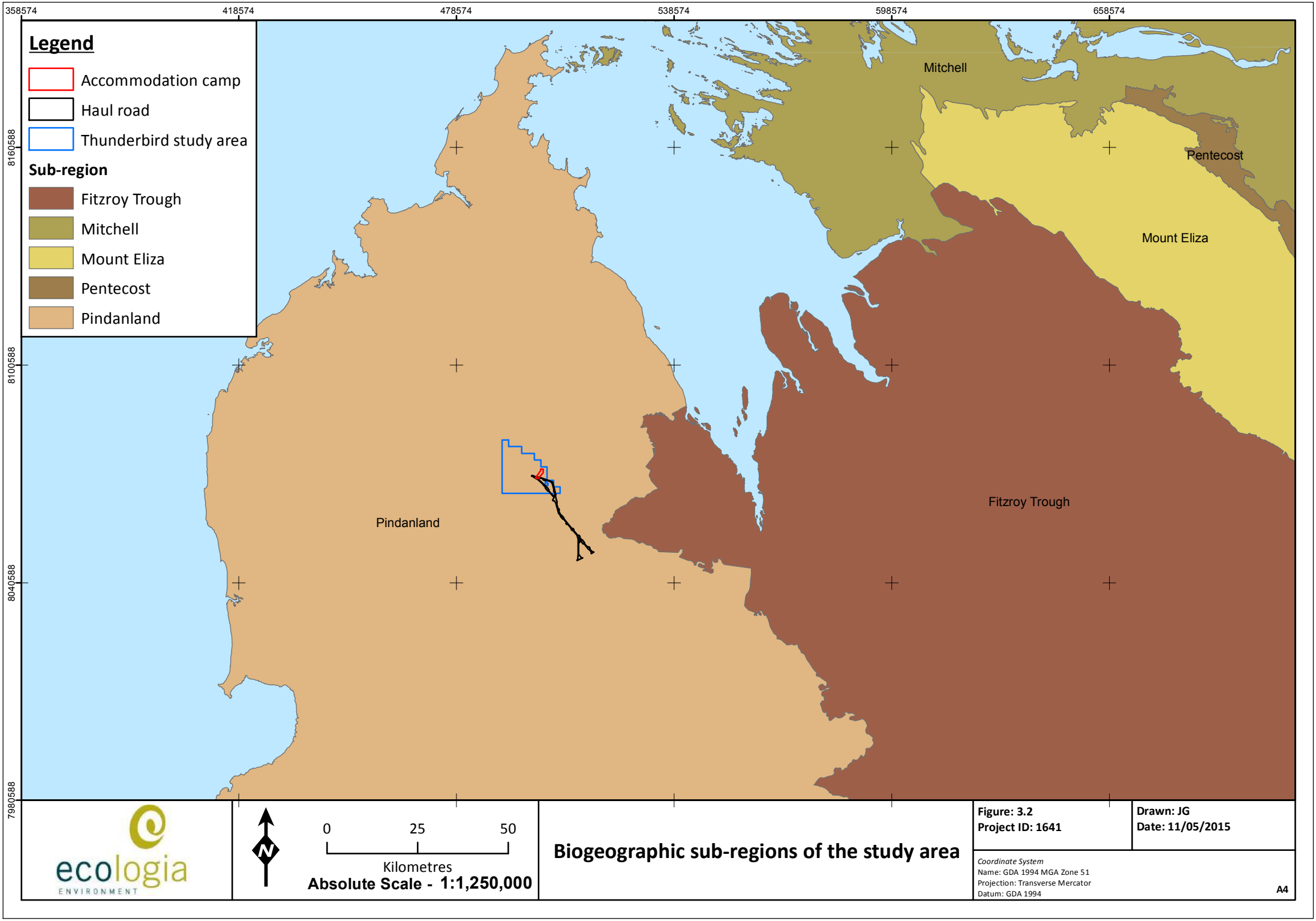


Figure 3.1 – Climate data for Derby and Broome (BoM 2015)

3.2 BIOGEOGRAPHIC REGIONS

The Interim Biogeographic Regionalisation for Australia (IBRA) (Version 7) classifies the Australian continent into bioregions of similar geology, landform, vegetation, fauna and climate characteristics (DSEWPaC 2012a). The study area lies within the Dampierland bioregion. The Dampierland bioregion is further subdivided into two subregions, these being the Fitzroy Trough (DL1) and Pindanland (DL2) subregions. The study area lies entirely within the Pindanland subregion of the Dampierland Bioregion (Figure 3.2).

The Pindanland subregion covers approximately 59% of the Dampierland bioregion. This subregion consists of sandplains of a fine-textured sand-sheet with subdued dunes and includes the paleodelta of the Fitzroy River. The vegetation is described primarily as pindan (Graham 2002). The dominant land uses are grazing, unallocated crown land, crown reserves and native pastures.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Accommodation camp
Haul road
Thunderbird study area
Sub-region
Fitzroy Trough
Mitchell
Mount Eliza
Pentecost
Pindanland
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Absolute Scale - 1:1,250,000
Biogeographic sub-regions of the study area
Figure: 3.2
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
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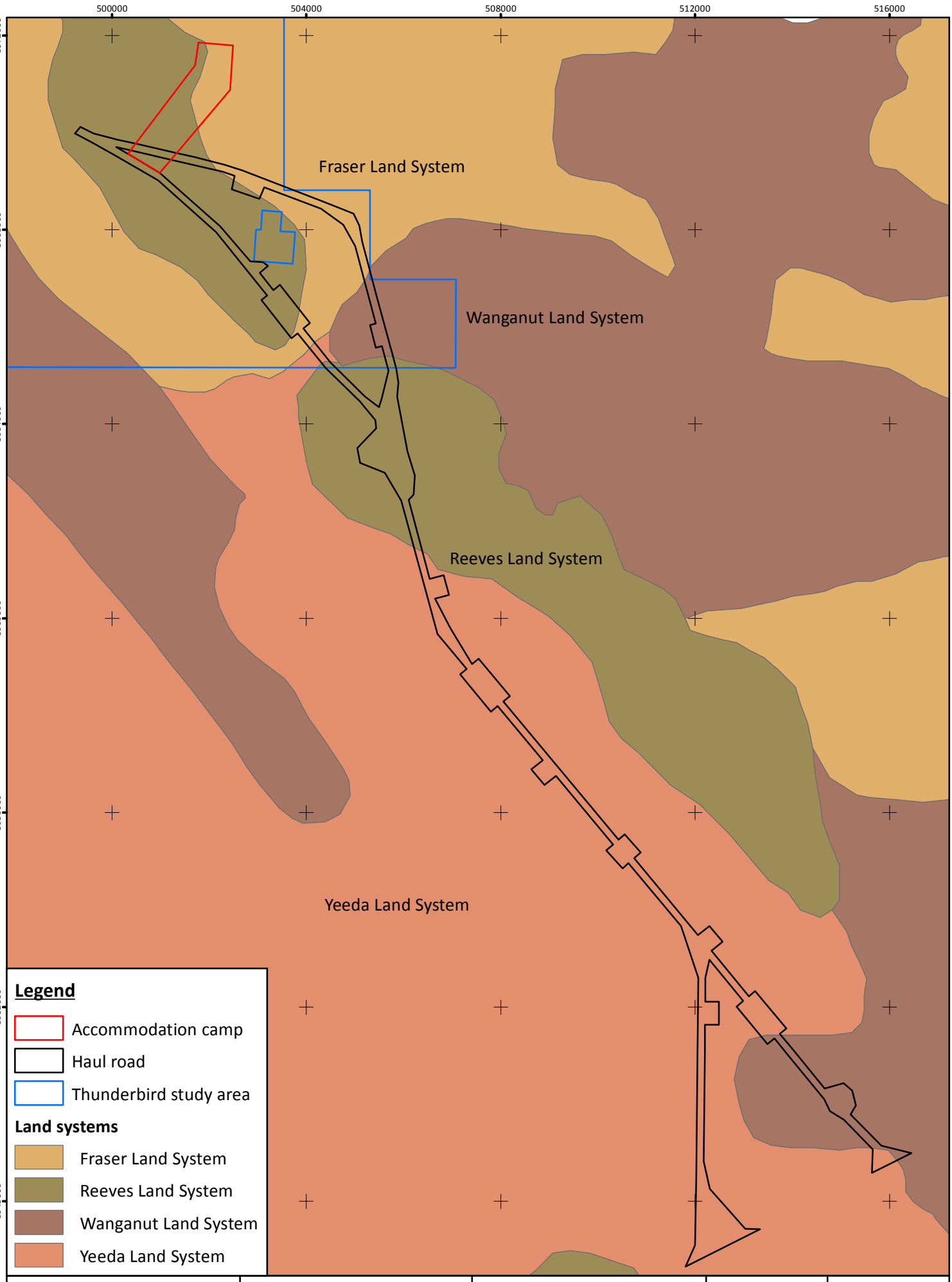
3.3 LAND SYSTEMS

Land systems are described using the biophysical characteristic of geology, landform, vegetation and soils. The study areas fall across four of these land systems; Fraser, Reeves, Waganut and Yeeda. The haul road study area encompasses all four of the listed land systems, while the camp study area covers two land system types; Fraser and Reeves. A brief description and details on the extent of each land system within the study area are provided in Table 3.1 and mapped in Figure 3.3. All four land systems are quite widely distributed within the region; Reeves land system has the highest proportion of its total extent located within the study areas; approximately 1.1% in total.

Table 3.1 – Land systems of the study area

Land System	Description	Total area in Dampierland (ha)	Study area (outside Thunderbird) (ha)	Study area (inside Thunderbird) (ha)	Total area (ha)	Proportion in study area (%)	Percentage of total extent within Dampierland (%)
Fraser	Sand plain with irregular dunes and local stony surfaces, pindan and low grassy woodlands.	73,275	0.6	189.5	190.1	14.1	0.259
Reeves	Sand plain with scattered hills and minor plateaux, reddish sandy soils, pindan.	44,794	185.0	309.1	494.1	36.6	1.103
Waganut	Low lying sandplains and dune fields with through going drainage supporting pindan *Acacia* shrublands with emergent eucalypt trees.	518,511	83.5	33.3	116.8	8.7	0.023
Yeeda	Sandplains with red and yellow sands supporting pindan *Acacia* shrublands with emergent eucalypt trees.	1,653,086	541.7	6.6	548.3	40.6	0.033
Total	**N/A**	**N/A**	**810.8**	**538.5**	**1,349.3**	**100%**	**N/A**



ecologia ENVIRONMENT

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Absolute Scale - 1:100,000

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Land systems of the study area

Figure: 3.3
Project ID: 1641

Drawn: BG
Date: 7/5/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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3.4 REGIONAL VEGETATION

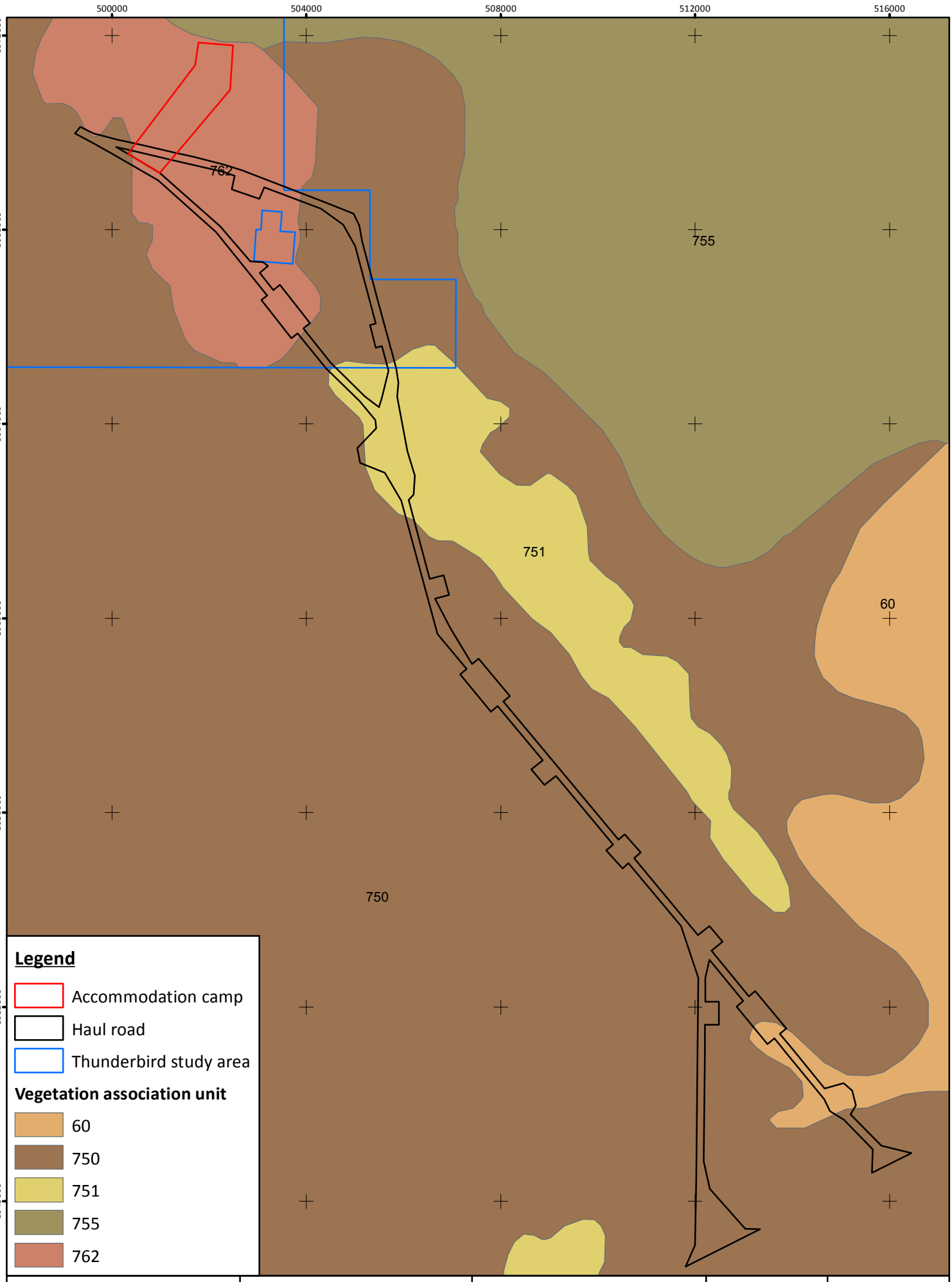
The Dampier Peninsula on which the study area is located lies within the Northern Botanical Province of Western Australia. The vegetation of Western Australia was originally mapped at the 1:1,000,000 scale by Beard (1979), and was subsequently reinterpreted and updated to reflect the NVIS standards (Shepherd *et al.* 2001). Four of the vegetation types identified by (Shepherd *et al.* 2001) are found within the study area: vegetation associations 60, 750, 751, and 762. The majority of the camp study area (99.7%) consists of vegetation association 762, whilst association 750 is the most extensive association within the haul road study area, covering 61.5% of the area (Figure 3.4, Table 3.2).

Vegetation associations 750 and 762 collectively comprise 82.1% of the study area and are described as having similar vegetation; typically that of pindan shrubland with *Acacia tumida* and other *Acacia* species, with open eucalypt woodlands over ribbon grass and curly spinifex (Shepherd *et al.* 2001)**.**

In a regional context, three vegetation units occur extensively outside of the study areas. Unit 762 is the least extensive of the four units, with the study area representing 7.75% of its total extent.

Table 3.2 –Vegetation association units of the study area

Shepherd Veg. Unit	Description	Total area in Dampierland (ha)	Study area (outside Thunderbird) (ha)	Study area (inside Thunderbird) (ha)	Total area (ha)	Proportion in study area (%)	Percentage of total extent within Dampierland (%)	Total current extent (ha)	Pre-European extent (ha)	Remaining (%)
60	Grasslands; tall bunch grass savannah woodland, grey box & cabbage gum over ribbon grass	8,278.5	70.0	-	70	5.2	0.85	179,276.6	179,256.7	99.99
750	Shrublands, pindan; *Acacia tumida* shrubland with grey box & cabbage gum medium woodland over ribbon grass & curly spinifex	1,218,427.5	570.8	125.0	695.8	51.6	0.06	1,231,155.5	1,225,687.5	99.56
751	Hummock grasslands, shrub steppe; *Acacia eriopoda* over soft spinifex	15,994.7	169.4	1.9	171.3	12.7	1.07	15,994.7	16,045.3	99.68
762	Shrublands, pindan; *Acacia eriopoda & A. tumida* shrubland with scattered low *Eucalyptus confertifolia* over curly spinifex	5,319.6	0.6	411.6	412.2	30.5	7.75	6,807.4	6,811.4	99.94
Total	**N/A**	**N/A**	**810.9**	**538.5**	**1,349.3**	**100**	**N/A**	**N/A**	**N/A**	**N/A**



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Vegetation association units of the study area

Figure: 3.4
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Date: 7/5/15

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Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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4 LITERATURE REVIEW

4.1 FLORA

A search of the DPaW's Threatened and Priority Flora Database (DPaW search reference 15-0313) and a literature review of previous projects in the vicinity was conducted with a buffer of 50 km around the Thunderbird study area.

Currently, 74 Threatened or Priority flora taxa are listed as occurring in the Dampierland bioregion (Western Australian Herbarium, July 2015). A database search of the DPaW Threatened (Declared Rare) and Priority Flora Database indicated that 26 Priority Flora have previously been recorded within 50 km of the study area, however the previously Priority 3 taxon *Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946) is no longer considered to be a Priority flora taxon. Two additional Priority taxa were found to occur within 50 km of the study area from the literature review of three *ecologia* reports within the vicinity of the study area (*ecologia* 2004a, b, 2012, 2014a). The likelihood of a conservation significant species being present within the study area (categorised by Table 4.1) was determined by examining the following:

- Potential habitats, and their condition, known to exist within the study area;
- Distance of previously recorded locations from the study area;
- Frequency of occurrence of records in the region; and
- Time elapsed since recorded within, or surrounding, the study area.

Of the 27 Priority Flora recorded within 50 km of the Thunderbird project study area (Table 4.2), five have previously been recorded within the Thunderbird study area by *ecologia* in previous surveys completed in 2012 (*ecologia* 2012) and 2014 (*ecologia* 2014a): *Fuirena nudiflora* (Priority 1), *Fuirena nudiflora* (Priority 1), *Pterocaulon intermedium* (Priority 3), *Tephrosia valleculata* (Priority 3) and *Triodia caelestialis* (Priority 3).

Table 4.1 – Criteria used to assess likelihood of occurrence of significant flora

Likelihood of Occurrence	Criteria
Recorded	The taxon has been recorded within the study area.
Probable	Due to the proximity of previous records (0-5 km) and the presence of suitable habitat, the taxon is considered highly likely to occur within the study area.
Likely	Given the presence of suitable habitat and moderate proximity (2-5 km) of previous records, the taxon is considered likely to occur within the study area.
Possible	The habitat specificity of the taxon is only broadly defined, or is not defined and/or there are no current records within 5-10 km. However there is insufficient information available to exclude the possibility of occurrence within the study area.
Unlikely	The habitat specificity of the taxon is well defined from previous records and the habitat is considered unlikely to be present within the study area.

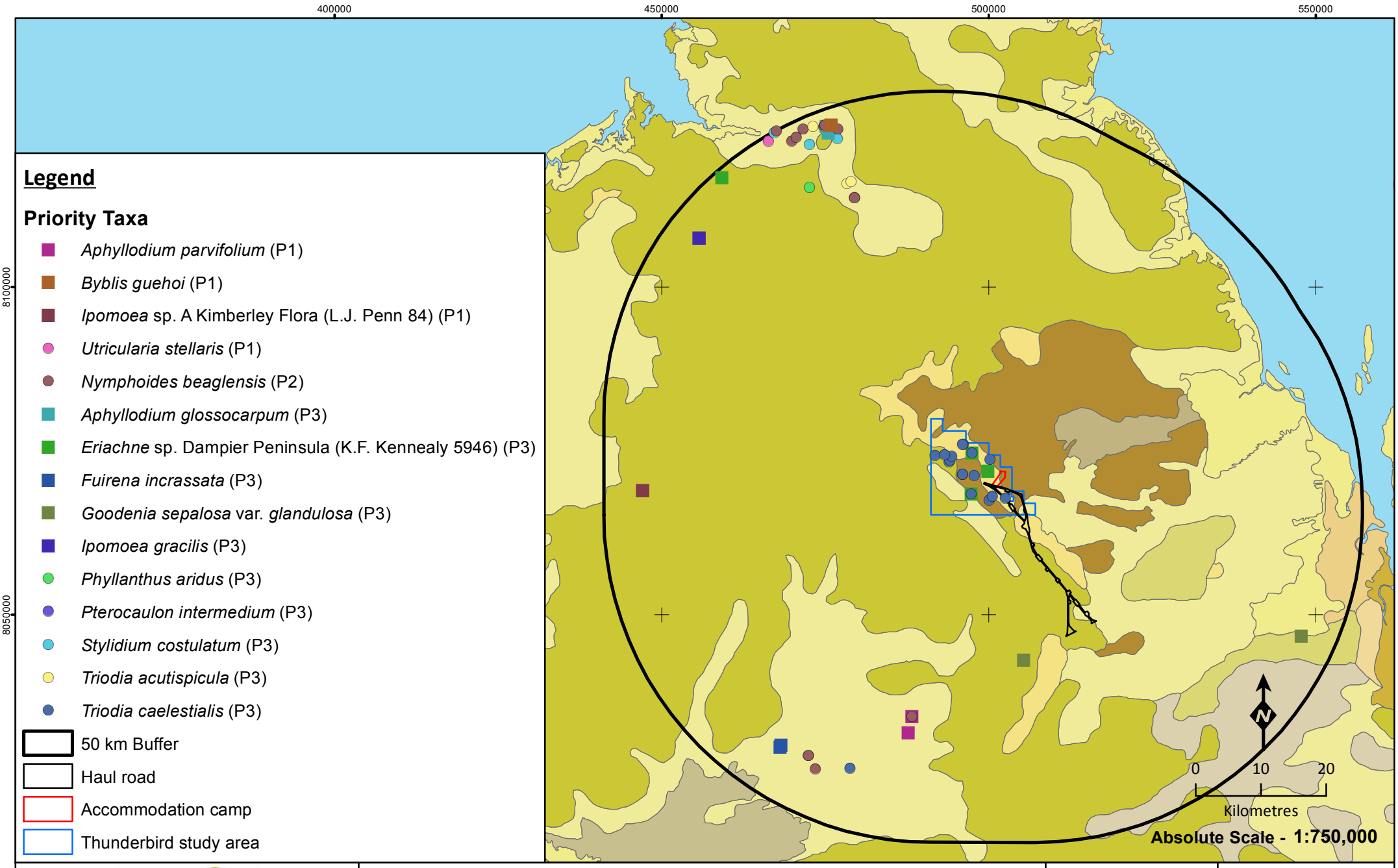
Table 4.2 – Priority flora recorded within 50 km of the Thunderbird study area

Taxon	DPaW Status	Preferred Habitat	Distribution	Likelihood of Occurrence
Aphyllodium parvifolium	P1	Occurs in sand and clay, can be close to water.	Broome, McLarty Hills	Unlikely
Byblis guehoi	P1	Occurs in sand and silt-loam soils that are waterlogged in the wet season but dry soon after.	Dampier Peninsula	Possible
Cyperus haspan subsp. *haspan*	P1	Occurs in peat bank on the edge of spring	Dampier Peninsula	Unlikely
Ipomoea gracilis	P1	Occurs on clay or irrigated sand, close to rivers.	Kununurra, Ord River.	Unlikely

Taxon	DPaW Status	Preferred Habitat	Distribution	Likelihood of Occurrence
Ipomoea sp. A Kimberley Flora (L.J. Penn 84)	P1	Occurs in shallow soils on sandstone	Dampier Peninsula	Possible
Jacquemontia sp. Broome (A.A. Mitchell 3028)	P1	Occurs in woodlands on Pindan plain	Dampier Peninsula	Likely
Nicotiana heterantha	P1	Black clay. Seasonally wet flats.	Broome, Dampier Peninsula, Roy Hill, Mandora, Anna Plains	Possible
Parsonsia kimberleyensis	P1	Occurs on vine thickets	Dampier Peninsula	Unlikely
Thespidium basiflorum	P1	Occurs in sandy soil creek beds	Dampier Peninsula	Unlikely
Utricularia stellaris	P1	Occurs in swampy areas, commonly submerged in water.	Wyndham, Dampier Peninsula, Mitchell Plateau	Possible
Nymphoides beaglensis	P2	In shallow freshwater. Edges of permanent waterholes or in seasonally inundated claypans & depressions.	Dampier Peninsular, Beagle Bay, Lake Campion, Yabbagoody Clay Pan	Unlikely
Acacia sp. Riddell Beach (T. Willing 71)	P3	Occurs on cliffs and gullys, and close to roads. In sand, loam and rocky soil.	Broome, Dampier Peninsula	Unlikely
Aphyllodium glossocarpum	P3	Occurs in sand verging onto cleared areas and open grassland fringes	Dampier Peninsula	Possible
Cupaniopsis anacardioides	P3	Vine thickets	Dampier Peninsula, Mitchell Plateau, Middle Osborn Is., Bouganville Peninsula, NT, QLD	Possible
Dendrophthoe odontocalyx	P3	Occurs in swamp areas and woodlands.	Koolan Is., Dampier Peninsula, Prince Regent N.R.,	Likely
†*Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946)	P3	Plain. Red-brown sandy loam. Pindan Sands	Scattered on Dampierland an in the Fitzroy Trough	Recorded
Fuirena incrassata	P3	Occurs in sand and claypans, generally close to water	Googhenama Creek, Broome	Unlikely
Gomphrena pusilla	P3	Occurs on coastal sand dunes, with either calcrete sands or fine shell grit	Dampier Peninsula, Pt Hedland	Likely
Goodenia sepalosa var. *glandulosa*	P3	Occurs in Pindan sand or loam	Derby, Lake Argyle, Robinson River, Fitzroy Crossing, Yeeda	Possible
Lophostemon grandiflorus subsp. *grandiflorus*	P3	Occurs in damp habitats	Dampier Peninsula, Edgar Range	Likely
Phragmites karka	P3	Edges of pools and creeks	Scattered throughout the Kimberley and Pilbara	Unlikely
Phyllanthus aridus	P3	Rangeland and hillside. Sandstone. Red sand and ironstone gravel. With exposed rocks	Broome, Derby-West Kimberley, East Pilbara, Halls Creek, Wyndham-East Kimberley.	Likely
Pterocaulon intermedium	P3	Flat plains and sometimes claypans. In pindan red sand - loam.	Broome, Derby-West Kimberley, Port Hedland, Wyndham-East Kimberley.	Recorded
Stylidium costulatum	P3	Sandy or clayey soils. Creeks or seasonally wet areas.	Dampier Peninsula, Beverley Springs Stn, Mt Barnett Stn, Coulomb Point	Possible
Triodia acutispicula	P3	Sandy soils. River levees, pindan plains, rocky hillslopes & outcrops.	Scattered throughout Western Kimberley	Possible

Taxon	DPaW Status	Preferred Habitat	Distribution	Likelihood of Occurrence
Triodia caelestialis	P3	Red-brown, sand-silt-clay and pindan soils usually in low plains	Central Kimberley, Dampierland, Northern Kimberley. Broome, Derby-West Kimberley.	Recorded
Haemodorum gracile	P4	Occurs in sand, and sandy clay in open woodlands and creek banks	Cahmpagny Is., Yampi Peninsula, Dampier Peninsula, Edkins Range, Kimbolton Stn.,Prince Regent River N.R., Derby	Unlikely
Pittosporum moluccanum	P4	White sand. Sand dunes	Dampier Peninsula, N of Broome, Berthier Is., Maret Is., N.T., SE Asia	Unlikely

†*Eriachne* sp. Dampier Peninsula (K.F. Kenneally 5946) is no longer considered to be a Priority flora taxon.



ecologia ENVIRONMENT

Previously Recorded Priority Flora (includes DPaW Search: 15-0313)

Figure: 4.1
Project ID: 1641

Drawn: MM
Date: 10/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Datum: GDA 1994

A4

4.2 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

A search of Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) within and adjacent to the study area was undertaken as part of the literature review. Two priority 3 PECs were recorded within 60 km of the study area; vegetation assemblages of Lolly Well Springs wetland complex and assemblages of Disaster Bay organic mound springs (Table 4.3, Figure 4.2).

Table 4.3 – TECs and PECs recorded within 60 km of the Thunderbird study area

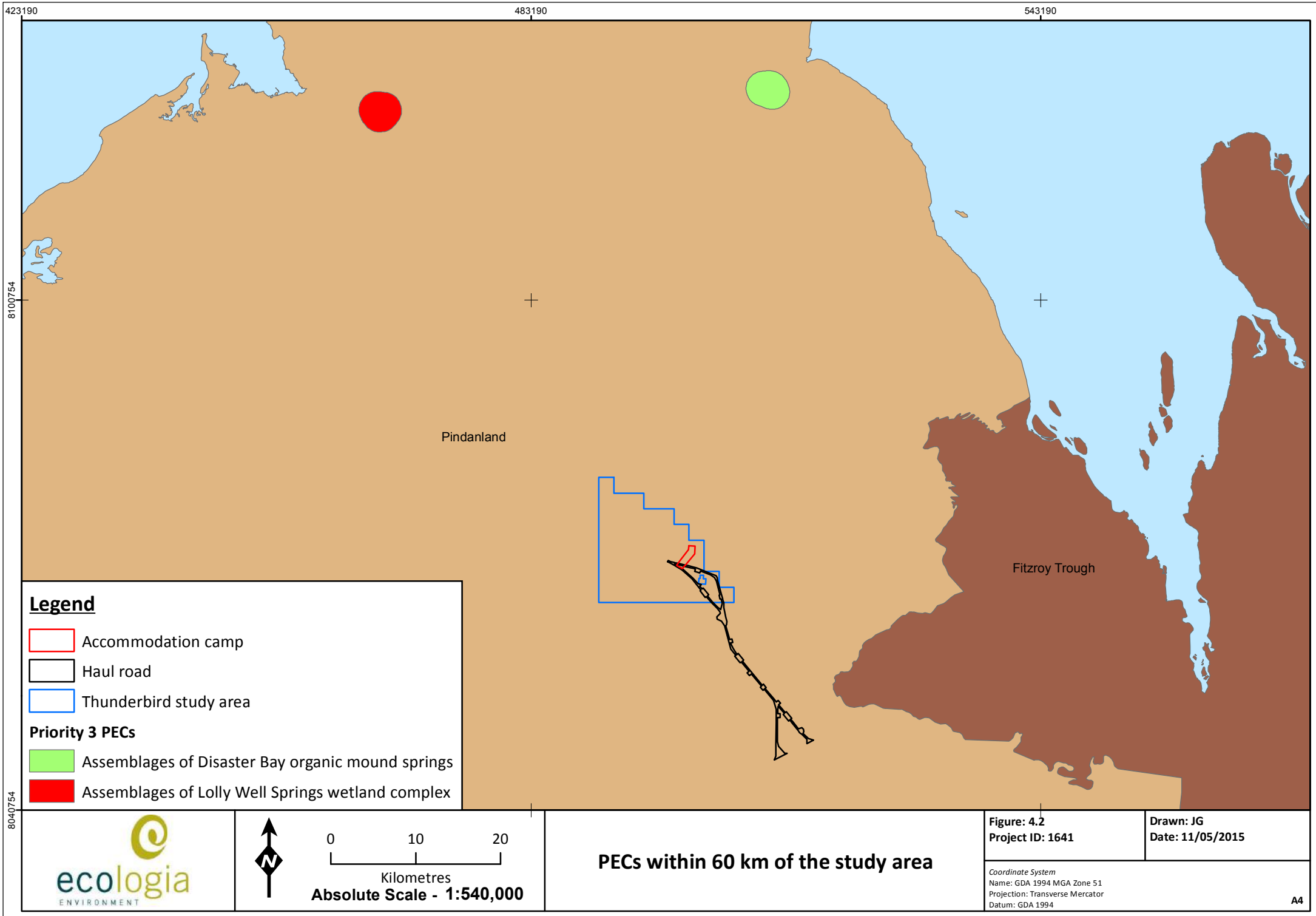
Status	Description	Distance from study area
PEC (Priority 3)	Assemblages of Disaster Bay organic mound springs	50 km NNE
PEC (Priority 3)	Assemblages of Lolly Well Springs wetland complex	60 km NW

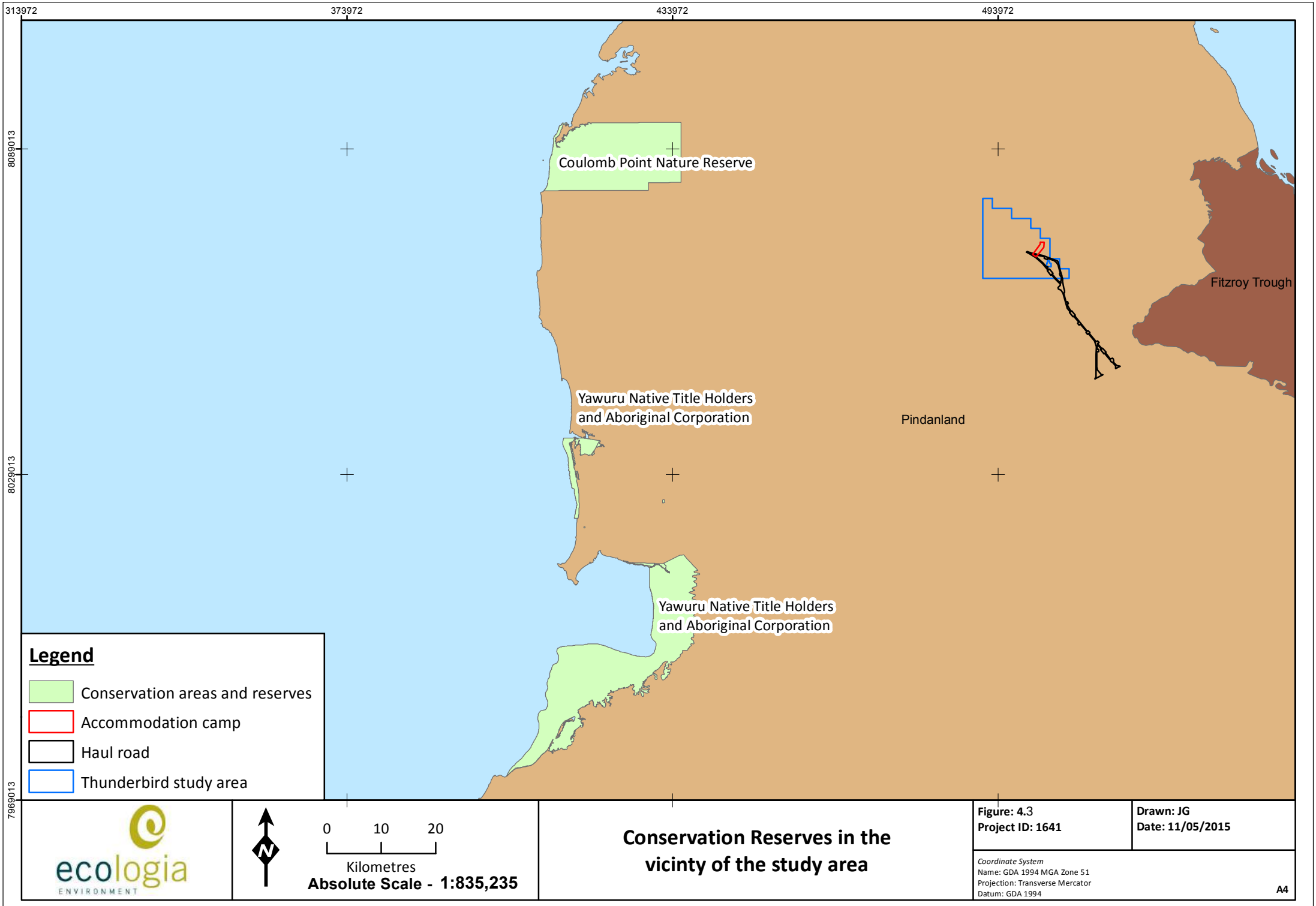
4.3 CONSERVATION RESERVES

The study area does not intersect with any conservation areas or reserves. The Coulomb Point Nature Reserve is situated approximately 65 km west of the study area, while two reserves belonging to the Yawuru Native Title Holders and Aboriginal Corporation are located approximately 90 km south-west of the study area (Figure 4.3).

4.4 ENVIRONMENTALLY SENSITIVE AREAS

Environmentally Sensitive Areas (ESAs) are declared by notice under Section 51B of the *Environmental Protection Act 1986* (EP Act). A search of DER's online Native Vegetation Viewer (DER 2014) was undertaken to determine the locations of any ESAs within the study area. No ESAs occur at the study area.


423190
483190
543190
8100754
8040754
Pindanland
Fitzroy Trough
Legend
Accommodation camp
Haul road
Thunderbird study area
Priority 3 PECs
Assemblages of Disaster Bay organic mound springs
Assemblages of Lolly Well Springs wetland complex
ecologia
ENVIRONMENT
N
0
10
20
Kilometres
Absolute Scale - 1:540,000
PECs within 60 km of the study area
Figure: 4.2
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

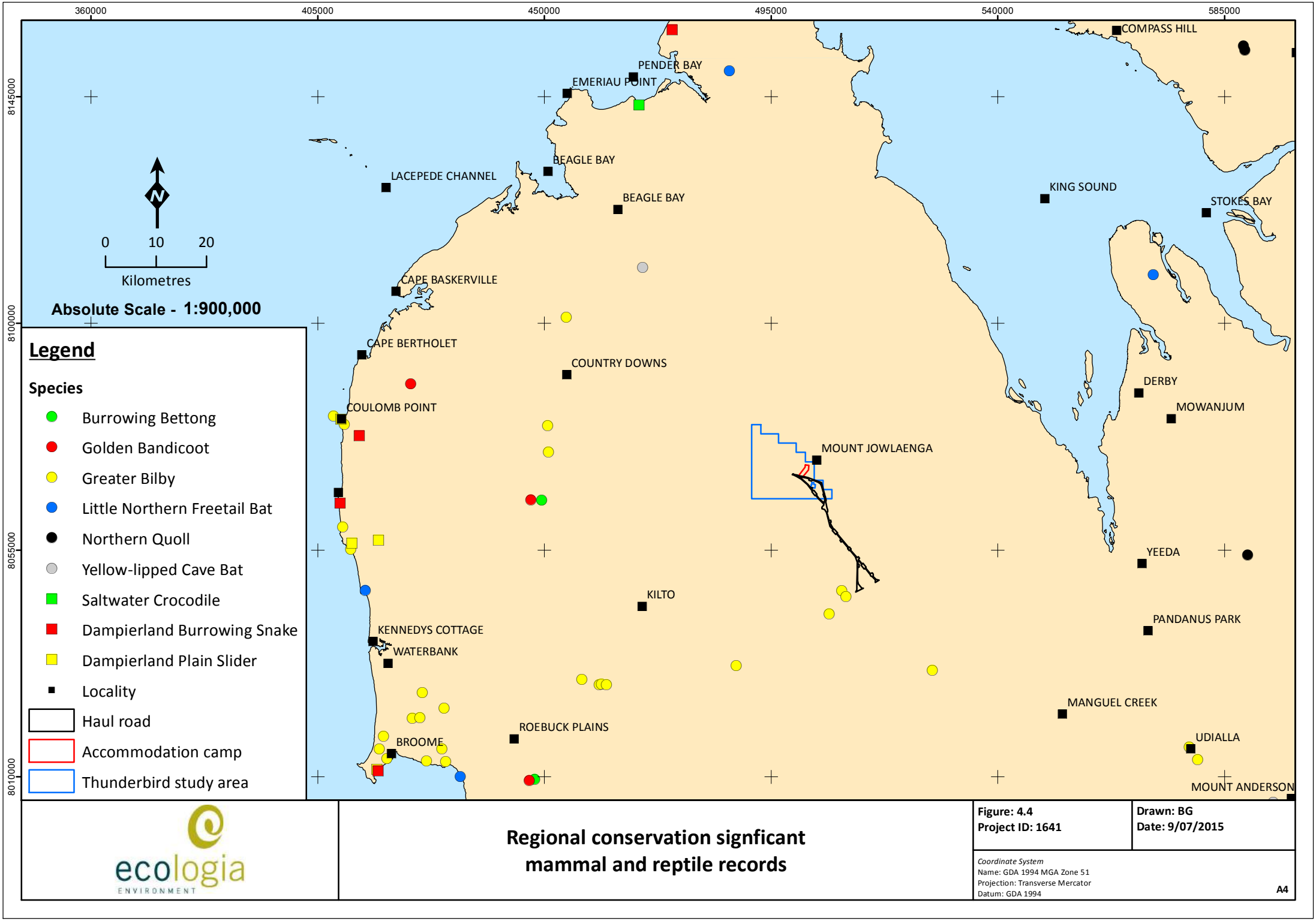

313972
373972
433972
493972
8089013
8029013
7969013
Coulomb Point Nature Reserve
Yawuru Native Title Holders and Aboriginal Corporation
Yawuru Native Title Holders and Aboriginal Corporation
Pindanland
Fitzroy Trough
Legend
Conservation areas and reserves
Accommodation camp
Haul road
Thunderbird study area
ecologia ENVIRONMENT
N
0 10 20
Kilometres
Absolute Scale - 1:835,235
Conservation Reserves in the vicinty of the study area
Figure: 4.3
Project ID: 1641
Drawn: JG
Date: 11/05/2015
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

4.5 FAUNA

The literature review identified a total of 383 fauna species as potentially occurring in the study area. This includes 32 native and six introduced mammal species, 249 bird species, 82 reptiles and 14 amphibians. A comprehensive list of potentitally occurring species is provided in Appendix B.

Included in the species recorded from the literature review are a total of 69 conservation significant vertebrate fauna species, comprising six mammal species, 59 bird species, and four reptile species. Previous records of conservation significant fauna recorded in the region are mapped in Figure 4.4 and Figure 4.5.

All potential conservation significant species recorded from the literature review had their likelihood of occurrence assessed, based on the methodology described in Section 2.6.1. The results of this analysis are discussed in Section 5.3.3



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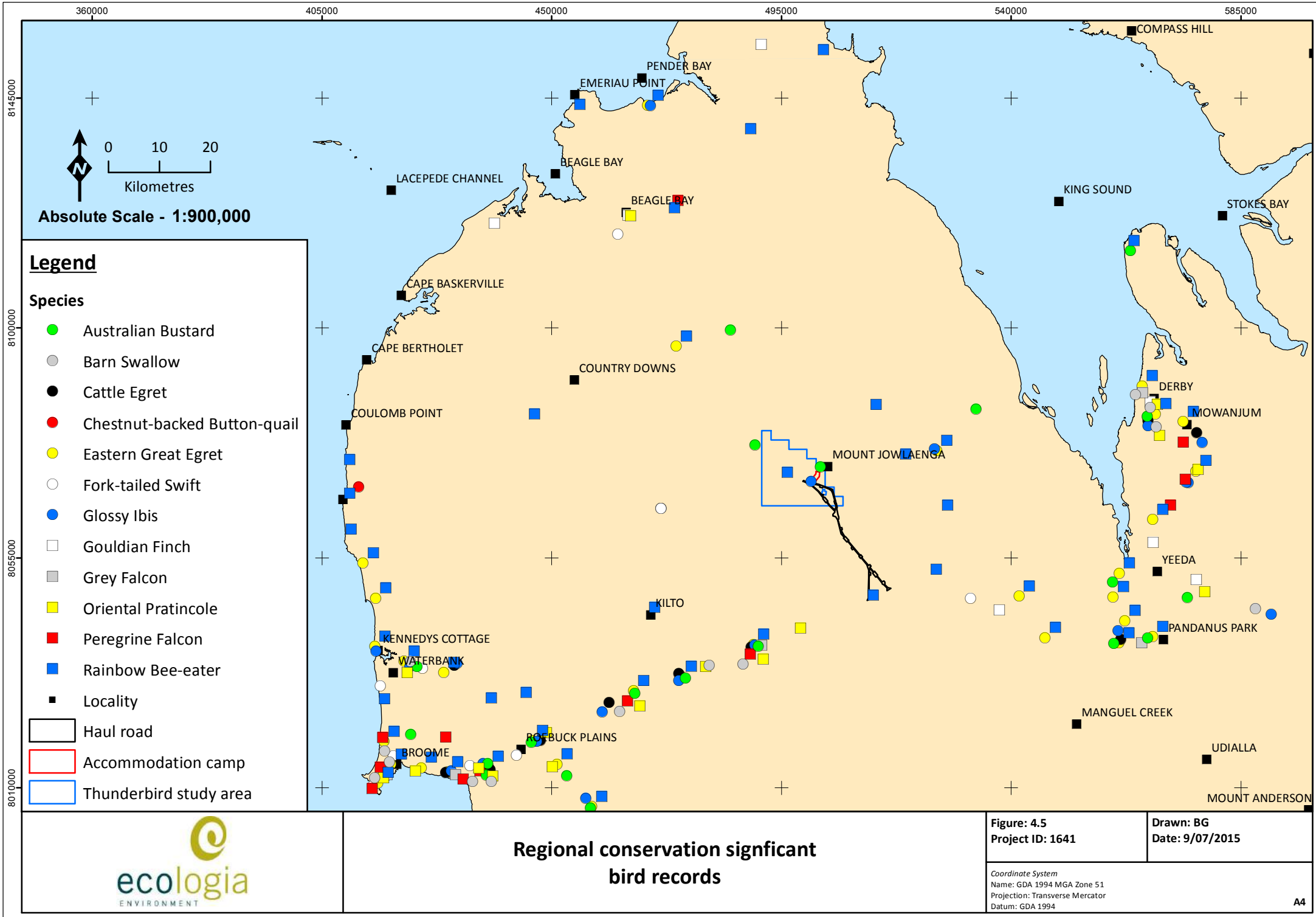
Regional conservation signficant mammal and reptile records

Figure: 4.4
Project ID: 1641

Drawn: BG
Date: 9/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4



ecologia ENVIRONMENT

Regional conservation signficant bird records

Figure: 4.5
Project ID: 1641

Drawn: BG
Date: 9/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4

5 RESULTS

5.1 FLORA

A total of 162 vascular plant taxa (including species, infraspecific taxa, and phrase name taxa) were recorded from the study area, representing 97 genera and 41 families. This includes two Priority Flora species: *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3) and four introduced species: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*. A complete list of taxa recorded, including opportunistic collections and partially identified specimens, is included in Appendix E. The most species rich families are Poaceae and Fabaceae with 31 and 30 taxa respectively, and the most species rich genus is *Acacia,* with seven taxa.

Species richness within quadrats ranged from 16 to 31 taxa, with a mean species richness of 22.7 (± 3.9 standard deviation). The quadrat with the highest species richness of 31 taxa was quadrat 1 and the quadrat with the lowest species richness of 16 taxa was quadrat 16. Site descriptions for each quadrat are provided in Appendix F.

5.1.1 Survey Adequacy

When using the 16 quadrats completed at the study area, the predicted taxa richness, as calculated by Chao 2 Mean is 196 taxa. The total number of taxa recorded from quadrats within the study area is 138 (excluding opportunistic collections and potential duplicates), which represents between 71% of the expected taxa richness for the study area (Figure 5.1). When combined with the previous Thunderbird data from 2012 (*ecologia* 2012) and 2014 (*ecologia* 2014a) the expected number of taxa (Chao 2 Mean) is 340, of which the 282 collected from the combined projects represents 83%.

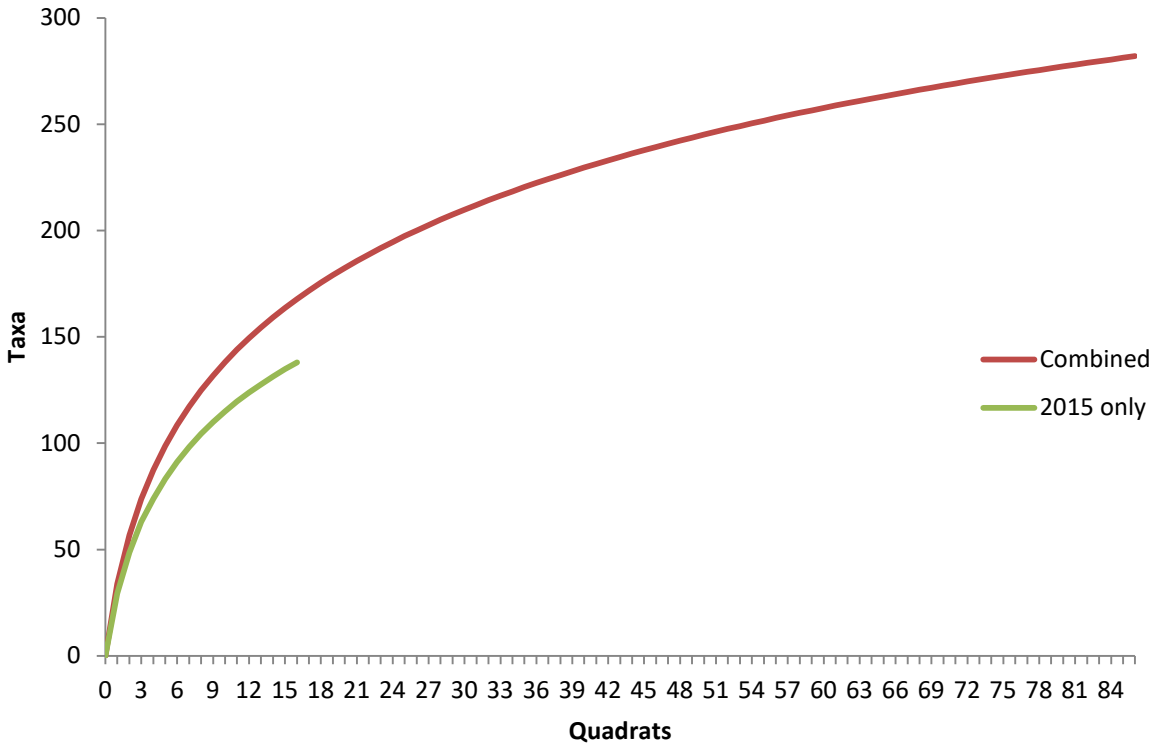


Figure 5.1 – SAC analysis for the study area

5.1.2 Flora of Conservation Significance

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth of Australia)

No EPBC Act listed Threatened Flora taxa were recorded at the study area.

Wildlife Conservation Act 1950 (Western Australia)

No WC Act listed Threatened Flora taxa were recorded at the study area.

Priority Flora

Two Priority flora species were recorded at the study area: *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3). Both of these species were recorded during previous assessments at Thunderbird (*ecologia* 2012, 2014a). Coordinates and abundance of Priority flora records are provided in Appendix G, and locations mapped in Figure 5.2.

Pterocaulon intermedium (Priority 3) was recorded at 14 locations (representing 14 individuals) across the study area, on red sandy plains.

Triodia caelestialis (Priority 3) recorded at 25 locations representing 8,271 individuals, and is the dominant understorey species in some of the vegetation units identified in the study area, such as *GpAmStTc*.

5.1.3 Introduced Flora

Weeds of National Significance

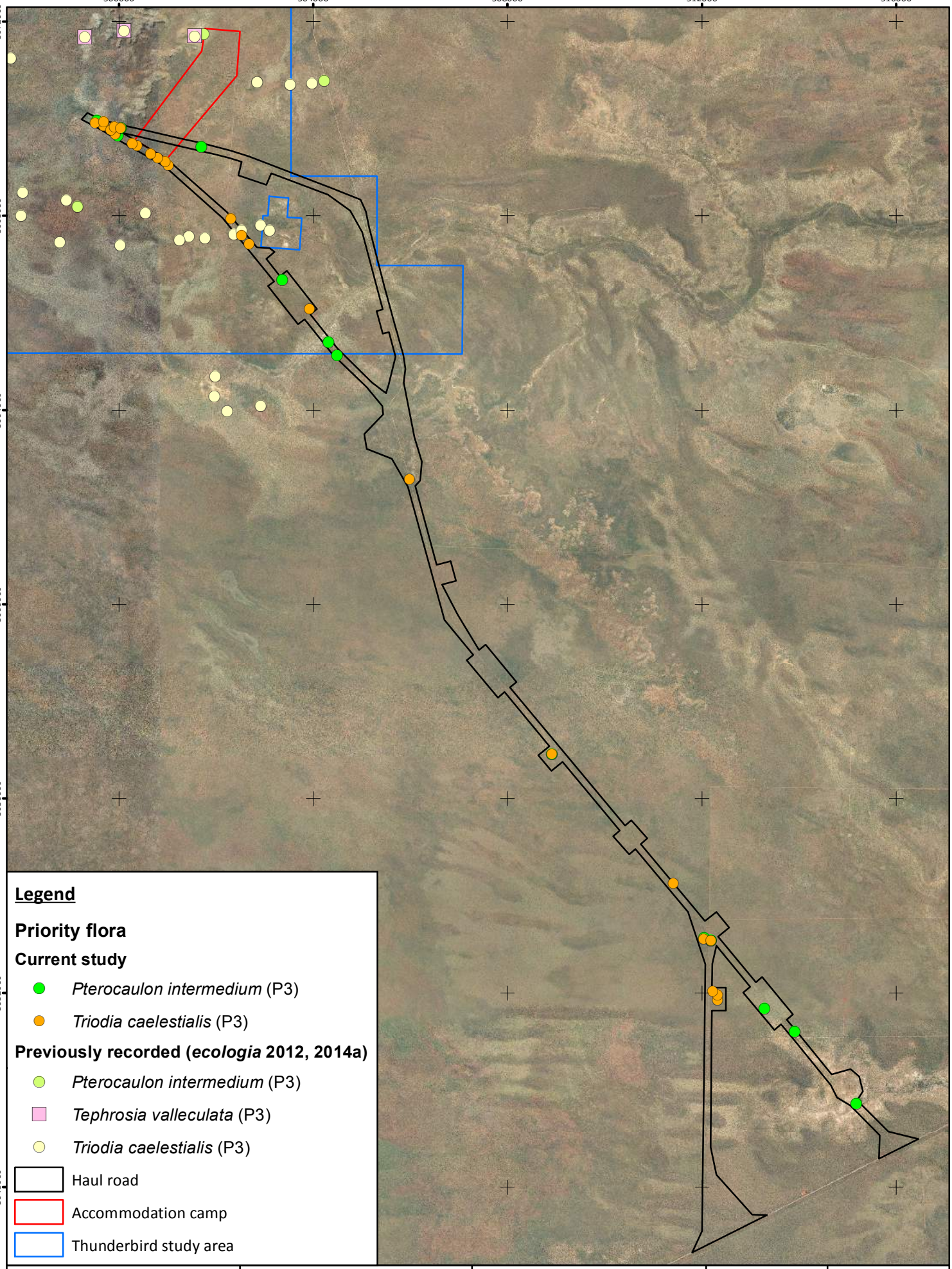
No WONs were recorded at the study area.

Declared Pest (Weeds)

No Declared Pests (Weed) species were recorded at the study area.

Environmental Weeds

Four environmental weeds were recorded at the study area: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*. Coordinates and abundance of Priority flora records are provided in Appendix G, and locations mapped in Figure 5.3.



ecologia ENVIRONMENT

0 1.5 3

Kilometres

Absolute Scale - 1:100,000

Priority flora locations

Figure: 5.2
Project ID: 1641

Drawn: MM
Date: 10/7/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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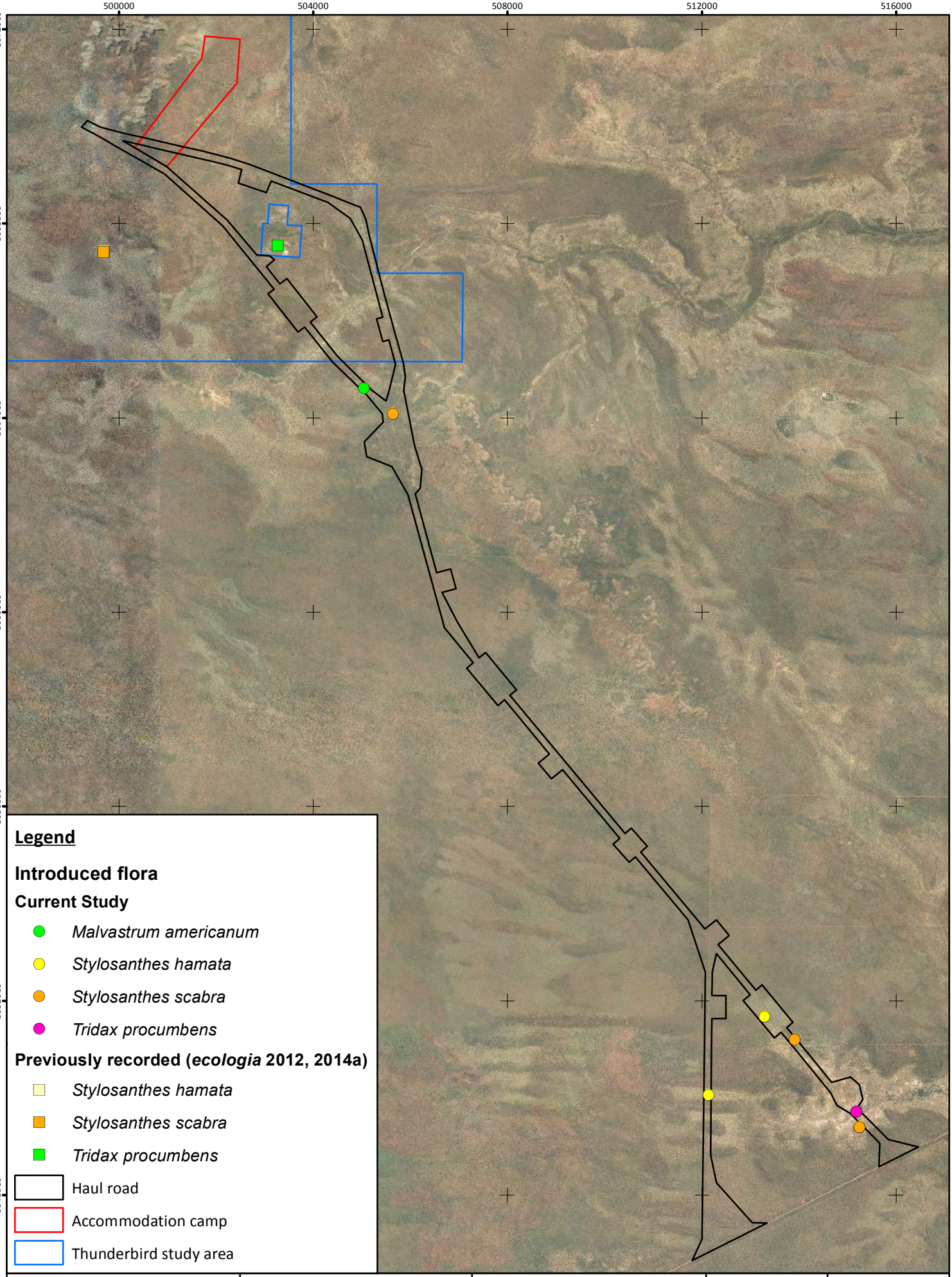

ecologia ENVIRONMENT

0 1.5 3

Kilometres

Absolute Scale - 1:100,000

Introduced flora locations

Figure: 5.3
Project ID: 1641

Drawn: MM
Date: 10/7/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4

5.2 VEGETATION

5.2.1 Vegetation Units

Eleven vegetation units were mapped from the study area and are described in Table 5.1 and mapped on Figure 5.4. Nine of these units are identical to those described in the previous Level 2 flora and vegetation assessment of the Thunderbird project (*ecologia* 2014a). Two vegetation units: *AtStCpHc* and *CgDhHc* are not described in the previous Level 2 flora and vegetation assessment of the Thunderbird project (*ecologia* 2014a)

The most abundant vegetation unit at the study area *AtStCpHc*, comprising 46.3% of the study area (and represented by 8 quadrats in the study area), followed by *EcAtSt* (13.6% of the study area) and *GpAmStTc* (13.1% of the study area).

The least abundant vegetation units in the study area are *EtApStCpEo*, *CdTcTc* and *CgApSt*, each occupying less than 0.5% of the study area, but relatively well represented in the Thunderbird project area.

The two newly mapped vegetation units *AtStCpHc* and *CgDhHc* are both wholly within the study area, but as they are associated with widespread landforms in the region (i.e. sandy plains), they are not expected to be restricted to the study area and are likely to represent vegetation that is abundant in the surrounding landscape.

The dendrogram used to map the vegetation at the study area is shown in Figure 5.5 – Dendogram used to define the vegetation units.

5.2.2 Vegetation Condition

The majority of the vegetation at the study area was rated as of “Very Good” condition, representing 56% of the study area. Of the remainder, 25% was mapped as “Good” and 19% as “Excellent”. The vegetation condition has been mapped in Figure 5.6.

Table 5.1 – Vegetation units of the study area

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
AtStCpHC	1 3 4 5 7 16 17 18	Landform: Sandy plain *Acacia tumida* var. *tumida* tall shrubland, over *Sorghum timorense, Chrysopogon pallidus* and *Heteropogon contortus* tussock grassland. Average species richness = 22.1 ± 5.6 Sample size = 8	*Brachychiton diversifolius subsp. diversifolius* *Corymbia greeniana* *Dolichandrone heterophylla* *Eriachne obtusa* *Erythrophleum chlorostachys* *Galactia tenuiflora* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Terminalia canescens*	625	625 (100%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
BdEcAtApSt	None from 2015 survey	Landform: Sandy plain *Brachychiton diversifolius* subsp. *diversifolius* and *Erythrophleum chlorostachys* low open woodland over *Acacia tumida* var. *tumida* and *Acacia platycarpa* tall, sparse shrubland over *Sorghum timorense* sparse tussock grassland Average species richness = 32.2 ± 3.8 Sample size = 5	*Acacia platycarpa* *Acacia tumida var. tumida* *Brachychiton diversifolius subsp. diversifolius* *Chrysopogon pallidus* *Corchorus sidoides subsp. vermicularis* *Corymbia greeniana* *Dodonaea hispidula var. arida* *Erythrophleum chlorostachys* *Microstachys chamaelea* *Sorghum timorense*	35	541 (6.4%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
BdEcAtSt	2	Landform: Sandy plain *Brachychiton diversifolius* subsp. *diversifolius* and *Erythrophleum chlorostachys* low open woodland over *Acacia tumida* var. *tumida* sparse shrubland over *Sorghum timorense* sparse tussock grassland Average species richness = 22.2 ± 1.3 Sample size = 10	*Acacia platycarpa* *Aristida hygrometrica* *Bauhinia cunninghamii* *Chrysopogon pallidus* *Corymbia greeniana* *Dolichandrone heterophylla* *Eragrostis eriopoda* *Eriachne obtusa* *Grevillea refracta subsp. refracta* *Solanum cunninghamii* *Spermacoce occidentalis* *Waltheria indica*	75	2,111 (3.6%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CdTcTc	None from 2015 survey	Landform: Hillslope - midslope or ridgetop *Corymbia* dendromerinx and *Terminalia canescens* low, open woodland, over *Triodia caelestialis* (P3) open hummock grassland Average species richness = 24.9 ± 1.7 Sample size = 12	*Corymbia dendromerinx* *Eriachne obtusa* *Gomphrena canescens subsp. canescens* *Grevillea pyramidalis subsp. pyramidalis* *Indigofera linifolia* *Sorghum timorense* *Stemodia lythrifolia* *Terminalia canescens* *Triodia caelestialis* *Wrightia saligna*	4.1	1,308 (0.3%)
					

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CgApSt	None from 2015 survey	Landform: Sandy plain *Corymbia greeniana* mid, open woodland, over *Acacia platycarpa* tall, sparse shrubland, over *Sorghum timorense* open tussock grassland Average species richness = 18.3 ± 2.2 Sample size = 6	*Acacia platycarpa* *Aristida hygrometrica* *Chrysopogon pallidus* *Corymbia dendromerinx* *Corymbia greeniana* *Erythrophleum chlorostachys* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Solanum cunninghamii* *Sorghum timorense*	4.2	1,155 (0.4%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CgDhHc	8 9 11 13	Landform: Floodplains adjacent to ephemeral waterways *Corymbia greeniana* low open forest over *Dolichandrone heterophylla* sparse shrubland, over *Heteropogon contortus* sparse tussock grassland. Average species richness = 23.8 ± 2.8 Sample size = 4	*Acacia colei* *Acacia drepanocarpa* *Acacia tumida var. tumida* *Aristida inaequiglumis* *Bauhinia cunninghamii* *Brachychiton diversifolius subsp. diversifolius* *Chrysopogon pallidus* *Eriachne obtusa* *Gomphrena canescens* *Indigofera linifolia* *Stylosanthes hamata* *Triodia schinzii*	110.7	110.7 (100%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
CgDhSt	12 6	Landform: Sandy plain *Corymbia greeniana* low open woodland over *Dolichandrone heterophylla* sparse shrubland over *Sorghum timorense* tussock grassland Average species richness = 19.1 ± 1.5 Sample size = 12	*Acacia tumida var. tumida* *Bauhinia cunninghamii* *Brachychiton diversifolius subsp. Diversifolius* *Chrysopogon pallidus* *Corymbia zygophylla* *Eriachne obtusa* *Erythrophleum chlorostachys* *Galactia tenuiflora* *Triodia caelestialis* *Wrightia saligna*	97	2,041 (4.8%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
EcAtSt	None from 2015 survey	Landform: Sandy plain *Erythrophleum chlorostachys* low, open woodland, over *Acacia tumida* var. *tumida* mid, sparse shrubland, over *Sorghum timorense* open tussock grassland Average species richness = 24.1 ± 2.4 Sample size = 10	*Acacia tumida var. tumida* *Aristida hygrometrica* *Dodonaea hispidula var. arida* *Erythrophleum chlorostachys* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Sorghum timorense* *Spermacoce occidentalis* *Terminalia canescens* *Wrightia saligna*	183	4,106 (4.5%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
EtApStCpEo	None from 2015 survey	Landform: Sandy floodplain *Eucalyptus tectifica* low, open woodland, over *Acacia platycarpa* tall, over *Sorghum timorense*, *Chrysopogon pallidus* and *Eriachne obtusa* open tussock grassland Average species richness = 23.6 ± 1.9 Sample size = 7	*Acacia platycarpa* *Bauhinia cunninghamii* *Brachychiton diversifolius subsp. diversifolius* *Chrysopogon pallidus* *Dolichandrone heterophylla* *Eriachne obtusa* *Eucalyptus tectifica* *Glycine tomentella* *Sorghum timorense* *Spermacoce occidentalis*	1.6	1,760 (0.1%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
GpAmStTc	None from 2015 survey	Landform: Gravelly plains *Grevillea pyramidalis* subsp. *pyramidalis* low, open woodland, over *Acacia monticola* mid, sparse shrubland, over *Sorghum timorense* sparse tussock grassland and *Triodia caelestialis* (P3) sparse hummock grassland. Average species richness = 25.0 ± 1.6 Sample size = 7	*Acacia hippuroides* *Acacia monticola* *Chrysopogon pallidus* *Corchorus sidoides subsp. vermicularis* *Corymbia greeniana* *Grevillea pyramidalis subsp. pyramidalis* *Grevillea refracta subsp. refracta* *Microstachys chamaelea* *Sorghum timorense* *Triodia caelestialis*	177	1,634 (10.8%)

Vegetation unit mapping code	Quadrat numbers	Vegetation description (NVIS Level III and Level VI)	Associated species	Area in study (ha)	Total area (ha) mapped (% in study area)
MaMvEtCpCc	10	Landform: Sandy floodplain *Melaleuca alsophila* or *Melaleuca viridiflora* and *Eucalyptus tectifica* low open woodland, over *Chrysopogon pallidus* sparse tussock grassland and *Cyperus conicus* sparse sedgeland Average species richness = 17.5 ± 2.5 Sample size = 3	*Acacia colei* *Aristida hygrometrica* *Bauhinia cunninghamii* *Chrysopogon pallidus* *Cyperus conicus* *Eragrostis cumingii* *Eriachne obtusa* *Eucalyptus tectifica* *Grevillea striata* *Sorghum timorense* *Stylosanthes hamata* *Xerochloa laniflora*	37	353 (10.4%)

500000 505000 510000 515000

8070000 8065000 8060000 8055000 8050000

CdTcTc
GpAmStTc
EtApStCpEo
EcAtSt
BdEcAtSt
MaMvEtCpCc
BdEcAtApSt
CgApSt
AtStCpHc
CgDhSt
CgDhHc

Legend

- Quadrat (2015)
- Haul road
- Accommodation camp
- Thunderbird study area

Vegetation Unit

- AtStCpHc
- BdEcAtApSt
- BdEcAtSt
- CdTcTc
- CgApSt
- CgDhHc
- CgDhSt
- EcAtSt
- EtApStCpEo
- GpAmStTc
- MaMvEtCpCc

N

0 1.5 3

Kilometres

Absolute Scale - 1:75,000

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Vegetation Units

Figure: 5.4
Project ID: 1641

Drawn: MM
Date: 10/07/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A3

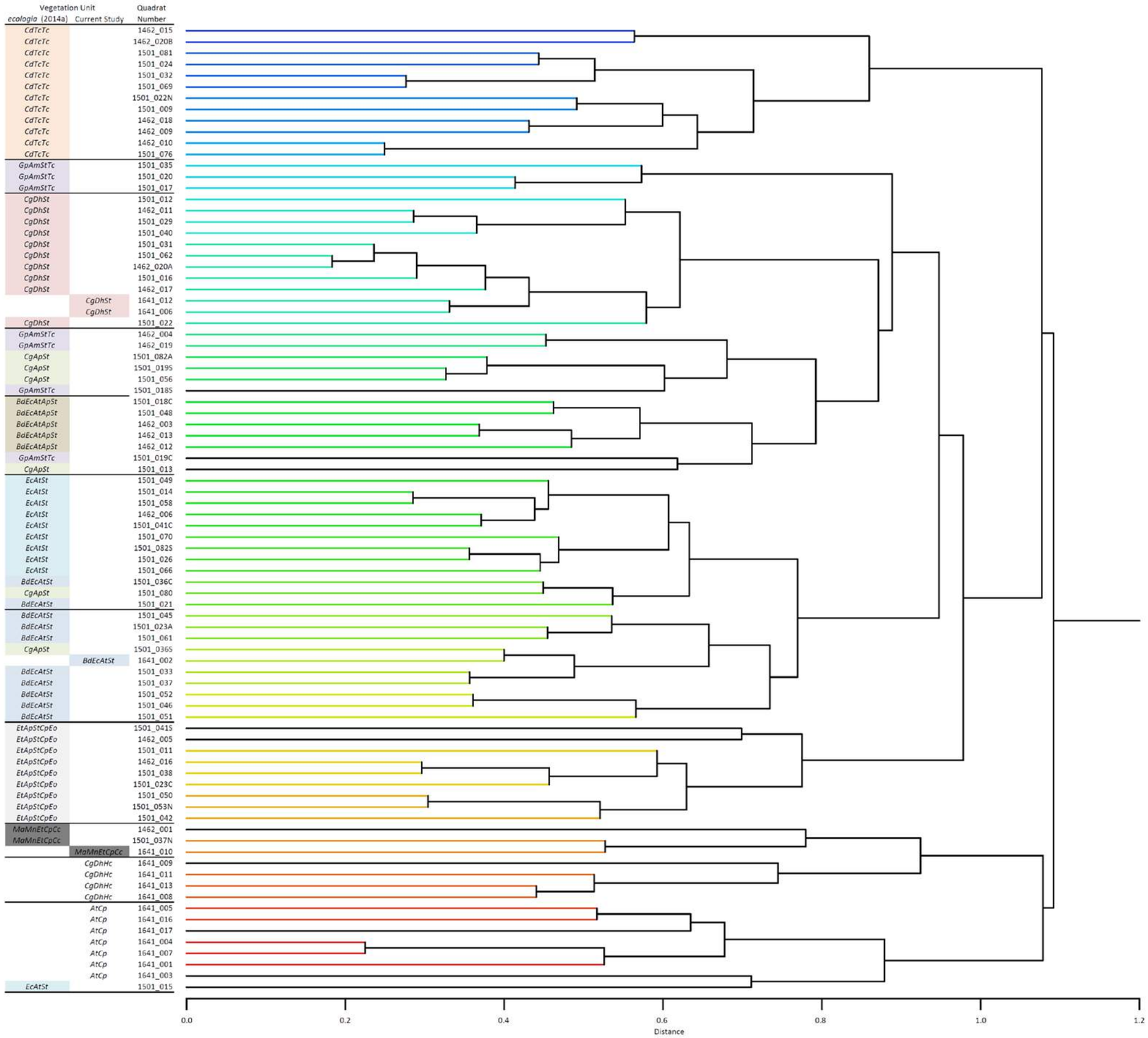
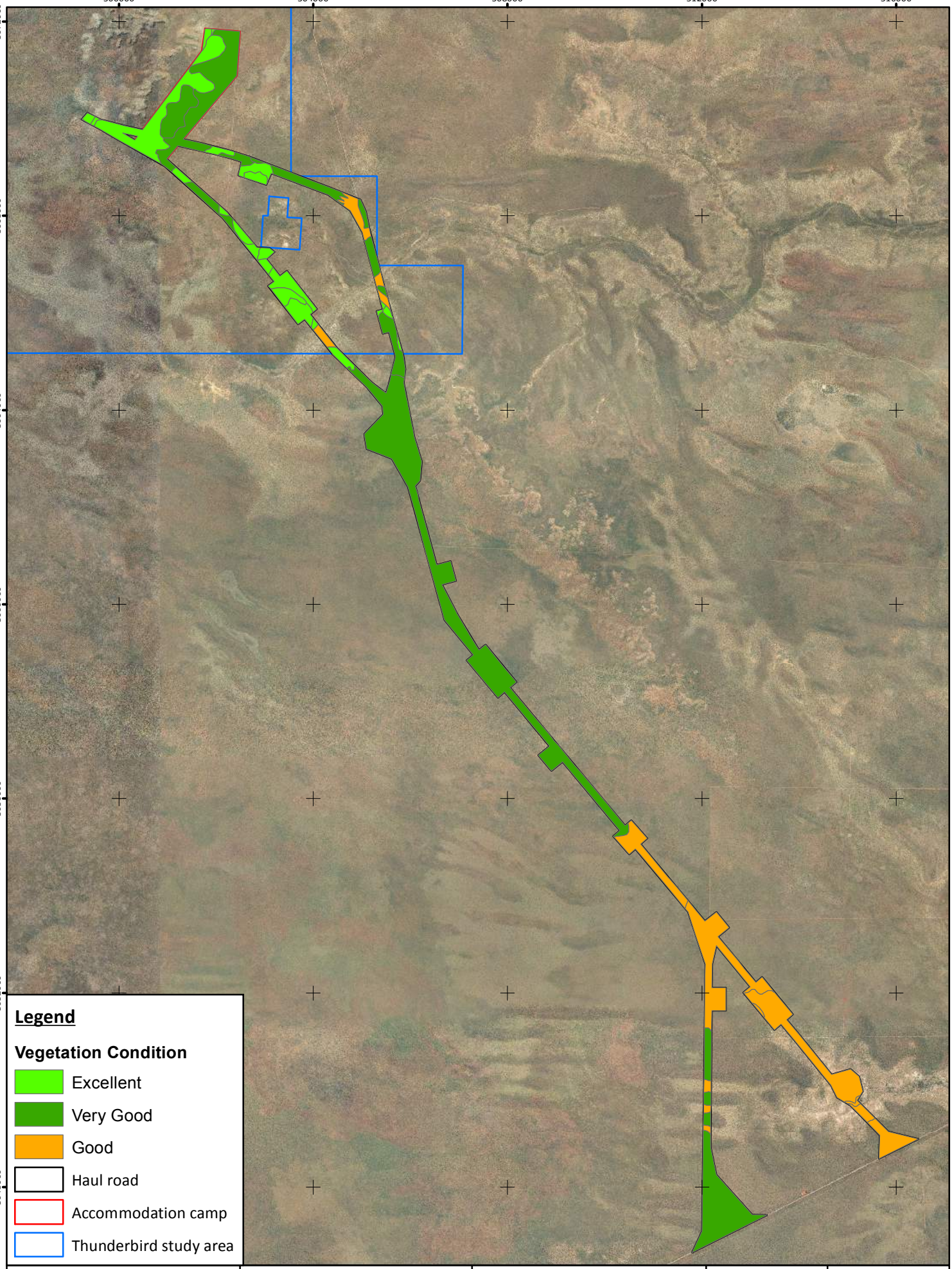


Figure 5.5 – Dendogram used to define the vegetation units



ecologia ENVIRONMENT

0 1.5 3

Kilometres

Absolute Scale - 1:100,000

Vegetation Condition

Figure: 5.5
Project ID: 1641

Drawn: MM
Date: 10/7/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

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5.3 FAUNA

5.3.1 Species recorded

The field survey recorded a total of 79 fauna species from direct sightings and secondary evidence such as scats and tracks, including 13 mammal, 63 bird and three reptile species (Table 5.2).

Table 5.2 – Vertebrate fauna recorded in the study area

Common name	Scientific name
Mammals	
Short-beaked Echidna^	*Tachyglossus aculeatus*
Greater Bilby^	*Macrotis lagotis*
Agile Wallaby	*Macropus agilis*
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*
Gould's Wattled Bat	*Chalinolobus gouldii*
Hoary Wattled Bat	*Chalinolobus nigrogriseus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*
Little Broad-nosed Bat	*Scotorepens greyii*
Northern Freetail Bat	*Chaerophon jobensis*
Delicate Mouse	*Pseudomys delicatulus*
European Cattle*	*Bos taurus*
Dog/dingo*	*Canis lupus*
Cat*	*Felis catus*
Birds	
Crested Pigeon	*Ocyphaps lophotes*
Diamond Dove	*Geopelia cuneata*
Peaceful Dove	*Geopelia striata*
Tawny Frogmouth	*Podargus strigoides*
Spotted Nightjar	*Eurostopodus argus*
White-necked Heron	*Ardea pacifica*
Straw-necked Ibis	*Threskiornis spinicollis*
Square-tailed Kite	*Lophoictinia isura*
Black-breasted Buzzard	*Hamirostra melanosternon*
Whistling Kite	*Haliastur sphenurus*
Black Kite	*Milvus migrans*
Wedge-tailed Eagle	*Aquila audax*
Nankeen Kestrel	*Falco cenchroides*
Brown Falcon	*Falco berigora*
Australian Hobby	*Falco longipennis*
Australian Bustard	*Ardeotis australis*
Bush Stone-curlew	*Burhinus grallarius*
Common Greenshank	*Tringa nebularia*
Red-tailed Black-Cockatoo	*Calyptorhynchus banksii*
Galah	*Eolophus roseicapillus*
Little Corella	*Cacatua sanguinea*
Cockatiel	*Nymphicus hollandicus*
Red-collared Lorikeet	*Trichoglossus haematodus rubritorquis*
Varied Lorikeet	*Psitteuteles versicolor*
Red-winged Parrot	*Aprosmictus erythropterus*
Budgerigar	*Melopsittacus undulatus*
Blue-winged Kookaburra	*Dacelo leachii*
Rainbow Bee-eater	*Merops ornatus*

Common name	Scientific name
Black-tailed Treecreeper	*Climacteris melanura*
Red-backed Fairy-wren	*Malurus melanocephalus*
Variegated Fairy-wren	*Malurus lamberti*
Weebill	*Smicrornis brevirostris*
White-throated Gerygone	*Gerygone albogularis*
Red-browed Pardalote	*Pardalotus rubricatus*
Striated Pardalote	*Pardalotus striatus*
Singing Honeyeater	*Lichenostomus virescens*
Yellow-tinted Honeyeater	*Lichenostomus flavescens*
Brown Honeyeater	*Lichmera indistincta*
Black-chinned Honeyeater	*Melithreptus gularis*
Grey-crowned Babbler	*Pomatostomus temporalis*
Varied Sittella	*Daphoenositta chrysoptera*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
White-bellied Cuckoo-shrike	*Coracina papuensis*
White-winged Triller	*Lalage sueurii*
Rufous Whistler	*Pachycephala rufiventris*
Grey Shrike-thrush	*Colluricincla harmonica*
Olive-backed Oriole	*Oriolus sagittatus*
White-breasted Woodswallow	*Artamus leucorynchus*
Black-faced Woodswallow	*Artamus cinereus*
Little Woodswallow	*Artamus minor*
Pied Butcherbird	*Cracticus nigrogularis*
Australian Magpie	*Cracticus tibicen*
Grey Fantail	*Rhipidura albiscapa*
Willie Wagtail	*Rhipidura leucophrys*
Torresian Crow	*Corvus orru*
Paperbark Flycatcher	*Myiagra nana*
Magpie-lark	*Grallina cyanoleuca*
Jacky Winter	*Microeca fascinans*
Hooded Robin	*Melanodryas cucullata*
Tree Martin	*Petrochelidon nigricans*
Mistletoebird	*Dicaeum hirundinaceum*
Zebra Finch	*Taeniopygia guttata*
Long-tailed Finch	*Poephila acuticauda*
Reptiles	
Skink	*Ctenotus inornatus*
Sand Goanna	*Varanus gouldii*
Mulga Snake^	*Pseudichis australis*

^ Recorded from secondary evidence (scats, tracks, nest sites etc)
* Introduced species

5.3.2 Fauna Habitats

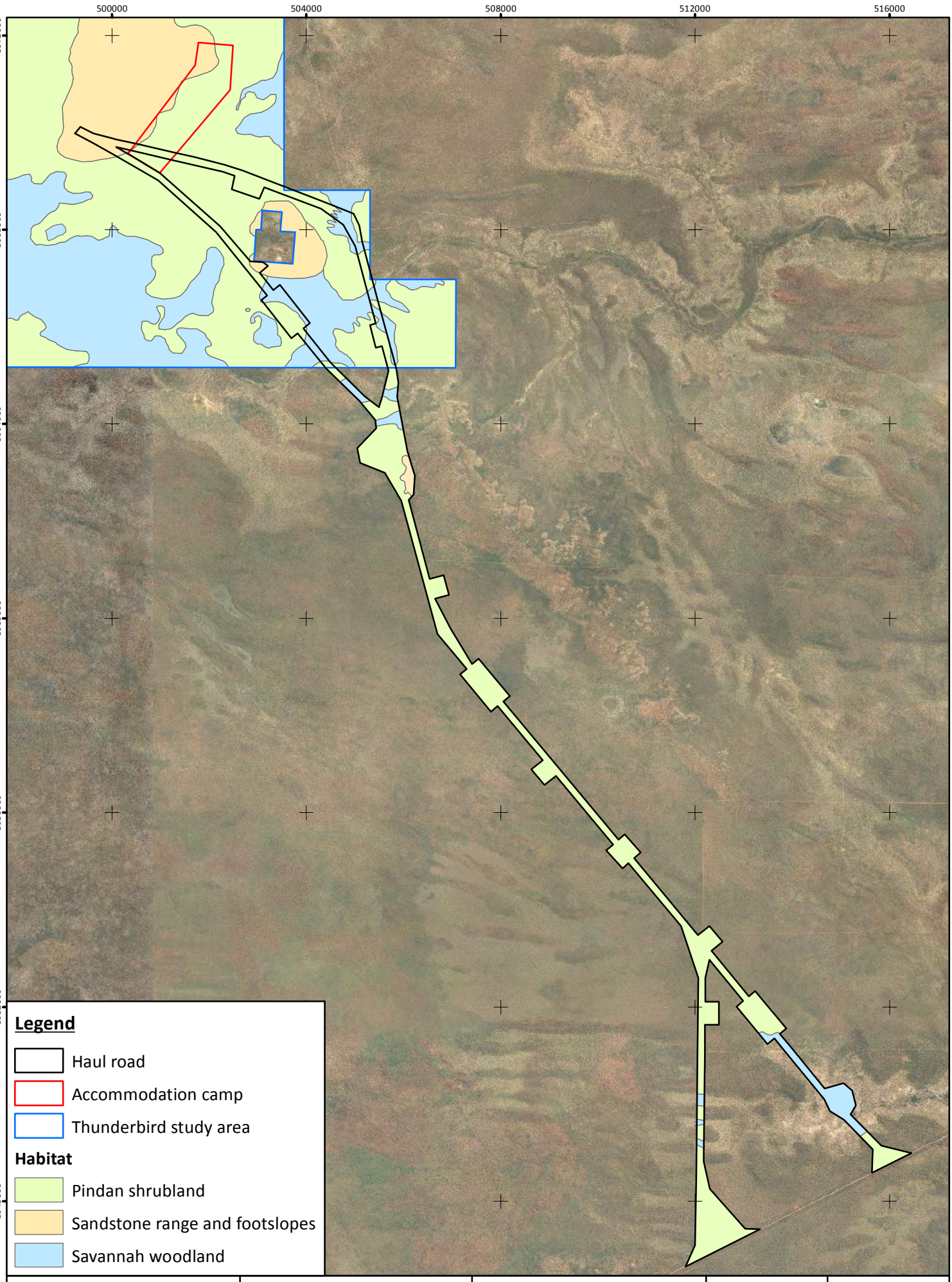
Three broad habitat types were identified within the study area based upon the information outlined in Section 2.6.5. Habitats were assessed against the previous Thunderbird assessment (*ecologia* 2014b) and in order of consistency applied to this assessment where practical. The details of each habitat type are shown in Table 5.3 and mapped in Figure 5.7 below.

The study area contains the following habitat types:

- Pindan shrubland;
- Sandstone range and footslopes; and,
- Savannah woodland.

Table 5.3 – Fauna habitats at the study area

Fauna habitat	Area outside Thunderbird Assessment (ha)	Area inside Thunderbird Assessment (ha)	Total (ha)	Percentage of total study area (%)
Pindan shrubland	691.6	401.2	1,092.8	80.9
Savannah woodland	104.4	62.3	166.7	12.4
Sandstone range and footslopes	15.0	74.9	89.9	6.7
Total	**811**	**538.4**	**1,349.4**	**100%**



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Absolute Scale - 1:100,000

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Fauna habitats

Figure: 5.7
Project ID: 1641

Drawn: BG
Date: 7/5/15

Coordinate System
Name: GDA 1994 MGA Zone 50
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Datum: GDA 1994

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Pindan shrubland

The pindan shrubland habitat is the most extensive fauna habitat type identified within the study area, comprising 80.9% (1,092.8 ha) of the total study area (Figure 5.7). The landscape feature of this habitat type is a flat plain, with soil substrate weak orange to red sandy-loam soils. Subtle differences exist in the soil substrate with some areas more clayey and therefore harder. The dominant tree species is scattered *Corymbia greeniana*, over a moderately open to dense shrub layer consisting primarily of *Acacia tumida* var. *tumida*, *Acacia platycarpa* and *Grevillea refracta*. The ground vegetation layer consists of a mix of grasses including *Triodia caelestialis*, *Aristida holathera* var. *holathera*, *Chrysopogon* sp., *Eriachne obtusa* and *Sorghum plumosum*. Leaf litter density is highly variable as a result of fire history and patchy shrub density.

A mosaic of vegetation as a result of fire history exists within this habitat type, and appears older fire age (>2 years) is characterised by large, dense mature *Acacia tumida* var. *tumida* forming a dense canopy layer but relatively open ground cover (Figure 5.9). In contrast, areas within this habitat type which appear to have been burnt more frequently are characterised by dense ground vegetation.

Figure 5.8 – Example of pindan shrubland habitat type

Figure 5.9 – Example of dense, mature Acacia tumida var tumida within pindan shrubland

Savannah woodland

The savannah woodland habitat is second most extensive, covering 12.4% (166.7 ha) of the study area. It is characterised by plains in the low-lying areas in the south and north of the study area, with firm brown-white sandy clay soils. The dominant vegetation consists of scattered *Eucalyptus tectifica* and *Brachychiton diversifolius*, with open to moderately dense shrubs of mainly *Acacia platycarpa*. There is a ground vegetation layer of *Eriachne obtusa* tussock grassland and *Triodia caelestialis* hummock grassland, and termite mounds are frequently present. A number of minor drainage lines exist within

this habitat type which was not deemed unique enough to be included as a separate habitat type. These drainage lines are likely to contain water during periods of the wet season.

Figure 5.10 – Example of savannah woodland habitat type

Sandstone range and footslopes

The sandstone range and footslopes habitat is the least widespread within the study area, covering 6.7% (89.9 ha) of the total study area. It is found in one location in the northern section of the study area. The geology is sandstone rocks, with outcropping and boulders present on the upper hills, while the footslopes contain isolated rocks and sandy soil substrate. The vegetation in this habitat is characterised by sparse *Corymbia dendromerinx* over moderately dense *Acacia drepanocarpa* subsp. *latifolia* over a ground vegetation layer of dense *Triodia caelestialis* hummock grassland and *Sorghum plumosum* tussock grassland (Figure 5.11).

Figure 5.11 – Example of sandstone range and footslopes habitat type

5.3.3 Potential conservation significant fauna likelihood of occurrence assessment

Based on the methodology described in Section 2.6.1 and the habitats recorded within the study area (Section 5.3.2), the likelihood of occurrence for all potential conservation significant fauna has been assessed and summarised in Table 5.4.

A total of 46 species were recorded as low likelihood, 16 species as medium likelihood and seven species recoded as high likelihood or recorded during current survey.

Species assessed as a medium or high likelihood of occurrence, or were recorded on the current survey, are discussed in greater detail in Section 7.2. Species assessed as having a low likelihood of occurrence are not discussed further.

Table 5.4 – Likelihood of occurance assessment of potential conservation significant fauna

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Mammals						
Northern Quoll *Dasyurus hallucatus*	EN	S1	EN	Most common on dissected rocky escarpments, but also found in eucalypt forest and woodland, and around human settlements (Oakwood 2008).	Not previously recorded on the Dampier Peninsula, but has been recorded in similar habitat to that present, 90 km east of the study area in 2001 (NatureMap).	**LOW**
Greater Bilby *Macrotis lagotis*	VU	S1	VU	Variety of habitats on soft soil including spinifex hummock grassland, acacia shrubland, open woodland and cracking clays (Johnson 2008; Menkhorst and Knight 2011)	Numerous regional records, including over 50 records from 2012 25-30 km SW of the study area, one recent record (2013) c. 5 km NW of the northern end of the study area, and a cluster of several records (most recent 1996) within 1 km of the southern end of the study area (DPaW 2015a). recorded during Thunderbird assessment (*ecologia* 2014b).	**RECORDED** **Resident – breeding**
Golden Bandicoot *Isoodon auratus auratus*	VU	S1		Rocky sandstone spinifex and vine thickets.	One record from 1971 on the Dampier Peninsula (NatureMap).	**LOW**
Little Northern Freetail Bat *Mormopterus loriae cobourgiana*			P1	Mangrove stands, particularly those that include mature Grey Mangrove (*Avicennia marina*), and adjacent vegetation (Milne *et al.* 2008; Menkhorst and Knight 2011).	Recorded on the Dampier Peninsula (ENV 2008), but no records within 75 km of the study area (DPaW 2015a).	**LOW**
Yellow-lipped Cave Bat *Vespadelus douglasorum*			P2	Forages in tropical woodlands, particularly in association with *Melaleuca* and *Pandanus*-lined waterways and streams (Churchill 2008; Menkhorst and Knight 2011). Use both sandstone and limestone caves for roosting, usually near water (Churchill 2008).	One record from c. 50 km NW of the northern end of the study area (*ecologia* 2004c; DPaW 2015b).	**LOW**
Lakeland Downs Mouse (Short-tailed Mouse) *Leggadina lakedownensis*			P4	Spinifex and tussock grassland on cracking clays. Also acacia shrubland, samphire and woodlands (Moro and Kutt 2008; Menkhorst and Knight 2011).	One record c. 2 km north of the northern end of the study area, from Sheffield's Thunderbird project (*ecologia* 2014b; DPaW 2015b).	**HIGH** **Resident – breeding**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Birds						
Gouldian Finch *Erythrura gouldiae*	EN		P4	Tropical woodlands and forest, with grassy understorey; usually near water. Breed in eucalypt hollows, usually in stony hilled areas (Garnett and Crowley 2000; Johnstone and Storr 2004)	Species or species habitat likely to occur in the area (DoE 2015a). Numerous records from far northern Dampier Peninsula (Cape Leveque), but only two old records within 50 km of the study area; both c. 30 km E of the southern end of the study area from 1973 (DPaW 2015a).	**MEDIUM**
Australian Painted Snipe *Rostratula australis*	EN, M	S1, S3	EN	Shallow, vegetated wetlands (Garnett and Crowley 2000)	Seven records (most recent 1999) from within 50 km of the study area, all from Roebuck Plains to the WSW of the study area; closest c. 25 km SW of southern end of study area from 1994 (DPaW 2015a).	**LOW**
Red Goshawk *Erythrotriorchis radiatus*	VU	S1	VU	Open forests and woodlands, tropical savannas traversed by wooded rivers, rainforest margins, and gorge and escarpment country (Garnett and Crowley 2000)	Species or species habitat likely to occur in the area (DoE 2015a). No records within 100 km of the study area (DPaW 2015a).	**LOW**
Masked Owl (Kimberley subspecies) *Tyto novaehollandiae kimberli*	VU		P1	Rainforest and gallery forest, open forest, paperbark swamps, mangrove fringes (Johnstone and Storr 1998; Garnett and Crowley 2000).	Species or species habitat likely to occur in the area (DoE 2015a). No records within 100 km of the study area (DPaW 2015a).	**LOW**
Rainbow Bee-eater *Merops ornatus*	M	S3	IA	Open country, most vegetation types, dunes, banks; prefer lightly wooded, preferably sandy, country near water (Johnstone and Storr 1998; Pizzey and Knight 2003).	Numerous records from the Dampier Peninsula (DPaW 2015a). Previously recorded during Thunderbird assessment including breeding burrows (*ecologia* 2014b).	**RECORDED** **Resident – breeding**
Fork-tailed Swift *Apus pacificus*	M	S3	IA	Aerial over a variety of habitat types, movements often associated with summer storm fronts (Johnstone and Storr 1998; Pizzey and Knight 2003)	Numerous records from western Dampier Peninsula; two records within 50 km of study area, one from within 5 km of the northern end of the study area from Sheffield's Thunderbird project in 2013 and one record c. 30 km E of the study area from 2006 (*ecologia* 2014b; DPaW 2015b).	**HIGH** **Migratory visitor**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Eastern Great Egret *Ardea modesta*	M	S3	IA	Wide range of wetland habitats, including floodwaters, rivers, shallows of wetlands, intertidal mudflats (Johnstone and Storr 1998).	Numerous records throughout the Dampier Peninsula region; nearest are 12 records c. 25 km SW of the study area, most recently from 2007 (DPaW 2015a).	**MEDIUM**
Cattle Egret *Ardea ibis*	M	S3	IA	Grassy habitats, shallow wetlands and waterbodies, particularly damp pastures (Johnstone and Storr 1998).	11 records within 50 km of the study area, nearest are two records (most recent from 2007) from c. 25 km SW of southern end of study area (DPaW 2015a).	**MEDIUM**
Glossy Ibis *Plegadis flacinellus*	M	S3	IA	Shallows and adjacent flats of freshwater wetlands; also river pools, flooded samphire and sewage ponds (Johnstone and Storr 1998).	Numerous records throughout the southern Dampier Peninsula region; nearest are 31 records c. 25 km SW of the study area, most recently from 2013 (DPaW 2015a).	**LOW**
Eastern Osprey *Pandion cristatus*	M			Coasts, estuaries, coastal and offshore islands, and the lower reaches of rivers (Johnstone and Storr 1998).	Several records along the coast of the Dampier Peninsula, but no records within 75 km of study area (DPaW 2015a).	**LOW**
White-bellied Sea-Eagle *Haliaeetus leucogaster*	M	S3	IA	Offshore islands, coasts, estuaries, coastal lakes. Occasionally inland along larger watercourses (Johnstone and Storr 1998).	Numerous records throughout the southern Dampier Peninsula region; nearest are seven records c. 25 km SW of the study area, most recently from 2010 (DPaW 2015a).	**LOW**
Oriental Plover *Charadrius veredus*	M	S3	IA	Open plains, including samphire; bare rolling country; bare claypans; open ground near inland swamps.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Australian Painted Snipe *Rostratula australis*	EN, M	S1, S3	EN	Shallow, vegetated wetlands (Garnett and Crowley 2000).	A few records within 50 km SW of the study area within the last 15 years (DPaW 2015a).	**LOW**
Swinhoe's Snipe *Gallinago megala*	M	S3	IA	Shallow freshwater wetlands of various kinds including paddy fields and sewage farms, with bare mud or shallow water for feeding, with nearby vegetation cover (Johnstone and Storr 1998)..	One record within 50 km of the study area (DPaW 2015a).	**LOW**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Little Curlew *Numenius minutus*	M	S3	IA	Short dry grasslands, including artificial grassed areas.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Wood Sandpiper *Tringa glareola*	M	S3	IA	Mainly shallow, fresh waters, river pools, claypans; occasionally brackish swamps; rarely salt lakes, estuaries and intertidal mudflats.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a), recorded at Mt Jowlaenga during Thunderbird assessment (*ecologia* 2014).	**MEDIUM**
Common Greenshank *Tringa nebularia*	M	S3	IA	Intertidal mudflats, estuaries, freshwater and saline wetlands along the coast and inland.	Many records within the regional area of the study area.	**RECORDED Transient visitor**
Red-necked Stint *Calidris ruficollis*	M	S3	IA	Costal areas: sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks; also saline and freshwater inland wetlands.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Long-toed Stint *Calidris subminuta*	M	S3	IA	Shallow water surrounded by dense low vegetation.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Sharp-tailed Sandpiper *Calidris acuminata*	M	S3	IA	Coasts and well-watered parts of the interior. Prefer grassy areas of non-tidal fresh or brackish wetlands, coastal marshes and tidal flats.	Number of relatively recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
Pectoral Sandpiper *Calidris melanotos*	M	S3	IA	Uncommon in WA. Shallow, fresh waters, often with low grass or other herbage; swamp margins, flooded pastures, sewage ponds; occasionally tidal areas, saltmarshes. Breeds in Arctic.	Few nearby records within 50 km of the study area (DPaW 2015a).	**LOW**
Oriental Pratincole *Glareola maldivarum*	M	S3	IA	Plains, shallow wet and dry edges in open bare wetlands, tidal mudflats, beaches.	Numerous recent records within 50 km SW of the study area (DPaW 2015a).	**MEDIUM**
White-winged Black Tern *Chlidonias leucopterus*	M	S3	IA	Mainly estuaries and sheltered seas in north, freshwater lakes and swamps in south.	Few surrounding records (DPaW 2015a).	**LOW**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Barn Swallow *Hirundo rustica*	M	S3	IA	In Australia, primarily around towns and wetlands (Johnstone and Storr 2004).	13 records within 50 km of the study area; nearest are three records (most recent from 2010) c. 25 km SW of the study area, most recently from 2010 (DPaW 2015a).	**LOW**
Eastern Yellow Wagtail *Motacilla tschutschensis*	M	S3	IA	Short grasslands (usually damp or watered), swamp margins, sewage ponds, bore overflows, and irrigated areas (Johnstone and Storr 1998)	Few surrounding records (DPaW 2015a), but recorded during previous Thunderbird assessment (*ecologia* 2014b).	**MEDIUM**
Grey Wagtail *Motacilla cinerea*	M	S3	IA	Predominantly banks and rocky areas along flowing freshwater habitats (Johnstone and Storr 1998); however, uses a variety of habitats in Australia, all usually close to water	Few surrounding records (DPaW 2015a), but recorded during previous Thunderbird assessment (*ecologia* 2014b).	**MEDIUM**
Coastal restricted conservation significant birds* (Appendix D)	M	S3	IA	Near coastal habitats.	-	**LOW**
Grey Falcon *Falco hypoleucos*		S1	VU	Lightly wooded plains (Johnstone and Storr 1998), typically nesting in tall trees along watercourses (Garnett and Crowley 2000)	One record c. 25 km to the SW of the southern end of the study area from 2008, and one record c. 55 km SE of the southern end of the study area from 1999 (DPaW 2015a).	**MEDIUM**
Peregrine Falcon *Falco peregrinus*		S4	Other	Wide variety of habitats; woodlands, treed grasslands, wetlands, timbered watercourses, rocky gorges, cities. Breeds on ledges on cliffs, outcrops, quarries, and city buildings, in hollow trees, or in abandoned nests of other raptors (Johnstone and Storr 1998; Pizzey and Knight 2003).	Five records within 50 km of the study area; nearest are three records (most recent from 2005) c. 25 km SW of the study area, most recently from 2010 (DPaW 2015a).	**MEDIUM**

Species	Conservation significance			Habitat	Previous records	Likelihood of occurrence[#]
	EPBC Act	WC Act	DPaW			
Australian Bustard *Ardeotis australis*			P4	Open grasslands, shrublands, chenopod flats and low heathland (Johnstone and Storr 1998; Simpson and Day 2010).	Numerous records from the Dampier Peninsular (DPaW 2015a), including a number of records within or very close to the northern end of the study area from 2014 (*ecologia* 2014b).	**RECORDED Resident – breeding**
Star Finch (western subspecies) *Neochmia ruficauda subclarescens*			P4	Long grass and reeds in and around wetlands; also irrigated crops and pastures, sewage ponds, and rank grasslands (Johnstone and Storr 2004).	One record (undated) c. 65 km E of the study area (Derby), and one old record (1975) c. 90 km W of the study area (DPaW 2015a).	**LOW**
Chestnut-backed Button-quail *Turnix castanota*			P4	Savannah woodlands in sandstone and lateritic country.	No records on the Dampier Peninsula (DPaW 2015a), but recorded at James Price Point (AECOM 2010).	**LOW**
Reptiles						
Saltwater Crocodile *Crocodylus porosus*	M	S4	Other	Coastal rivers and swamps, extending inland along major rivers to floodplains and billabongs (Cogger 2000)	Recorded on the Dampier Peninsula (ENV 2008), but no records within 75 km of the study area (DPaW 2015a).	**LOW**
Lerista separanda			P2	Consolidated coastal dunes, and other sandy coastal areas (Cogger 2000; Wilson and Swan 2013).	Several records near the coast on the Dampier Peninsula, but no records within 75 km of the study area (DPaW 2015a).	**MEDIUM**
Dampierland Burrowing Snake *Simoselaps minimus*			P2	Coastal dunes and sandy areas between dunes and adjacent acacia shrublands (Wilson and Swan 2013).	Several records near the coast on the Dampier Peninsula, but no records within 75 km of the study area (DPaW 2015a).	**MEDIUM**
Dampier Peninsula Goanna^ *Varanus sparnus*	^	^	^	Pindan shrubland with sandy soils (Doughty *et al.* 2014).	Species recently described, currently restricted to four point locations of specimes used to describe species. Includes coastal areas at Coulomb Point and 90 km east to central Dampier Peninsula (Doughty *et al.* 2014).	**HIGH Resident – breeding**

*28 Conservation significant coastal and shorebird species assessed as low likelihood listed in (Appendix D)
^Species not formally protected and listed as conservation significant under current legislation. However species recently described and currently has restricted distribution. Species may carry conservation significant status in the future so included in this assessment. Appendix H details the recent description and clarifies the Dampier Peninsula Goanna's occurrence in relation to the Thunderbird project.
[#]Likely habitat utilisation category assigned to species assessed as high likelihoof of occurrence or recorded species only (Section 2.6.1).

5.3.4 Conservation significant fauna species records

A total of four species of conservation significance were recorded during the field study; Greater Bilby (EPBC Act Vulnerable, WC Act Schedule 1, DPaW Vulnerable), Common Greenshank (EPBC Act Migratory,WC Act Schedule 3, DPaW Internation Agreement), Rainbow Bee-eater (EPBC Act Migratory,WC Act Schedule 3, DPaW Internation Agreement) and Australian Bustard (Priority 4). These records are summarised in Table 5.5 and Appendix C (Greater Bilby) and are mapped in Figure 5.15 and Figure 5.16.

Greater Bilby was recorded on the basis of secondary evidence only. These records consisted of diggings, scats and active burrows (Figure 5.12). Common Greenshank, Rainbow Bee-eater (Figure 5.13) and Australian Bustard (Figure 5.14) were all recorded from visual observations.

Table 5.5 – Conservation significant fauna recorded

Species	Count	Date	Location Name	Easting	Northing	Notes
Mammals						
Greater Bilby (Appendix C)	-	-	-	-	-	A total of 18 active burrows and numerous diggings (Appendix C).
Birds						
Common Greenshank	2	14/5/2015	Opportunistic	514901	8049981	Two individuals foraging along shoreline of turkey nest.
Rainbow Bee-eater	1	13/05/2015	Opportunistic	505271	8066951	-
Rainbow Bee-eater	1	14/05/2015	Opportunistic	500867	8069754	-
Rainbow Bee-eater	3	11/05/2015	Opportunistic	508388	8057835	-
Rainbow Bee-eater	3	12/05/2015	Diurnal active search 2	505003	8064661	-
Rainbow Bee-eater	1	12/05/2015	Diurnal active search 1	505687	8065383	-
Rainbow Bee-eater	3	12/05/2015	Diurnal active search 5	505829	8064742	-
Rainbow Bee-eater	1	13/05/2015	Bird point count 1	514901	8049981	-
Rainbow Bee-eater	2	13/05/2015	Diurnal active search 13	504605	8068400	-
Rainbow Bee-eater	1	15/05/2015	Bird point count 1	514901	8049981	-
Australian Bustard	1	13/05/2015	Opportunistic	506739	8059754	-
Australian Bustard	1	14/05/2015	Opportunistic	502389	8070589	-
Australian Bustard	2	15/05/2015	Opportunistic	500379	8069674	-
Australian Bustard	1	12/05/2015	Opportunistic	508998	8057021	-

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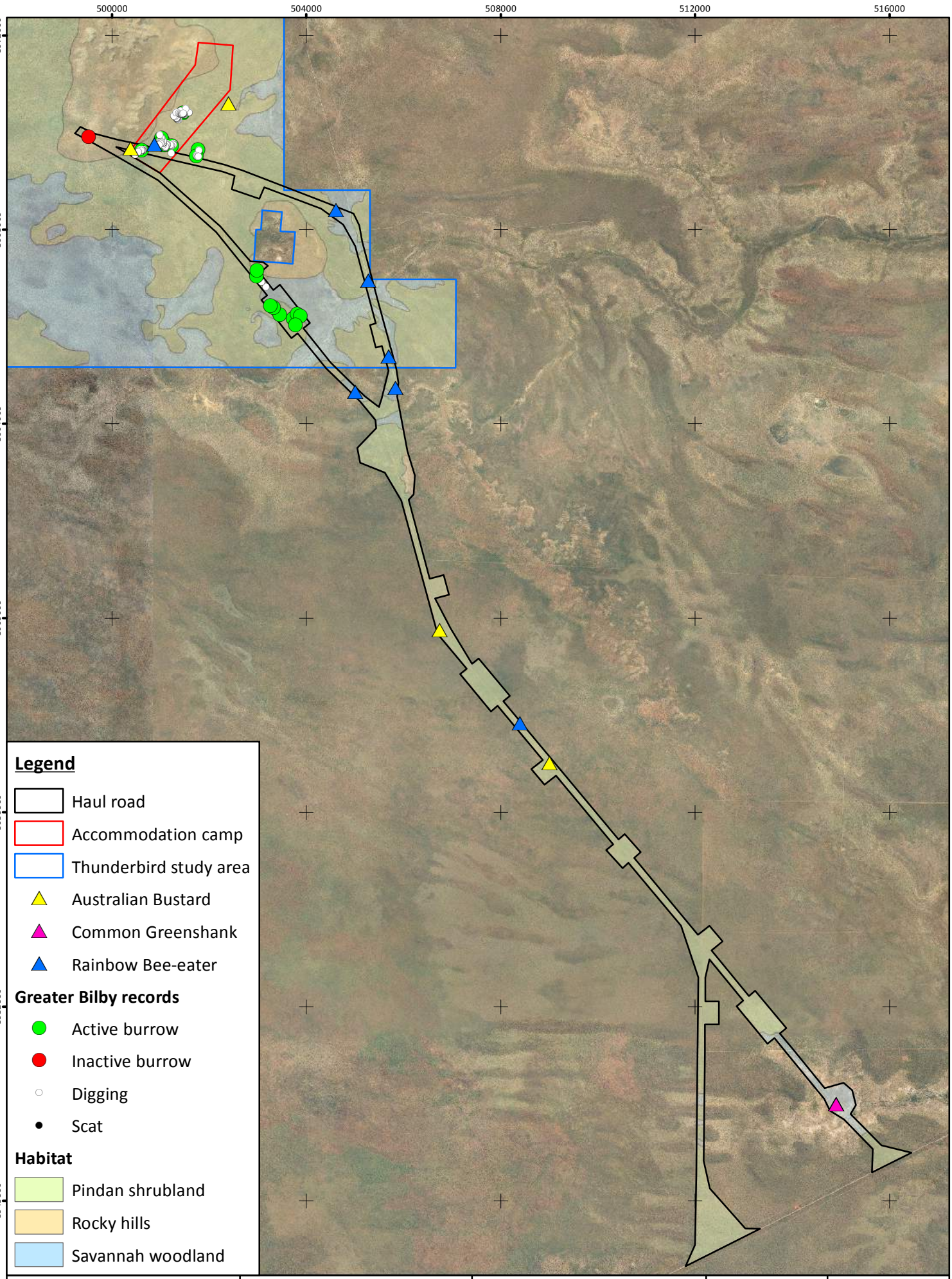
Figure 5.12 – Greater Bilby digging (top left), scat (top right) and active burrow (bottom)

Figure 5.13 – Rainbow Bee-eater recorded from the study area

Figure 5.14 – Australian Bustard recorded from the study area



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Kilometres

Absolute Scale - 1:100,000

N

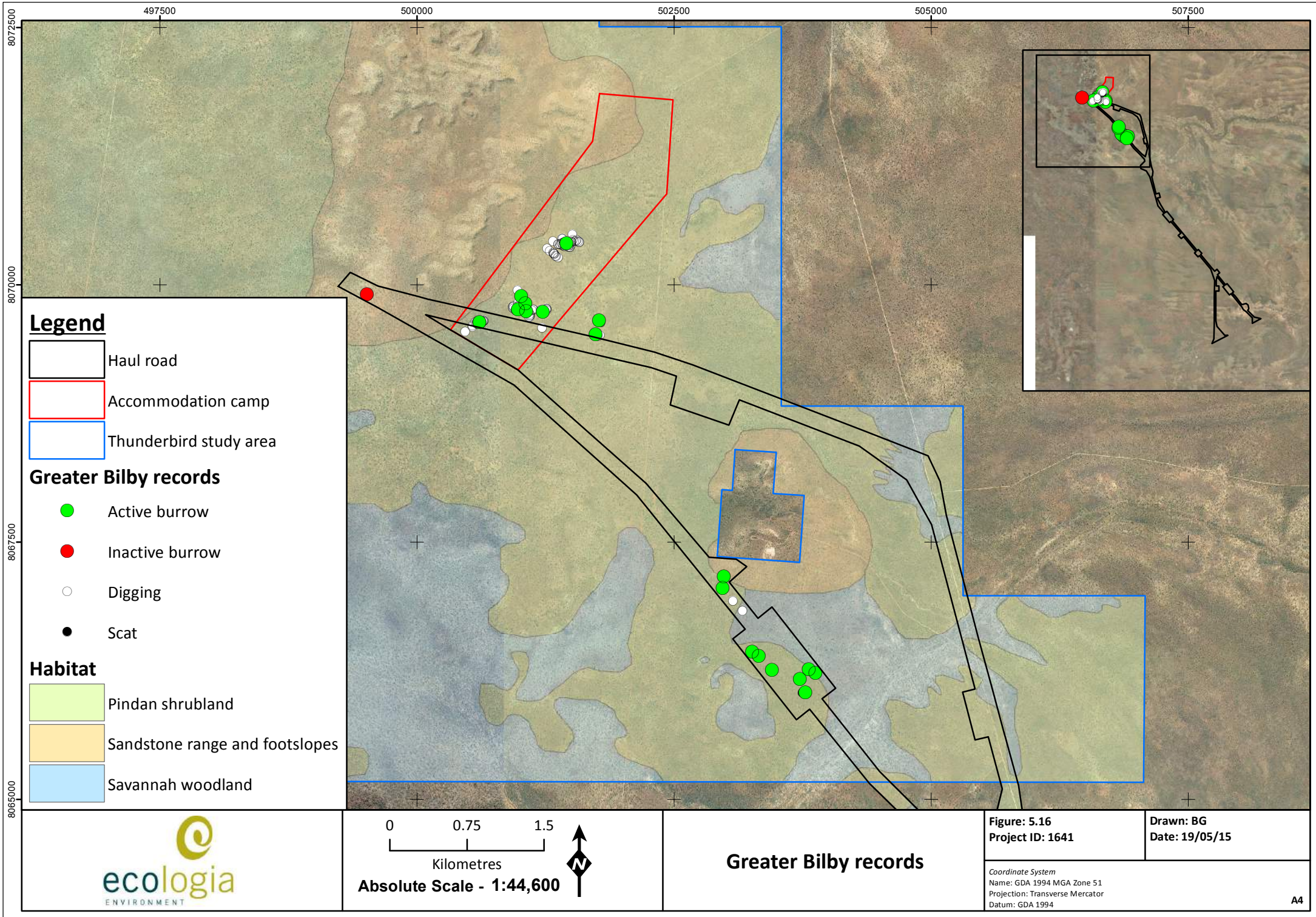
Conservation significant fauna recorded

Figure: 5.15
Project ID: 1641

Drawn: BG
Date: 7/5/15

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

A4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Legend
Haul road
Accommodation camp
Thunderbird study area
Greater Bilby records
Active burrow
Inactive burrow
Digging
Scat
Habitat
Pindan shrubland
Sandstone range and footslopes
Savannah woodland
ecologia
ENVIRONMENT
0
0.75
1.5
Kilometres
Absolute Scale - 1:44,600
N
Greater Bilby records
Figure: 5.16
Project ID: 1641
Drawn: BG
Date: 19/05/15
Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994
A4

5.3.5 Conservation significant fauna habitat utilisation

A summary of the habitat types recorded and potential usage of conservation significant fauna is provided in Table 5.6. Only species recorded during the current survey or were assessed as high likelihood of occurrence were assessed.

Table 5.6 – Summary of potential conservation significant fauna habitat at the study area

Species	Critical habitat types(breeding/roosting)	Area of critical habitat within study area (ha)*	Non-critical habitat types(foraging/dispersal)	Area of non-critical habitat within study area (ha)*
Greater Bilby *Macrotis lagotis*	• Pindan shrubland	1,092.8	• Savannah woodland • Sandstone range and footslopes	256.6
Lakeland Downs Mouse *Leggadina lakedownensis*	• Pindan shrubland • Savannah woodland	1,259.5	-	-
Rainbow Bee-eater *Merops ornatus*	• Pindan shrubland	1,092.8	• Savannah woodland • Sandstone range and footslopes	256.6
Fork-tailed Swift *Apus pacificus*	-	-	• Pindan shrubland • Savannah woodland • Sandstone range and footslopes	1,349.4
Common Greenshank^ *Tringa nebularia*	-	-	• Savannah woodland	166.7
Australian Bustard *Ardeotis australis*	• Pindan shrubland • Savannah woodland	1,259.5	• Sandstone range and footslopes	89.9
Dampier Peninsula Goanna *Varanus sparnus*	• Pindan shrubland • Savannah woodland	1,259.5	• Sandstone range and footslopes	89.9

*Total area within study area used, which includes area previously assessed within Thunderbird assessment
^Suitable habitat within Savannah woodland only during wet season if woodland floods.

6 SURVEY LIMITATIONS AND CONSTRAINTS

According to EPA Guidance Statement 51 and 56 (EPA 2004b), biological surveys may be limited by several aspects. An assessment of these aspects with regard to this study is detailed in Table 6.1. below. Given the few limitations encountered, it can be confirmed that an adequate level of survey was undertaken.

Table 6.1 – Summary of survey limitations

Aspect	Constraint	Comment
Sources of information and availability of contextual information (i.e. pre-existing background versus new material)	Nil	Broad scale (1:1,000,000) mapping by Shepherd *et al* (2006), based on the mapping by Beard (1979), is available. Information on Threatened and Priority flora and fauna species, as well as introduced species in a local context was not limited due to a large number of records in the NatureMap and DPaW databases.
The scope (i.e. what life forms were sampled)	Nil	The flora, vegetation and fauna survey of the study area was conducted in accordance with EPA Guidance Statements 51 and 56.
Proportion of flora collected and identified (based on sampling, timing and intensity)	Nil	A total of 162 vascular plant taxa (including species, infraspecific taxa, and phrase name taxa) were recorded from the study area, representing 97 genera and 41 families. When combined with the data collected from the 2012 and 2014 *ecologia* surveys, approximately 83% of expected number of taxa has been recorded from the Thunderbird Project area. Survey timing between 11 and 15 May 2015 was considered appropriate with the majority of perennial taxa bearing fertile material and the presence of annual and ephemeral species enabling accurate taxonomic identification. Therefore, it is likely that some species, particularly ephemerals and grasses, are likely to have been overlooked.
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	Nil	The quadrat sampling intensity is considered adequate for the assessment (16 quadrats), given the number of vegetation units mapped in the study area (11 units) of which nine were previously surveyed and sampled during the 2014 ecologia Level 2 survey (with a relatively even coverage throughout the study area.
Mapping reliability	Nil	High resolution aerial imagery was available and the number and distribution of quadrats was considered adequate for definition of vegetation units within the study area.
Timing/weather/season/cycle	Nil	The surveys were conducted during favourable weather conditions, following the period of highest rainfall for the region. Although rainfall (for both the Broome and Derby BOM sites) during the months preceding the surveys was below the long-term average, it is likely that it is considered that the majority of species likely to be present (71% from this survey and 83% when previous survey data is included), including ephemerals and grasses, are likely to have been recorded during this survey.
Disturbances (e.g. fire, flood, accidental human intervention)	Nil	There were no natural or human interventions that constrained the survey.
Intensity (in retrospect, was the intensity adequate?)	Nil	The flora species inventory for the assessment is considered large, with 162 vascular plant taxa. Eleven vegetation units were mapped and described, of which nine had been previously described during the 2014 Level 2 assessment (*ecologia,* 2014a*)*. The survey timeframe was adequate for assessment of fauna habitats and the likelihood of occurrence of potential conservation significant species.
Resources	Nil	A total of tenperson-days were expended across the field trip which provided adequate coverage of the area.

Aspect	Constraint	Comment
Experience levels (e.g. degree of expertise in plant identification to taxon level)	Nil	The project manager has 10+ years' of experience conducting botanical surveys and the report has been reviewed by the ecologia Principal Scientist with 25+ years' experience in ecological surveys and environmental impact assessments. Biologists engaged in survey work have between 7 and 10+ years' experience in conducting botanical and zoological surveys. The two taxonomists responsible for identifications of collected, unconfirmed plant specimens both have Doctorates in botanical taxonomy and have completed identifications for many projects within WA, and where necessary, expertise from the Western Australian Herbarium was sought.

7 DISCUSSION

7.1 FLORA CONSERVATION SIGNIFICANCE ASSESSMENT

7.1.1 Flora of National and State Significance

National significance refers to those features of the environment which are recognised under legislation as being of importance to the Australian community; in particular, species & TECs listed under the *EPBC Act* are regarded as nationally significant.

No taxa listed under the EPBC Act or of National significance were recorded at the study area.

State significance refers to those features of the environment that are recognised under State legislation as being of importance to the Western Australian community, in particular, species listed as Threatened and communities as TECs or PECs under the *WC Act* are of state significance.

No taxa listed under WC Act or of State significance were recorded at the study area.

7.1.2 Flora of Regional and Local Significance

Regional significance addresses the representation of species and habitats at a biogeographic regional level. Species or vegetation communities that are restricted to the Dampierland IBRA region and whose distributions are limited or unknown are considered regionally significant.

Local significance is when a species is confined to a specialised habitat type that is not common and potentially restricted to the local area and whose disturbance or removal may lead to local extinction.

Pterocaulon intermedium (Priority 3) was recorded from 14 locations (representing 14 individuals) across the study area, on red sandy plains. *Pterocaulon intermedium* has previously been recorded at nine additional locations within the Thunderbird project (*ecologia* 2014a), and 23 records on Flora Base (Western Australian Herbarium 1998-2015). It is distributed relatively widely across northern WA and also in the Northern Territory and Queensland.

Triodia caelestialis (Priority 3) was recorded from 25 locations representing 8,271 individuals, and is the dominant understorey species in some of the vegetation units identified in the study area, such as *GpAmStTc*. *Triodia caelestialis* has previously been recorded at 79 additional locations within the Thunderbird project (*ecologia* 2014a), and 18 records on Flora Base (Western Australian Herbarium 1998-2015). It is distributed across northern WA in the Dampierland, Central Kimberley and Northern Kimberley bioregions.

Neither of these Priority species is confined to specialised habitats, occurring on widespread pindan sandplains in the study area. Both species are expected to also occur in similar habitat outside the study area, and therefore the project does not pose the threat of extinction to the local populations.

7.1 VEGETATION CONSERVATION SIGNIFICANCE ASSESSMENT

7.1.1 Vegetation of National and State Significance

No ecological communities listed under the EPBC Act or listed as TECs or PECs in Western Australia were recorded at the study area.

7.1.2 Vegetation of Regional and Local Significance

The proposed Thunderbird Haul road and camp study area covers approximately 10% or less of the nine vegetation units mapped in the study area previously described by *ecologia* (2014a). The two vegetation units described from the Haul Road and Camp study area which were not previously described (*AtStCpHc* and *CgDhHc*) are associated with widespread landforms, extensive and plains

(*AtStCpHc*) and floodplains adjacent to ephemeral waterways (*CgDhHc*). These two vegetation units are therefore considered likely to be represented extensively in the surrounding landscape, where such landforms are widespread.

7.2 CONSERVATION SIGNIFICANT FAUNA SPECIES DESCRIPTIONS

Seventeen conservation significant vertebrate fauna species were evaluated as having a medium or high likelihood of occurrence (or were recorded from within the study area, Table 5.4). These species are discussed in further detail below.

7.2.1 Mammals

Greater Bilby (*Macrotis lagotis*)

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

Distribution and habitat: Once common over 70% of mainland Australia's arid and semiarid regions, the Greater Bilby is currently patchily distributed through the Tanami, Great Sandy and Gibson Deserts, extending north onto the Dampier Peninsula near Broome, west to the eastern Pilbara, and south to approximately Warburton (Maxwell *et al.* 1996; Johnson 2008). Isolated populations also occur in south-west Queensland and to the north-east of Alice Springs. Bilbies occur in a variety of habitats, including spinifex grassland, *Acacia* shrubland, open woodland and cracking clays (Maxwell *et al.* 1996; Johnson 2008). The species underwent a sudden and widespread collapse in population size in the early 1900s, and the distribution may still be contracting and fragmenting. Reasons for the decline include predation by feral predators on both young and adult Bilbies, competition from rabbits and livestock, reduced food as a result of changed fire regimes, and drought (Maxwell *et al.* 1996; O'Malley 2006a; Johnson 2008).

Biology: The Bilby is a nocturnal marsupial with soft, silky fur (Pavey 2006b). It uses its strong forelimbs and claws to construct an extensive tunnel system of up to 3 m long and 1.8 m deep in which it shelters during the day. Its long tongue is an adaptation to its specialised diet of seeds, insects, bulbs, fruit and fungi (Johnson 2008).

Likelihood of occurrence: Recorded (resident – breeding). The Greater Bilby was recorded via secondary evidence from numerous locations within the study area (Figure 5.16, Appendix C). These records build on information gathered relatig to Greater Bilby occupation of the Thunderbird study area from the previous assessment (*ecologia* 2014b). Habitat utilisation was consistent with previous records of the study area. Active burrows were predominately located within the pindan shrubland habitat type (Figure 5.16), and more specifically within the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat within the broader pindan shrubland (Section 5.3.2, Figure 5.9).

It appears that the dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat is a product of fire age. Stands of *Acacia tumida* var. *tumida* were observed in areas that had been burnt within the previous year, with a resultant open canopy with dense ground covering vegetation. These areas are unlikely to be suitable to support Greater Bilby in their current condition. However, as these areas mature and increase in fire age, the *Acacia tumida* var. *tumida* shrubs mature and form a canopy layer with ground vegetation becoming sparser, which would then provide suitable habitat for the Greater Bilby to occupy.

The dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat is suitable habitat for Greater Bilby as it provides habitat and a food source. The lack of ground covering vegetation allows for easy movement for the Greater Bilby, the sandy soil substrate allows for the construction of burrows and the canopy allows for protection from aerial predators. Additionally, it was observed a strong feeding association exists between *Acacia tumida* var. *tumida* plants and the Greater Bilby, as numerous diggings were observed at the base of these plants (Figure 5.12). It is likely Greater Bilby are extracting root dwelling insect larvae from these plants, an important food source for the Greater Bilby (Pavey 2006a). This feeding association and general habitat characteristics and utilisation are

consistent with *ecologia's* previous experience with the Greater Bilby on the Dampier Peninsular and the Pilbara.

The Greater Bilby was only recorded from haul road sections of the Thunderbird study area. It is unlikely to occur within the remainder of the haul road study area, due to the narrow linear corridor and lack of dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat and sandy soil substrate. Evidence of Greater Bilby is likely to indicate part of a resident breeding population, however occupation at these areas will be dictated by fire history and will therefore continue to fluctuate accordingly.

Lakeland Downs 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. However, Short-tailed Mice are usually found in seasonally inundated habitats on red or white sandy-clay soils (Moro and Kutt 2008).

Biology: 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: High (resident – breeding). The Lakeland Downs Mouse was recorded during the previous Thunderbird assessment (*ecologia* 2014b). No trapping was completed during this assessment and therefore this species would be difficult to detect. It is likely to occur within pindan shrubland and savannah woodland habitat types, where it will be a resident breeding population.

7.2.2 Birds

Gouldian Finch (*Erythrura gouldiae*)

Conservation status: EPBC Act Endangered, DPaW Priority 4.

Distribution and habitat: The Gouldian Finch was formally distributed throughout the tropical savannahs of northern Australia. It is now restricted to isolated areas mostly within the Northern Territory and the Kimberley region of Western Australia (Woinarski and Palmer 2006). Known breeding habitat is characterised by rocky hills with hollow-bearing, smooth-barked gums that are close to small waterholes or springs that persist through the dry season (O'Malley 2006b).

Biology: Gouldian finches forage on the ground, feeding on seeding grasses, particularly native *Sorghum* spp. (Pizzey and Knight 2003). Due to the restricted diet of Gouldian Finches, they are particularly vulnerable to seed shortages (O'Malley 2006b). The decline in populations of the Gouldian Finch is representative of the general decline of granivorous birds occurring as a result of current land management practices. Ongoing key threats to the Gouldian Finch are vegetation change through inappropriate fire regimes, and grazing impacts of stock and feral herbivores (O'Malley 2006b).

Likelihood of occurrence: Medium. The Gouldian Finch is rarely recorded on the Dampier Peninsular with the exception of the Northern tip. The study area contains suitable foraging and breeding habitat, however given the scarcity in surrounding records, it is only a medium likelihood to occur, and based on current knowledge most likely to be a transient visitor.

Rainbow Bee-eater (*Merops ornatus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

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).

Biology: 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.

Likelihood of occurrence: High (resident – breeding). The Rainbow Bee-eater was recorded on nine occasions during the current survey (Table 5.5), and was recorded within breeding burrows during previous assessment (*ecologia* 2014b). It is likely to forage in all habitat types and construct breeding burrows in any habitats where suitable sandy substrate exists.

Fork-tailed Swift (*Apus pacificus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

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. 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).

Biology: 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: High (migratory visitor). The Fork-tailed Swift has a high likelihood of occurrence within the study area during summer months when this species is present in Australia. As this species is completely aerial whilst in Australia, it will not utilise habitats within the study area directly.

Eastern Great Egret (*Ardea modesta*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Eastern Great Egrets mainly inhabit shallow waterbodies; both fresh (lakes, lagoons, swamps and floodwaters) and saline (mangrove creeks, estuaries and tidal pools) (Johnstone and Storr 1998). They occur across a large part of Western Australia, including the South-west, Kimberley and Pilbara (Johnstone and Storr 1998). The Eastern Great Egret is common to very common in the well-watered Kimberley flatlands, and scarce to moderately common elsewhere within its range (Johnstone and Storr 1998).

Biology: This species' diet consists predominantly of small fish and crustaceans. Eastern Great Egrets breed colonially in trees standing in water around wooded swamps and river pools, 4-13 m above water (Morcombe 2000). The nest is built as a rough, loose, shallow platform. Four eggs are laid in summer in the Kimberley and during the spring in regions further south (Johnstone and Storr 1998).

Likelihood of occurrence: Medium. The Eastern Great Egret has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Cattle Egret (*Ardea ibis*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Cattle Egret has a worldwide distribution, occurring across India, south-east Asia, Papua New Guinea, Australia and New Zealand (Johnstone and Storr 1998; McKilligan 2005; Seedikkoya *et al.* 2005). The Cattle Egret is a partial migrant occurring in the better-watered areas of Australia. In Western Australia Cattle Egrets are casual visitors to the Kimberley and also occasionally to the south-west corner, principally in autumn (Johnstone and Storr 1998).

Biology: Cattle Egrets occur typically in small flocks in grassy habitats and wetlands, particularly damp pastures, and are usually found in the company of cattle or other livestock (Johnstone and Storr 1998; Seedikkoya *et al.* 2005). Unlike most herons, they feed largely on insects such as grasshoppers, but also eat many other invertebrates. Cattle Egrets breed in colonies, usually with other waterbirds. Their nests, rough, loose platforms of sticks, can be found in trees and bushes in wetland areas (Morcombe 2000; RPS 2008).

Likelihood of occurrence: Medium. The Cattle Egret has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features. The open grassland features of this habitat type provides suitable foraging habitat.

Oriental Plover (*Charadrius veredus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Oriental Plover is a lightly built shorebird with long, yellowish legs and a distinctly upright stance (Johnstone and Storr 1998; Simpson and Day 2004). In Western Australia, this species occurs in the Kimberley, north-eastern interior (Lake Gregory) and north-west coastal plains.

Biology: The preferred habitat of the Oriental Plover consists of sparsely vegetated plains, including samphire and short-grass flats, where it feeds largely on insects (Johnstone and Storr 1998). They often forage at night and roost during the day with other waders on beaches or mudflats (Morcombe 2000). Oriental Plovers breed in Mongolia, south Siberia and north China, returning to northern Australia during summer. They are uncommon to common, being most common in the drier parts of their range, occurring usually in flocks of up to 200 birds.

Likelihood of occurrence: Medium. The Oriental Plover has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Little Curlew (*Numenius minutus*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Little Curlews may be found throughout coastal areas of Australia, but are most frequently recorded on the northern and eastern coasts. The species is typically found on short, dry grasslands and often on artificially grassed areas; also on the dry grass edges of freshwater wetlands (Geering *et al.* 2007). Little Curlew flocks are highly mobile, often congregating in wetlands to drink in hot conditions (Geering *et al.* 2007).

Biology: This shorebird is the smallest curlew, which forms small to huge, mobile flocks in northern Australia in short, dry grasslands and sedges (Pizzey and Knight 2003; Geering *et al.* 2007). Little Curlews breed in north-eastern Siberia, with most of the population migrating to the sub-coastal plains of northern Australia in winter (September to April) (Pizzey and Knight 2003; Geering *et al.* 2007). Little Curlews exhibit wary behaviour, walking rapidly, and squatting, freezing or flushing with quick calls.

Likelihood of occurrence: Medium. The Little Curlew has a medium likelhood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Wood Sandpiper (*Tringa glareola*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and Habitat: The Wood Sandpiper breeds in the Europe and northern Asia during the austral winter, migrating south to Africa, south Asia and Australia for the austral summer (Johnstone and Storr 1998). The species is a regular migrant to Western Australia in small numbers, mostly from August to May (Johnstone and Storr 1998). It occurs most commonly in coastal, better-watered regions of the state but will visit areas of suitable habitat in the interior (Johnstone and Storr 1998). In Australia, the species typically occurs around the muddy or grassy margins of freshwater wetlands, including swamps, lagoons, river pools, dams, bore overflows and sewage ponds (Johnstone and Storr 1998; Pizzey and Knight 2003).

Biology: The Wood Sandpiper is a sharp-tailed wader with long legs, a black bill and a long neck, dark brown back and wings and white spots (Simpson and Day 2004)The Wood Sandpiper is a transequatorial migrant, breeding in the northern hemisphere and migrating long distances to winter in the southern hemisphere. In Australia, the species typically occurs in singles, pairs or small parties (Johnstone and Storr 1998).

Likelihood of Occurrence: Medium. The Wood Sandpiper has a medium likelhood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Common Greenshank (*Tringa nebularia*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Common Greenshank is a non-breeding visitor to well-watered regions of Australia that can be observed in all months. It is uncommon to moderately common on coasts and coastal plains and rare to scarce elsewhere (Johnstone and Storr 1998). It can be found in shallow, fresh waters (e.g. claypans, swamps, river pools) and salt waters (e.g. estuaries, samphire flats, reef flats).

Biology: Like most waders, Common Greenshanks feed on small invertebrates, but will also take small fish (Johnstone and Storr 1998; Pizzey and Knight 2003).

Likelihood of Occurrence: Recorded (transient visitor). Two individuals of the Common Greenshank were recorded during the current survey (Table 5.5). The individuals were recorded flying in to land at a relatively small man made turkey nest containing water, in the southern section of the haul road, within the savannah woodland habitat type (Figure 5.15). Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Red-necked Stint (*Calidris ruficollis*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Red-necked Stints are primarily coastal, occurring on the edge of sheltered estuaries, beaches and saltlakes both on the mainland and on offshore islands. They can also occasionally occur on inland saltlakes and freshwater swamps. The species is a non-breeding migrant, arriving from Siberia and Alaska in October and returning in March, and is common to very common on most coasts, rare in the northern interior and moderately common in the southern interior (Johnstone and Storr 1998).

Biology: The species typically occurs in small flocks and is highly gregarious with other species. They are omnivorous, feeding on insects and molluscs captured from exposed mudflats as well as seeds and plant matter.

Likelihood of Occurrence: Medium. The Red-necked Stint has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Long-toed Stint (*Calidris subminuta*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Long-toed Stints are primarily coastal with scattered inland records. They occur in a variety of terrestrial wetlands, prefering shallow freshawater or brackish waters including lakes, swamps, river floodplains, streams lagoons and sewage works (DoE 2015b).

Biology: Long-toed Stints are omnivorous, feeding on seeds, insects, crustaceans and molluscs captured within freshwater habitats where they forage singly or in small flocks (DoE 2015b).

Likelihood of Occurrence: Medium. The Long-toed Stint has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Sharp-tailed Sandpiper (*Calidris acuminata*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Sharp-tailed Sandpiper is a non-breeding visitor to Australia. The species is widespread in a variety of freshwater and saline habitats, and is more often found on the coasts than in the interior, where it prefers well-watered areas (Higgins and Davies 1996; Johnstone and Storr 1998). Sharp-tailed Sandpipers are widespread from Cape Arid to Carnarvon, around coastal and subcoastal plains of Pilbara Region to the south-west and east Kimberley Division. Inland records indicate the species is widespread and scattered from Newman, east to Lake Cohen, south to Boulder and west to Meekatharra (Higgins and Davies 1996).

In Australasia, the Sharp-tailed Sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. They may be attracted to mats of algae and water weed either floating or washed up around terrestrial wetlands and coastal areas with much beachcast seaweed (Higgins and Davies 1996).

Biology: The Sharp-tailed Sandpiper is migratory, breeding in northern Siberia and moving to non-breeding areas south of the equator (Higgins and Davies 1996). They are usually found in ones, twos or small parties, occasionally flocks of up to 300, and rarely in large aggregations of up to 20,000 soon after arrival or shortly before departure (Johnstone and Storr 1998).

Likelihood of Occurrence: Medium. The Sharp-tailed Sandpiper has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small

drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species.

Oriental Pratincole (*Glareola maldivarum*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: The Oriental Pratincole is a non-breeding migrant to Australia. The species breeds from Mongolia, Siberia and China, south to Sri Lanka, Thailand and Vietnam. It then spends the winter period (late October to May) in northern Australia (Johnstone and Storr 1998). Oriental Pratincoles occur on open plains, bare ground around swamps, and claypans.

Biology: Oriental Pratincoles hawk insects from the ground and can sometimes occur in huge flocks. Birds may feed in the evening until nearly dark (Johnstone and Storr 1998).

Likelihood of occurrence: Medium. The Oriental Pratincole has a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Eastern Yellow Wagtail (*Motacilla tschutschensis*) and Grey Wagtail (*Motacilla cinerea*)

Conservation status: EPBC Act Migratory, WC Act Schedule 3, DPaW International Agreement.

Distribution and habitat: Both wagtail species are a relatively uncommon non-breeding migrant to Australia. The Eastern Yellow Wagtail typically occurs in damp, short-grass flats, while the Grey Wagtail more typically occurs along freshwater habitats such as creeks and streams, however both species could occur in any habitats during migration (Johnstone and Storr 2004).

Biology: Both species forage along the ground surface where they pick small insects from the ground after a short chase or bounce in the air (Johnstone and Storr 2004)..

Likelihood of occurrence: Medium. Both wagtail species have a medium likelihood of occurrence. Suitable habitat exists within the savannah woodland habitat type which contains small drainage lines and occurs in low lying landscape features and grasslands. Should these pastures flood during the wet season, then temporary suitable forgaing habitat may exist for this species, along with permanent open and bare areas.

Grey Falcon (*Falco hypoleucos*)

Conservation status: WC Act Schedule 1, DPaW 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. Grey Falcons once occurred across much of Western Australia, with sightings as far south as York and New Norcia during colonial times. 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).

Biology: 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 (Garnett and Crowley 2000; Ehmann and Watson 2008).

Likelihood of occurrence: Medium. The low density and scarce sightings of the Grey Falcon suggest this species has a medium likelihood of occurrence within the study area. Utilisation of the study would most likely be of a transient foraging nature.

Peregrine Falcon (*Falco hypoleucos*)

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.

Biology: 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 low density and scarce sightings of the Peregrine Falcon suggest this species has a medium likelihood of occurrence within the study area. Utilisation of the study would most likely be of a transient foraging nature.

Australian Bustard (*Ardeotis australis*)

Conservation status: DPaW Priority 4.

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

Biology: 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.

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 (resident – breeding). The Australian Bustard was recorded on four occasions during the current survey (Table 5.5). This species is likely to be resident within the study area, and when conditions are suitable likely to breed within the study area.

7.2.3 Reptiles

Dampierland Plain Slider (*Lerista separanda*)

Conservation status: DPaW Priority 2.

Distribution and habitat: *Lerista separanda* is currently known to be found in sandy soils along the south-west Kimberley coastline, between Kimbolton and Nita Downs (Wilson and Swan 2010).

Biology: There is little information on the biology of this species. *L. separanda* is one of the smallest species in the genus and has a fused lower eyelid (Wilson and Swan 2010). Whereas most other *Lerista* species have greatly reduced or only two limbs, *L. separanda* has four of the relatively largest limbs. This strongly suggests that it is not only able to push its way through sand but also walk across it.

Likelihood of occurrence: Medium. Although the only records are from the western coast of the Dampier Peninsula, they are from a sandy loam soil with pindan shrubland habitat. This habitat is widespread and abundant across the peninsula, and is present within the study area. It is therefore possible for the distribution of *Lerista separanda* to include the study area. Similarly, *Lerista apoda* and *Lerista greeri* were previously only known from the western coastline and to the east of the Dampier Peninsula respectively, yet both were recorded during the previous Thunderbird assessment (*ecologia* 2014b).

Dampierland Burrowing Snake (*Simoselaps minimus*)

Conservation status: DPaW Priority 2.

Distribution and habitat: This snake is currently known only from the western side of the Dampier Peninsula. Its preferred habitat is on coastal dunes or the sandy areas between dunes and adjacent *Acacia* shrublands (Wilson and Swan 2010).

Biology: Little is known of the Dampierland Burrowing Snake's biology, but it is presumably similar to other *Simoselaps* species, which are sand-swimmers that feed mostly on *Lerista* skinks (Wilson and Swan 2010).

Likelihood of occurrence: **Medium.** Although previous records are from the western coast of the Dampier Peninsula, they are from sandy soils. Given sandy soils extend across much of the peninsula, and are characteristic of the pindan shrubland and savannah woodland habitats found within the study area, the Dampierland Burrowing Snake may therefore occur within the study area.

Dampierland Peninsula Goanna (*Varanus sparnus*)

Conservation status: DPaW Priority 2.

Distribution and habitat: The Dampier Peninsula Goanna is currently only known from four point locations, which represent the specimens used to describe the species (Doughty *et al.* 2014). The known distribution extends from coastal areas at Coulomb Point, 90 km, east to central Dampier Peninsula. Specimens were collected from habitats broadly described as pindan shrubland with sandy soils associated with alluvial or sandstone deposits (Doughty *et al.* 2014). The previous Thunderbird assessment recorded *Varanus sparnus/brevicauda* across all habitat types present (pindan shrubland, savannah woodland, sandstone range and footslopes) (*ecologia* 2014b).

Biology: The Dampier Peninsula Goanna which weighs approximately 16 grams is the smallest known *Varanus* species in the world. It has been observed to be an active burrower in captivity, with a highly prehensile tail, possibly for assisting in navigation through spinifex clumps (Doughty *et al.* 2014).

Likelihood of occurrence: **High (resident – breeding).** The Dampier Peninsula Goanna was not recorded on the current survey. However the sampling methods sonducted were unlikely to record this cryptic species. Given the species was recorded within the Thunderbird project study area; it is likely to occur within the current study area where there is likely to be a resident breeding population. Appendix H details the recent description and clarifies the Dampier Peninsula Goanna's occurrence in relation to the Thunderbird project.

8 CONCLUSIONS

The key results and conclusions of the flora, vegetation and fauna assessment are as follows:

- No Threatened Flora taxa were recorded in the study area;
- Two Priority flora taxa were recorded at the study area; *Pterocaulon intermedium* (Priority 3) and *Triodia caelestialis* (Priority 3).
- No WONS or Declared Pests (Weeds) were recorded at the study area, but four introduced species of flora were recorded at the study area: **Malvastrum americanum*, **Stylosanthes hamata*, **Stylosanthes scabra* and **Tridax procumbens*.
- No TECs or PECs were recorded, or are considered likely to occur in the study area.
- Approximately 10% or less of the currently mapped extent of nine of the eleven vegetation units described in the study area is covered by the study area. The other two vegetation units, which were not described in the previous Thunderbird assessments (*AtStCpHc* and *CgDhHc*), are associated with widespread landforms: extensive and plains (*AtStCpHc*) and floodplains adjacent to ephemeral waterways (*CgDhHc*). These two vegetation units are therefore considered likely to be represented extensively in the surrounding landscape, where such landforms are widespread.
- The literature review identified a total of 383 fauna species that may potentially to occur within the study area, including 32 native and six introduced mammal species, 249 bird species, 82 reptiles and 14 amphibians. Species recorded from the literature review include a total of 69 conservation significant vertebrate fauna species, comprising six mammal species, 59 bird species and four reptile species.
- Three broad fauna habitat types were identified and delineated for the study area; pindan shrubland, savannah woodland and sandstone range and footslopes. All fauna habitat types were recorded during the previous Thunderbird assessment and are extensive through the region.
- Four conservation significant fauna species were recorded; Greater Bilby (EPBC Act Vulnerable), Rainbow Bee-eater (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement), Common Greenshank (EPBC Migratory, WC Act Schedule 3, DPaW International Agreement) and Australian Bustard (DPaW Priority 4).
- The Greater Bilby was only recorded from the haul road sections of the current Thunderbird project study area. It is unlikely to occur within the remainder of the haul road study area, due to the narrow linear corridor and absence of dense, mature *Acacia tumida* var. *tumida* woodland micro-habitat and sandy soil substrate. Locations where Greater Bilby were recorded may be part of a resident breeding population, however occupation at these areas will be determined by fire history and will therefore continue to fluctuate accordingly.
- Of the 69 conservation significant fauna species that may potentially occur within the study area, a total of 46 species were assessed as having a low likelihood, 16 species as medium likelihood and seven species as high likelihood or were recorded during the current survey.

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APPENDIX A CONSERVATION CODES

Definition of codes for Threatened and Priority Flora (DPaW)

Code	Definition
T	**Threatened Flora – (Declared Rare Flora – Extant)** Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection and have been gazetted as such (Schedule 1 under the *Wildlife Conservation Act 1950*).
X	**Presumed Extinct Flora (Declared Rare Flora - Extinct)** Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such Schedule 2 under the *Wildlife Conservation Act 1950*).
P1	**Priority One – Poorly Known Species** Species that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2	**Priority Two – Poorly Known Species** Species that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Species may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
P3	**Priority Three – Poorly Known Species** Species that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
P4	**Priority Four – Rare, Near Threatened and other species in need of monitoring** (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
P5	**Priority Five - Conservation Dependent species** Species that are not threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Definition of codes for Commonwealth Listed Threatened Flora

Code	Definition
Ex	**Extinct** Taxa which at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
ExW	**Extinct in the Wild** Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	**Critically Endangered** Taxa which at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	**Endangered** Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	**Vulnerable** Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	**Conservation Dependent** Taxa which at a particular time if, at that time, the species is the focus of a specific conservation programme, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Definition of codes for Threatened Ecological Communities

Code	Definition
PD: Presumed Totally Destroyed	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant
CR: Critically Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
EN: Endangered	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future.
VU: Vulnerable	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

Definition of codes for Priority Ecological Communities

Code	Definition
P1: Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or Pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) Communities made up of large, and/or widespread occurrences that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4: Priority Four	Ecological communities that are adequately known, Rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Ecological communities that have been removed from the list of threatened communities during the past five years. P5: Priority Five Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.
P5: Priority Five	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Definition of codes for Threatened Fauna (WC Act)

Code	Definition
T (Schedule 1)	Fauna that is rare or likely to become extinct Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction or otherwise in need of special protection, and have been gazetted as such. Further categorised as: • CR Critically Endangered – considered to be facing an extremely high risk of extinction in the wild • EN Endangered – considered to be facing a very high risk of extinction in the wild • VU Vulnerable – considered to be facing a high risk of extinction in the wild.
X (Schedule 2)	Presumed Extinct Fauna Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.
IA (Schedule 3)	Birds protected under an international agreement. Birds that 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 special protection.
S (Schedule 4)	Other specially protected fauna Fauna that is in need of special protection, otherwise than for the reasons mentioned [in Schedule 1 – 3].]

Definition of codes for Priority Fauna

Code	Definition
P1	**Priority One** Taxa with few, poorly known populations on threatened lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
P2	**Priority Two** Taxa with few, poorly known populations on conservation lands. Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
P3	**Priority Three** Taxa with several, poorly known populations, some on conservation lands. Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.
P4	**Priority Four** Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.
P5	**Priority Five** Taxa in need of monitoring. 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.

Definition of codes for Threatened Fauna (EPBC Act)

Code	Definition
Ex	**Extinct** Taxa not definitely located in the wild during the past 50 years
ExW	**Extinct in the Wild** Taxa known to survive only in captivity
CE	**Critically Endangered** Taxa facing an extremely high risk of extinction in the wild in the immediate future
E	**Endangered** Taxa facing a very high risk of extinction in the wild in the near future
V	**Vulnerable** Taxa facing a high risk of extinction in the wild in the medium-term
NT	**Near Threatened** Taxa that risk becoming Vulnerable in the wild
CD	**Conservation Dependent** Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.
DD	**Data Deficient (Insufficiently Known)** Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.

APPENDIX B FAUNA LITERATURE REVIEW RESULTS

Mammals

Species and family	Common name	EPBC Act	WC Act	DEC	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	J ames Price Point (AECOM 2010)	James Price Point (AECOM 2011)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
TACHYGLOSSIDAE																	
Tachyglossus aculeatus	Echidna					●		S				●		●			S
DASYURIDAE																	
Dasyurus hallucatus	Northern Quoll	**EN**	**S1**	**EN**												●	
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart					●	●							●			
PERAMELIDAE																	
Isoodon auratus	Golden Bandicoot	**VU**	**S1**	**VU**											●		
THYLACOMYIDAE																	
Macrotis lagotis	Greater Bilby	**VU**	**S1**	**VU**		●	**S**	S	S			S	S	●	●	●	S
PHALANGERIDAE																	
Trichosurus vulpecula arnhemensis	Northern Brushtail Possum						●					●					
MACROPODIDAE																	
Macropus agilis	Agile Wallaby					●	**S**	●		●	●	●		●			●
Macropus robustus	Euro				●	●						●		●			
Macropus rufus	Red Kangaroo											●					
EMBALLONURIDAE																	
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat					●	●			●		●					
Taphozous georgianus	Common Sheathtail Bat											●					
MOLOSSIDAE																	
Chaerophon jobensis	Northern Freetail Bat				●	●	●			●		●		●			
Mormopterus beccarii	Beccari's Freetail Bat											●					

Species and family	Common name	EPBC Act	WC Act	DEC	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	J ames Price Point (AECOM 2010)	James Price Point (AECOM 2011)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
Mormopterus loriae	Little Northern Freetail Bat			**P1**								●					
Tadarida australis	White-striped Freetail Bat											●					
VESPERTILIONIDAE																	
Chalinolobus gouldii	Gould's Wattled Bat				●	●	●			●		●		●			
Chalinolobus nigrogriseus	Hoary Wattled Bat				●	●	●			●		●		●			
Miniopterus schreibersii orianae	Common Bentwing Bat					●						●					
Myotis macropus	Large-footed Myotis					●											
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat									●		●					
Nyctophilus geoffroyi	Lesser Long-eared Bat					●	●					●					
Pipistrellus westralis	Northern Pipistrell											●					
Scotorepens greyii	Little Broad-nosed Bat				●	●	●			●		●		●			
Scotorepens sanborni	Northern broad-nosed Bat									●		●					
Vespadelus caurinus	Western Cave Bat											●					
Vespadelus douglasorum	Yellow-lipped Cave Bat			**P2**			●										
Vespadelus finlaysoni	Finlayson's Cave Bat											●		●			
MURIDAE																	
Leggadina lakedownensis	Lakeland Downs Mouse			**P4**		●						●		●			
Pseudomys delicatulus	Delicate Mouse					●	●	S		●	●	●		●			●
Pseudomys nanus	Western Chestnut Mouse					●	●					●		●			
Rattus tunneyi	Pale Field Rat											●	●				
CANIDAE																	
Canis lupus dingo	Dog/Dingo				●	●	●	●		●	●	●		●			●

Species and family	Common name	EPBC Act	WC Act	DEC	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	J ames Price Point (AECOM 2010)	James Price Point (AECOM 2011)	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	James price Point (ENV 2011)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
INTRODUCED MAMMALS																	
Mus musculus	House Mouse					●				●		●		●			
Rattus rattus	Black Rat							●				●					
Vulpes vulpes	Red Fox											●					
Felis catus	Cat				●	●	●	●		●	●	●		●			●
Equus asinus	Donkey						●					●					
Bos taurus	Cow				●	●		●				●		●			●

Birds

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	J ames Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
PHASIANIDAE																	
Coturnix ypsilophora	Brown Quail					●	●	●	●	●	●		●			●	
ANSERANATIDAE																	
Anseranas semipalmata	Magpie Goose					●							●			●	
ANATIDAE																	
Dendrocygna eytoni	Plumed Whistling-duck					●					●	●	●			●	
Dendrocygna arcuata	Wandering Whistling-duck					●					●	●	●			●	
Stictonetta naevosa	Freckled Duck					●							●				
Cygnus atratus	Black Swan												●				
Chenonetta jubata	Australian Wood Duck					●						●	●			●	
Malacorhynchus membranaceus	Pink-eared Duck					●						●	●			●	
Nettapus pulchellus	Green Pygmy-Goose					●						●	●			●	
Anas gracilis	Grey Teal				●	●					●	●	●			●	
Anas superciliosa	Pacific Black Duck				●	●					●	●	●			●	
Aythya australis	Hardhead					●					●	●	●			●	
PODICIPEDIDAE																	
Tachybaptus novaehollandiae	Australasian Grebe					●					●	●	●			●	
Poliocephalus poliocephalus	Hoary-headed Grebe											●	●			●	
Podiceps cristatus	Great Crested Grebe												●				
COLUMBIDAE																	

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Phaps chalcoptera	Common Bronzewing												●				
Phaps histrionica	Flock Bronzewing						●				●		●			●	
Ocyphaps lophotes	Crested Pigeon				●	●		●	●	●	●		●			●	●
Geopelia cuneata	Diamond Dove				●	●	●		●	●	●		●			●	●
Geopelia striata	Peaceful Dove				●	●	●	●	●	●	●		●			●	●
Geopelia humeralis	Bar-shouldered Dove						●	●	●	●	●		●			●	
PODARGIDAE																	
Podargus strigoides	Tawny Frogmouth					●	●	●	●	●	●		●			●	●
EUROSTOPODIDAE																	
Eurostopodus argus	Spotted Nightjar					●		●			●		●			●	●
AEGOTHELIDAE																	
Aegotheles cristatus	Australian Owlet-nightjar					●	●	●		●	●		●			●	
APODIDAE																	
Apus pacificus	Fork-tailed Swift	**M**	**S3**	**IA**		●	●	●		●			●		●	●	
FREGATIDAE																	
Fregata ariel	Lesser Frigatebird	**M**	**S3**	**IA**			●	●	●		●	●			●	●	
SULIDAE																	
Sula leucogaster	Brown Booby	**M**	**S3**	**IA**			●				●	●				●	
ANHINGIDAE																	
Anhinga novaehollandiae	Australasian Darter										●	●				●	
PHALACROCORACIDAE																	
Microcarbo melanoleucos	Little Pied Cormorant				●	●					●	●	●			●	

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Phalacrocorax carbo	Great Cormorant															●	
Phalacrocorax sulcirostris	Little Black Cormorant										●	●	●			●	
Phalacrocorax varius	Pied Cormorant							●			●	●				●	
PELECANIDAE																	
Pelecanus conspicillatus	Australian Pelican					●	●	●			●	●	●			●	
CICONIIDAE																	
Ephippiorhynchus asiaticus	Black-necked Stork										●	●	●			●	
ARDEIDAE																	
Ardea pacifica	White-necked Heron				●	●					●	●	●			●	●
Ardea modesta	Eastern Great Egret	**M**	**S3**	**IA**							●	●	●		●	●	
Egretta picata	Pied Heron										●					●	
Egretta novaehollandiae	White-faced Heron				●	●		●			●	●	●			●	
Ardea intermedia	Intermediate Egret												●				
Ardea ibis	Cattle Egret	**M**	**S3**	**IA**							●		●		●	●	
Ardea sumatrana	Great-billed Heron												●				
Butorides striatus	Striated Heron										●	●				●	
Egretta garzetta	Little Egret										●	●				●	
Egretta sacra	Eastern Reef Egret	**M**	**S3**	**IA**							●	●				●	
Nycticorax caledonicus	Nankeen Night Heron								●							●	
THRESKIORNITHIDAE																	
Plegadis falcinellus	Glossy Ibis	**M**	**S3**	**IA**							●	●	●			●	
Threskiornis molucca	Australian White Ibis										●	●	●			●	

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Threskiornis spinicollis	Straw-necked Ibis				●	●		●			●	●	●			●	●
Platalea regia	Royal Spoonbill					●						●	●			●	
Platalea flavipes	Yellow-billed Spoonbill												●				
ACCIPITRIDAE																	
Pandion cristatus	Eastern Osprey	**M**						●	●		●				●	●	
Elanus axillaris	Black-shouldered Kite							●			●					●	
Lophoictinia isura	Square-tailed Kite						●		●		●					●	●
Hamirostra melanosternon	Black-breasted Buzzard				●								●			●	●
Haliaeetus leucogaster	White-bellied Sea-Eagle	**M**	**S3**	**IA**			●	●	●	●	●		●		●	●	
Haliastur sphenurus	Whistling Kite				●	●		●			●		●			●	●
Haliastur indus	Brahminy Kite						●	●		●	●		●			●	
Milvus migrans	Black Kite				●	●	●	●			●		●			●	●
Accipiter fasciatus	Brown Goshawk				●	●	●	●	●	●	●		●			●	
Accipiter cirrhocephalus	Collared Sparrowhawk					●	●				●		●			●	
Circus assimilis	Spotted Harrier					●					●		●			●	
Circus approximans	Swamp Harrier										●		●			●	
Erythrotriorchis radiatus	Red Goshawk	**VU**	**S1**	**VU**											●		
Aquila audax	Wedge-tailed Eagle				●	●							●			●	●
Hieraaetus morphnoides	Little Eagle						●				●					●	
FALCONIDAE																	
Falco cenchroides	Nankeen Kestrel				●	●	●	●	●		●					●	●
Falco berigora	Brown Falcon				●	●	●	●	●	●	●		●			●	●

Species and family	Common name	EPBC Act	WC Act	DEC Act	Thunderbird Level1 (*ecologia* 2014b)	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	James Price Point (AECOM 2010)	Jmes Price Point (Biota 2009)	James Price Point (Bamford 2011)	Dampier Peninsula (ENV 2008)	North-West WA (Rogers *et al.* 2009)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	Birdata	This survey
Falco longipennis	Australian Hobby					●		●					●			●	●
Falco hypoleucos	Grey Falcon		**S1**	**VU**									●			●	
Falco subniger	Black Falcon												●				
Falco peregrinus	Peregrine Falcon		**S4**	**Other**				●	●		●		●	●		●	
GRUIDAE																	
Grus rubicunda	Brolga				●						●	●	●			●	
RALLIDAE																	
Porphyrio porphyrio	Purple Swamphen										●		●			●	
Rallina fasciata	Red-legged Crake										●						
Gallirallus philippensis	Buff-banded Rail										●					●	
Porzana pusilla	Baillon's Crake												●				
Fulica atra	Eurasian Coot					●						●	●			●	
OTIDIDAE																	
Ardeotis australis	Australian Bustard			**P4**	●	●	●				●		●	●		●	●
BURHINIDAE																	
Burhinus grallarius	Bush Stone-curlew				●	●	●		●		●		●	●		●	●
Esacus magnirostris	Beach Stone-curlew							●			●					●	
HAEMATOPODIDAE																	
Haematopus longirostris	Australian Pied Oystercatcher						●	●	●		●	●				●	
Haematopus fuliginosus	Sooty Oystercatcher						●	●			●	●				●	
RECURVIROSTRIDAE																	
Himantopus himantopus	Black-winged Stilt					●					●	●	●			●	

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Recurvirostra novaehollandiae	Red-necked Avocet											●	●			●	
CHARADRIIDAE																	
Pluvialis fulva	Pacific Golden Plover	**M**	**S3**	**IA**							●	●	●			●	
Pluvialis squatarola	Grey Plover	**M**	**S3**	**IA**							●	●	●			●	
Charadrius leschenaultii	Greater Sand Plover	**M**	**S3**	**IA**				●			●	●	●			●	
Charadrius mongolus	Lesser Sand Plover	**M**	**S1, S3**	**EN**				●				●				●	
Charadrius ruficapillus	Red-capped Plover						●				●	●	●			●	
Charadrius veredus	Oriental Plover	**M**	**S3**	**IA**								●	●		●	●	
Elseyornis melanops	Black-fronted Dotterel				●	●		●			●	●	●			●	
Erythrogonys cinctus	Red-kneed Dotterel					●					●	●	●			●	
Vanellus miles	Masked Lapwing				●	●		●			●	●	●			●	
JACANIDAE																	
Irediparra gallinacea	Comb-crested Jacana					●					●		●			●	
ROSTRATULIDAE																	
Rostratula australis	Australian Painted Snipe	**EN,M**	**S1**	**EN**									●	●	●	●	
SCOLOPACIDAE																	
Gallinago megala	Swinhoe's Snipe	**M**	**S3**	**IA**								●	●			●	
Limosa limosa	Black-tailed Godwit	**M**	**S3**	**IA**								●	●			●	
Limosa lapponica	Bar-tailed Godwit	**M**	**S1, S3**	**VU, IA**				●			●	●	●			●	
Numenius minutus	Little Curlew	**M**	**S3**	**IA**								●	●			●	
Numenius phaeopus	Whimbrel	**M**	**S3**	**IA**				●			●	●				●	
Numenius madagascariensis	Eastern Curlew	**CR, M**	**S1, S3**	**VU, IA**				●			●	●				●	

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Xenus cinereus	Terek Sandpiper	**M**	**S3**	**IA**								●				●	
Actitis hypoleucos	Common Sandpiper	**M**	**S3**	**IA**					●		●	●	●			●	
Tringa brevipes	Grey-tailed Tattler	**M**	**S3**	**P4**				●			●	●				●	
Tringa glareola	Wood Sandpiper	**M**	**S3**	**IA**		●		●				●	●			●	
Tringa nebularia	Common Greenshank	**M**	**S3**	**IA**				●			●	●	●			●	●
Tringa stagnatilis	Marsh Sandpiper	**M**	**S3**	**IA**								●				●	
Arenaria interpres	Ruddy Turnstone	**M**	**S3**	**IA**				●			●	●				●	
Limnodromus semipalmatus	Asian Dowitcher	**M**	**S3**	**IA**								●				●	
Calidris tenuirostris	Great Knot	**M**	**S1, S3**	**VU, IA**							●	●				●	
Calidris canutus	Red Knot	**M**	**S1, S3**	**VU, IA**								●				●	
Calidris alba	Sanderling	**M**	**S3**	**IA**				●			●	●				●	
Calidris ruficollis	Red-necked Stint	**M**	**S3**	**IA**				●			●	●	●			●	
Calidris subminuta	Long-toed Stint	**M**	**S3**	**IA**								●	●			●	
Calidris melanotos	Pectoral Sandpiper	**M**	**S3**	**IA**								●				●	
Calidris acuminata	Sharp-tailed Sandpiper	**M**	**S3**	**IA**				●				●	●			●	
Calidris ferruginea	Curlew Sandpiper	**CR, M**	**S1, S3**	**VU, IA**								●	●			●	
Limicola falcinellus	Broad-billed Sandpiper	**M**	**S3**	**IA**								●				●	
Philomachus pugnax	Ruff	**M**	**S3**	**IA**								●	●			●	
TURNICIDAE																	
Turnix maculosus	Red-backed Button-quail									●	●					●	
Turnix castanotus	Chestnut-backed Button-quail			**P4**				●									
Turnix pyrrhothorax	Red-chested Button-quail					●	●	●					●			●	

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Turnix velox	Little Button-quail				●	●	●				●		●			●	
	Button-quail sp.					●											
GLAREOLIDAE																	
Glareola maldivarum	Oriental Pratincole	**M**	**S3**	**IA**								●	●		●	●	
Stiltia isabella	Australian Pratincole										●	●	●			●	
STERCORARIIDAE																	
Stercorarius parasiticus	Arctic Jaeger	**M**	**S3**	**IA**												●	
LARIDAE																	
Sternula albifrons	Little Tern	**M**	**S3**	**IA**				●			●	●				●	
Sternula nereis	Fairy Tern										●					●	
Gelochelidon nilotica	Gull-billed Tern							●			●	●				●	
Hydroprogne caspia	Caspian Tern	**M**	**S3**	**IA**								●				●	
Chlidonias hybrida	Whiskered Tern										●	●				●	
Chlidonia leucopterus	White-winged Black Tern	**M**	**S3**	**IA**							●	●				●	
Sterna dougallii	Roseate Tern	**M**	**S3**	**IA**							●	●				●	
Sterna hirundo	Common Tern	**M**	**S3**	**IA**			●	●				●				●	
Thalasseus bengalensis	Lesser Crested Tern	**M**	**S3**	**IA**			●	●			●	●				●	
Thalasseus bergii	Crested Tern						●	●			●	●				●	
Chroicocephalus novaehollandiae	Silver Gull							●			●	●				●	
CACATUIDAE (PSITTACIDAE)																	
Calyptorhynchus banksii	Red-tailed Black-Cockatoo				●	●	●	●			●		●			●	●
Eolophus roseicapillus	Galah				●	●					●		●			●	●

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Cacatua sanguinea	Little Corella				●	●		●			●		●			●	●
Nymphicus hollandicus	Cockatiel				●	●	●						●			●	●
PSITTACIDAE																	
Trichoglossus haematodus	Rainbow Lorikeet						●		●	●			●			●	
Trichoglossus haematodus rubritorquis	Red-collared Lorikeet				●	●		●			●		●				●
Psitteuteles versicolor	Varied Lorikeet				●	●	●		●		●		●			●	●
Aprosmictus erythropterus	Red-winged Parrot				●	●	●	●	●	●	●		●			●	●
Melopsittacus undulatus	Budgerigar				●	●					●		●			●	●
CUCULIDAE																	
Centropus phasianinus	Pheasant Coucal				●	●	●	●	●	●	●		●			●	
Scythrops novaehollandiae	Channel-billed Cuckoo							●								●	
Chalcites basalis	Horsfield's Bronze-Cuckoo				●	●	●	●	●		●		●			●	
Chalcites osculans	Black-eared Cuckoo							●	●							●	
Chalcites minutillus	Little Bronze-Cuckoo					●	●				●		●			●	
Cacomantis pallidus	Pallid Cuckoo				●	●	●	●			●		●			●	
Cacomantis variolosus	Brush Cuckoo					●	●	●	●		●		●			●	
Cuculus optatus	Oriental Cuckoo							●								●	
STRIGIDAE																	
Ninox connivens	Barking Owl										●					●	
Ninox novaeseelandiae	Southern Boobook				●	●	●				●		●			●	
TYTONIDAE																	

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Tyto longimembris	Eastern Grass Owl										●					●	
Tyto novaehollandiae kimberli	Masked Owl	**VU**		**P1**										●	●		
HALCYONIDAE																	
Dacelo leachii	Blue-winged Kookaburra				●	●	●	●	●		●		●			●	●
Todiramphus pyrrhopygius	Red-backed Kingfisher					●		●	●		●		●			●	
Todiramphus sanctus	Sacred Kingfisher					●	●	●	●	●	●		●			●	
Todiramphus chloris	Collared Kingfisher										●		●			●	
MEROPIDAE																	
Merops ornatus	Rainbow Bee-eater	**M**	**S3**	**IA**	●	●	●	●	●	●	●		●		●	●	●
CORACIIDAE																	
Eurystomus orientalis	Dollarbird					●	●	●	●				●			●	
CLIMACTERIDAE																	
Climacteris melanura	Black-tailed Treecreeper				●	●	●				●		●			●	●
PTILINORHYNCHIDAE																	
Ptilonorhynchus nuchalis	Great Bowerbird				●	●	●	●	●	●	●		●			●	
MALURIDAE																	
Malurus lamberti	Variegated Fairy-wren					●	●	●	●	●	●		●			●	●
Malurus melanocephalus	Red-backed Fairy-wren				●	●	●	●	●		●		●				●
ACANTHIZIDAE																	
Smicrornis brevirostris	Weebill				●	●	●		●		●		●			●	●
Gerygone levigaster	Mangrove Gerygone							●			●		●			●	
Gerygone fusca	Western Gerygone										●					●	

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Gerygone tenebrosa	Dusky Gerygone										●					●	
Gerygone albogularis	White-throated Gerygone				●	●	●	●	●	●	●		●			●	●
PARDALOTIDAE																	
Pardalotus rubricatus	Red-browed Pardalote				●	●		●	●		●		●			●	●
Pardalotus striatus	Striated Pardalote				●	●	●		●	●	●		●			●	●
MELIPHAGIDAE																	
Certhionyx variegatus	Pied Honeyeater										●						
Lichenostomus virescens	Singing Honeyeater				●	●	●	●	●	●	●		●			●	●
Lichenostomus unicolor	White-gaped Honeyeater						●	●	●	●	●					●	
Lichenostomus plumulus	Grey-fronted Honeyeater								●								
Lichenostomus flavescens	Yellow-tinted Honeyeater				●	●	●		●		●					●	●
Lichenostomus penicillatus	White-plumed Honeyeater							●	●								
Manorina flavigula	Yellow-throated Miner										●					●	
Ramsayornis fasciatus	Bar-breasted Honeyeater												●				
Conopophila rufogularis	Rufous-throated Honeyeater					●	●	●	●		●		●			●	
Epthianura crocea	Yellow Chat												●				
Epthianura tricolor	Crimson Chat										●						
Sugomel niger	Black Honeyeater				●	●										●	
Myzomela erythrocephala	Red-headed Honeyeater							●			●					●	
Cissomela pectoralis	Banded Honeyeater					●	●						●			●	
Lichmera indistincta	Brown Honeyeater				●	●	●	●	●	●	●		●			●	●
Melithreptus gularis	Black-chinned Honeyeater				●	●	●	●	●	●	●		●			●	●

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Melithreptus albogularis	White-throated Honeyeater					●	●	●			●		●			●	
Philemon argenticeps	Silver-crowned Friarbird							●			●		●				
Philemon citreogularis	Little Friarbird				●	●	●	●	●	●	●		●			●	
POMATOSTOMIDAE																	
Pomatostomus temporalis	Grey-crowned Babbler				●	●	●	●	●	●	●		●			●	●
NEOSITTIDAE																	
Daphoenositta chrysoptera	Varied Sittella				●	●	●	●	●		●		●			●	●
CAMPEPHAGIDAE																	
Coracina novaehollandiae	Black-faced Cuckoo-shrike				●	●	●	●	●	●	●		●			●	●
Coracina papuensis	White-bellied Cuckoo-shrike												●				●
Lalage sueurii	White-winged Triller				●	●	●	●		●	●		●			●	●
PACHYCEPHALIDAE																	
Pachycephala melanura	Mangrove Golden Whistler										●					●	
Pachycephala rufiventris	Rufous Whistler				●	●	●	●	●	●	●		●			●	●
Pachycephala lanioides	White-breasted Whistler										●					●	
Colluricincla harmonica	Grey Shrike-thrush				●	●	●	●	●	●	●		●			●	●
Oreoica gutturalis	Crested Bellbird										●						
ORIOLIDAE																	
Oriolus sagittatus	Olive-backed Oriole				●	●	●	●			●		●			●	●
ARTAMIDAE																	
Artamus leucorhynchus	White-breasted Woodswallow					●		●	●	●	●		●			●	●

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Artamus personatus	Masked Woodswallow				●	●	●			●	●		●			●	
Artamus superciliosus	White-browed Woodswallow						●				●					●	
Artamus cinereus	Black-faced Woodswallow				●	●	●	●	●	●	●		●			●	●
Artamus minor	Little Woodswallow				●	●	●	●	●	●	●		●			●	●
Cracticus torquatus	Grey Butcherbird								●							●	
Cracticus nigrogularis	Pied Butcherbird				●	●	●	●	●	●	●		●			●	●
Cracticus tibicen	Australian Magpie												●				●
RHIPIDURIDAE (DICRURIDAE)																	
Rhipidura albiscapa	Grey Fantail				●						●		●			●	●
Rhipidura phasiana	Mangrove Grey Fantail										●					●	
Rhipidura rufiventris	Northern Fantail						●	●	●	●	●					●	
Rhipidura leucophrys	Willie Wagtail				●	●	●	●	●		●		●			●	●
CORVIDAE																	
Corvus bennetti	Little Crow						●				●					●	
Corvus orru	Torresian Crow				●	●	●	●	●	●	●		●			●	●
MONARCHIDAE (DICRURIDAE)																	
Myiagra ruficollis	Broad-billed Flycatcher										●					●	
Myiagra rubecula	Leaden Flycatcher						●	●	●							●	
Myiagra nana	Paperbark Flycatcher				●	●	●	●	●	●	●		●			●	●
Grallina cyanoleuca	Magpie-lark				●	●	●	●			●		●			●	●
PETROICIDAE																	
Microeca fascinans	Jacky Winter				●	●	●	●	●		●		●			●	●

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Microeca flavigaster	Lemon-bellied Flycatcher										●					●	
Melanodryas cucullata	Hooded Robin					●	●				●		●			●	●
Poecilodryas cerviniventris	Buff-sided Robin												●				
ALAUDIDAE																	
Mirafra javanica	Horsfield's Bushlark										●		●			●	
CISTICOLIDAE (SYLVIIDAE)																	
Cisticola exilis	Golden-headed Cisticola								●				●			●	
ACROCEPHALIDAE (SYLVIIDAE)																	
Acrocephalus australis	Australian Reed-Warbler										●		●			●	
MEGALURIDAE (SYLVIIDAE)																	
Megalurus timoriensis	Tawny Grassbird										●		●			●	
Cincloramphus mathewsi	Rufous Songlark				●	●	●			●	●		●			●	
Cincloramphus cruralis	Brown Songlark						●				●		●			●	
TIMALIIDAE (ZOSTEROPIDAE)																	
Zosterops luteus	Yellow White-eye							●		●	●					●	
HIRUNDINIDAE																	
Hirundo rustica	Barn Swallow	**M**	**S3**	**IA**									●		●	●	
Petrochelidon ariel	Fairy Martin				●		●				●					●	
Petrochelidon nigricans	Tree Martin				●	●	●		●	●	●		●			●	●
NECTARINIIDAE (DICAEIDAE)																	
Dicaeum hirundinaceum	Mistletoebird				●	●	●	●		●	●		●			●	●
ESTRILDIDAE																	

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Taeniopygia guttata	Zebra Finch				●	●			●	●	●		●			●	●
Taeniopygia bichenovii	Double-barred Finch						●		●		●		●			●	
Poephila acuticauda	Long-tailed Finch					●	●	●	●		●		●			●	●
Neochmia ruficauda subclarescens	Star Finch (western)			**P4**									●				
Emblema pictum	Painted Finch															●	
Erythrura gouldiae	Gouldian Finch	**EN**		**P4**				●	●	●	●		●	●	●	●	
Lonchura castaneothorax	Chestnut-breasted Mannikin															●	
MOTACILLIDAE																	
Motacilla cinerea	Grey Wagtail	**M**	**S3**	**IA**		●							●				
Motacilla tschutschensis	Eastern Yellow Wagtail	**M**	**S3**	**IA**		●					●	●	●			●	

Reptiles

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CROCODYLIDAE															
Crocodylus porosus	Salt-water Crocodile	**M**	**S4**	**Other**							●			●	
DIPLODACTYLIDAE															
Diplodactylus conspicillatus	Fat-tailed Gecko					●	●	●	●	●	●	●			
Lucasium stenodactylum	Sand-plain Gecko					●	●		●	●	●	●			
Oedura rhombifer								●			●				
Rhynchoedura ornata	Beaked Gecko														
Strophurus ciliaris						●	●	●	●	●	●	●			
Strophurus jeanae											●				
Strophurus taeniatus											●				
GEKKONIDAE															
Gehyra australis							●					●			
Gehyra nana						●					●	●			
Gehyra pilbara					●	●	●		●		●	●			
Gehyra punctata									●		●				
Gehyra variegata								●			●				
Heteronotia binoei	Bynoe's Gecko					●	●		●	●	●	●			
**Hemidactylus frenatus*	Asian House Gecko										●				
PYGOPODIDAE															
Delma borea											●				
Delma tincta						●			●		●	●			

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Lialis burtonis						●	●	●	●	●	●	●			
Pygopus nigriceps															
Pygopus steelescotti	Northern Hooded Scaly-foot					●			●			●			
AGAMIDAE															
Amphibolurus gilberti	Gilbert's Dragon					●	●	●	●	●	●	●			
Chelosania brunnea	Chameleon Dragon										●				
Chlamydosaurus kingii	Frilled Lizard					●	●	●	●	●	●	●			
Ctenophorus caudicinctus	Ring-tailed Rock Dragon										●				
Ctenophorus isolepis	Military Dragon										●	●			
Ctenophorus nuchalis	Central Netted Dragon										●	●			
Diporiphora magna						●						●			
Diporiphora pindan						●	●	●	●	●	●	●			
Diporiphora sp.							●								
Pogona minor	Dwarf Bearded Dragon				●	●	●	●	●	●	●	●			
EGERNIIDAE															
Tiliqua multifasciata	Central Blue-tongue								●		●	●			
Tiliqua scincoides	Common Blue-tongue					●	●	●	●	●	●	●			
EUGONGYLIDAE															
Carlia munda					●	●	●				●	●			
Carlia rufilatus						●	●		●	●	●	●			
Carlia triacantha							●								
Cryptoblepharus carnabyi							●								

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Cryptoblepharus metallicus											●				
Cryptoblepharus ruber	Tawny Snake-eyed Skink				●	●	●		●	●	●	●			
Cryptoblepharus sp.						●									
Menetia greyii										●					
Menetia maini						●						●			
Morethia ruficauda											●				
Morethia storri						●	●		●			●			
Proablepharus tenuis						●			●			●			
SPHENOMORPHIDAE															
Ctenotus colletti						●					●	●			
Ctenotus helenae											●				
Ctenotus inornatus					●	●	●	●	●	●	●	●			●
Ctenotus pantherinus						●	●					●			
Ctenotus robustus						●						●			
Ctenotus serventyi						●	●		●			●			
Eremiascincus isolepis						●	●	●	●	●	●	●			
Eremiascincus richardsonii	Banded Skink										●				
Lerista apoda					●	●	●		●	●		●			
Lerista bipes						●	●		●	●	●				
Lerista greeri						●					●	●			
Lerista griffini							●		●	●					
Lerista labialis											●				

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Lerista separanda				P2					●		●				
VARANIDAE															
Varanus acanthurus	Spiny-tailed Monitor					●		●			●	●			
Varanus brevicauda	Short-tailed Pygmy Monitor					●	●		●			●			
Varanus gouldii	Gould's Monitor					●	●	●	●		●	●			●
Varanus panoptes	Yellow-spotted Monitor							●	●						
Varanus scalaris	Spotted Tree Monitor						●								
Varanus sparnus	Dampier Peninsula Goanna					●									
Varanus tristis	Black-headed Monitor					●	●	●	●	●	●	●			
TYPHLOPIDAE															
Ramphotyphlops diversus							●		●	●	●				
Ramphotyphlops sp.						●									
BOIDAE															
Antaresia stimsoni	Stimson's Python					●	●	●	●		●	●			
Aspidites melanocephalus	Black-headed Python						●			●	●				
Liasis olivaceus	Olive Python										●				
COLUBRIDAE															
Dendrelaphis punctulata	Common Tree Snake									●	●				
ELAPIDAE															
Brachyurophis roperi	Northern Shovel-nosed Snake					●	●		●	●		●			
Demansia angusticeps						●	●		●	●		●			
Demansia olivacea	Olive Whipsnake										●				

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Demansia psammophis	Yellow-faced Whipsnake										●				
Ephalophis greyae	Mangrove Sea Snake													●	
Furina ornata	Moon Snake					●	●		●	●	●	●			
Pseudechis australis	Mulga Snake					●	●		●	●	●	●			S
Pseudonaja mengdeni	Western Brown Snake					●	●					●			
Pseudonaja nuchalis	Northern Brown Snake								●		●				
Simoselaps anomalus	Desert Banded Snake										●				
Simoselaps minimus	Dampierland Burrowing Snake			**P2**					●		●				
Suta punctata	Spotted Snake					●			●	●	●	●			

Amphibians

Family and Species	Common name	EPBC Act	WC Act	DEC	Thunderbird (*ecologia* 2014b)	*ecologia* internal database	Jmes Price Point (Biota 2009)	James Price Point (Biota 2010)	Dampier Peninsula (ENV 2008)	NatureMap	DPaW Fauna Search	DSEWPaC Protected Matters	This survey
HYLIDAE													
Cyclorana australis	Giant Frog				●	●	●		●	●			
Cyclorana cryptotis	Hidden-ear Frog									●			
Cyclorana longipes	Long-footed Frog				●		●			●			
Litoria caerulea	Green Tree Frog				●	●	●		●	●			
Litoria coplandi	Rock Frog								●				
Litoria meiriana	Rockhole Frog								●				
Litoria rothii	Northern Laughing Tree Frog				●				●	●			
Litoria rubella	Little Red Tree Frog				●	●			●	●			
LIMNODYNASTIDAE													
Notaden nichollsi	Desert Spadefoot				●					●			
Platyplectrum ornatum	Ornate Burrowing Frog				●	●	●	●	●	●			
MYOBATRACHIDAE													
Uperoleia mjobergii	West Kimberley Toadlet									●			
Uperoleia talpa	Mole Toadlet				●	●			●	●			

APPENDIX C GREATER BILBY RECORDS

Evidence	Date	Easting	Northing
Digging	14/05/2015	501261	8069764
Digging	14/05/2015	501261	8069767
Digging	14/05/2015	501259	8069761
Digging	14/05/2015	501258	8069748
Digging	14/05/2015	501227	8069724
Digging	14/05/2015	501219	8069740
Digging	14/05/2015	501216	8069742
Digging	14/05/2015	501203	8069755
Digging	14/05/2015	501128	8069761
Digging	14/05/2015	501129	8069756
Digging	14/05/2015	501114	8069750
Digging	14/05/2015	500956	8069749
Digging	14/05/2015	500934	8069766
Digging	14/05/2015	500926	8069776
Digging	14/05/2015	500933	8069786
Digging	14/05/2015	500934	8069790
Digging	14/05/2015	500621	8069649
Digging	14/05/2015	500649	8069649
Digging	14/05/2015	500647	8069651
Digging	14/05/2015	500642	8069641
Digging	14/05/2015	500638	8069647
Digging	14/05/2015	500620	8069648
Digging	14/05/2015	500629	8069630
Digging	14/05/2015	500624	8069628
Digging	14/05/2015	500617	8069627
Digging	14/05/2015	500594	8069611
Digging	14/05/2015	500592	8069613
Digging	14/05/2015	500581	8069620
Digging	14/05/2015	500568	8069633
Digging	14/05/2015	500584	8069642
Digging	14/05/2015	500584	8069638
Digging	14/05/2015	500594	8069634
Digging	14/05/2015	500594	8069636
Digging	14/05/2015	500600	8069636
Digging	14/05/2015	500468	8069541
Digging	14/05/2015	500536	8069590
Digging	14/05/2015	500540	8069599
Digging	14/05/2015	501499	8070386
Digging	14/05/2015	501496	8070400
Digging	14/05/2015	501502	8070417
Digging	14/05/2015	501497	8070418
Digging	14/05/2015	501511	8070434
Digging	14/05/2015	501529	8070422
Digging	14/05/2015	501544	8070419
Digging	14/05/2015	501552	8070430
Digging	14/05/2015	501565	8070424
Digging	14/05/2015	501575	8070418
Digging	14/05/2015	501577	8070411
Digging	14/05/2015	501488	8070363
Digging	14/05/2015	501478	8070364
Digging	14/05/2015	501471	8070370

Digging	14/05/2015	501474	8070377
Digging	14/05/2015	501452	8070386
Digging	14/05/2015	501460	8070390
Digging	14/05/2015	501452	8070402
Digging	14/05/2015	501444	8070408
Digging	14/05/2015	501440	8070400
Digging	14/05/2015	501428	8070412
Digging	14/05/2015	501426	8070409
Digging	14/05/2015	501406	8070403
Digging	14/05/2015	501389	8070395
Digging	14/05/2015	501374	8070395
Digging	14/05/2015	501406	8070446
Digging	14/05/2015	501415	8070448
Digging	14/05/2015	501783	8069629
Digging	14/05/2015	501781	8069632
Digging	14/05/2015	501733	8069530
Digging	14/05/2015	501740	8069517
Digging	14/05/2015	501758	8069498
Digging	14/05/2015	501777	8069510
Digging	14/05/2015	501213	8069580
Digging	14/05/2015	501097	8069683
Digging	14/05/2015	501087	8069688
Digging	14/05/2015	501096	8069697
Digging	14/05/2015	501099	8069701
Digging	14/05/2015	501096	8069712
Digging	14/05/2015	501049	8069748
Digging	14/05/2015	501037	8069780
Digging	14/05/2015	501044	8069795
Digging	14/05/2015	501048	8069798
Digging	14/05/2015	501048	8069830
Digging	14/05/2015	501024	8069893
Digging	14/05/2015	501006	8069888
Digging	14/05/2015	500980	8069821
Digging	14/05/2015	501006	8069811
Digging	14/05/2015	501013	8069801
Digging	14/05/2015	501000	8069771
Digging	14/05/2015	500960	8069749
Digging	14/05/2015	501369	8070264
Digging	14/05/2015	501350	8070271
Digging	14/05/2015	501347	8070279
Digging	14/05/2015	501334	8070295
Digging	14/05/2015	501330	8070296
Digging	14/05/2015	501327	8070303
Digging	14/05/2015	501323	8070308
Digging	14/05/2015	501290	8070326
Digging	14/05/2015	501263	8070350
Digging	14/05/2015	501321	8070418
Digging	14/05/2015	501372	8070394
Digging	14/05/2015	501396	8070387
Digging	14/05/2015	501416	8070384
Digging	14/05/2015	501424	8070373
Digging	14/05/2015	501438	8070372

Digging	14/05/2015	501438	8070381
Digging	14/05/2015	501446	8070388
Digging	14/05/2015	501445	8070392
Digging	14/05/2015	501508	8070488
Digging	13/05/2015	501462	8070400
Digging	13/05/2015	500977	8069946
Digging	14/05/2015	503165	8066826
Digging	14/05/2015	503071	8066928
Scat	14/05/2015	503748	8066030
Scat	13/05/2015	501573	8070421
Scat	13/05/2015	501449	8070406
Active burrow	13/05/2015	501452	8070397
Active burrow	14/05/2015	501769	8069648
Active burrow	14/05/2015	501734	8069517
Active burrow	14/05/2015	501060	8069737
Active burrow	14/05/2015	501051	8069815
Active burrow	14/05/2015	501011	8069889
Active burrow	15/05/2015	501222	8069733
Active burrow	14/05/2015	500978	8069759
Active burrow	15/05/2015	500606	8069630
Active burrow	14/05/2015	503721	8066163
Active burrow	14/05/2015	503450	8066252
Active burrow	14/05/2015	503322	8066391
Active burrow	14/05/2015	503257	8066429
Active burrow	14/05/2015	503807	8066263
Active burrow	14/05/2015	503872	8066222
Active burrow	14/05/2015	503775	8066033
Active burrow	14/05/2015	502969	8067046
Active burrow	14/05/2015	502980	8067161
Inactive burrow	15/05/2015	499512	8069908

GDA 94 Zone 51

APPENDIX D COASTAL HABITAT RESTRICTED CONSERVATION SIGNIFICANT BIRD SPECIES

Species name	Common name	EPBC Act	WC Act	DPaW	Likelihood of occurrence
Fregata ariel	Lesser Frigatebird	M	S3	IA	**LOW**
Sula leucogaster	Brown Booby	M	S3	IA	**LOW**
Egretta sacra	Eastern Reef Egret	M	S3	IA	**LOW**
Pluvialis squatarola	Grey Plover	M	S3	IA	**LOW**
Charadrius leschenaultii	Greater Sand Plover	M	S3	IA	**LOW**
Charadrius mongolus	Lesser Sand Plover	M	S1, S3	EN, IA	**LOW**
Limosa limosa	Black-tailed Godwit	M	S3	IA	**LOW**
Limosa lapponica	Bar-tailed Godwit	M	S1, S3	VU, IA	**LOW**
Numenius phaeopus	Whimbrel	M	S3	IA	**LOW**
Numenius madagascariensis	Eastern Curlew	CR, M	S1, S3	VU, IA	**LOW**
Xenus cinereus	Terek Sandpiper	M	S3	IA	**LOW**
Actitis hypoleucos	Common Sandpiper	M	S3	IA	**LOW**
Tringa brevipes	Grey-tailed Tattler	M	S3	P4	**LOW**
Tringa stagnatilis	Marsh Sandpiper	M	S3	IA	**LOW**
Arenaria interpres	Ruddy Turnstone	M	S3	IA	**LOW**
Limnodromus semipalmatus	Asian Dowitcher	M	S3	IA	**LOW**
Calidris tenuirostris	Great Knot	M	S1, S3	VU, IA	**LOW**
Calidris canutus	Red Knot	M	S1, S3	VU, IA	**LOW**
Calidris alba	Sanderling	M	S3	IA	**LOW**
Calidris ferruginea	Curlew Sandpiper	CR, M	S1, S3	VU, IA	**LOW**
Limicola falcinellus	Broad-billed Sandpiper	M	S3	IA	**LOW**
Philomachus pugnax	Ruff	M	S3	IA	**LOW**
Stercorarius parasiticus	Arctic Jaeger	M	S3	IA	**LOW**
Sternula albifrons	Little Tern	M	S3	IA	**LOW**
Hydroprogne caspia	Caspian Tern	M	S3	IA	**LOW**
Sterna dougallii	Roseate Tern	M	S3	IA	**LOW**
Sterna hirundo	Common Tern	M	S3	IA	**LOW**
Thalasseus bengalensis	Lesser Crested Tern	M	S3	IA	**LOW**

APPENDIX E FLORA SPECIES LIST

Sheffield Thunderbird Haul Road and Camp Vascular Flora Species List

Family	Taxon	Status
Acanthaceae	*Dicliptera armata*	
Aizoaceae	*Trianthema pilosum*	
Amaranthaceae	*Gomphrena canescens subsp. canescens*	
Amaranthaceae	*Gomphrena flaccida*	
Amaranthaceae	*Gomphrena leptoclada*	
Amaranthaceae	*Ptilotus corymbosus*	
Amaranthaceae	*Ptilotus polystachyus*	
Apocynaceae	*Carissa lanceolata*	
Apocynaceae	*Wrightia saligna*	
Araliaceae	*Trachymene oleracea subsp. oleracea*	
Asteraceae	*Blumea integrifolia*	
Asteraceae	*Pluchea rubelliflora*	
Asteraceae	*Pterocaulon intermedium*	P3
Asteraceae	*Pterocaulon paradoxum*	
Asteraceae	*Pterocaulon serrulatum var. velutinum*	
Asteraceae	*Pterocaulon sp.*	
Asteraceae	*Pterocaulon sphacelatum*	
Asteraceae	*Pterocaulon tricholobum*	
Asteraceae	*Tridax procumbens*	Weed
Bignoniaceae	*Dolichandrone heterophylla*	
Boraginaceae	*Ehretia saligna var. saligna*	
Boraginaceae	*Heliotropium cunninghamii*	
Boraginaceae	*Heliotropium leptaleum*	
Boraginaceae	*Heliotropium sp.*	
Boraginaceae	*Trichodesma zeylanicum var. latisepalum*	
Byblidaceae	*Byblis filifolia*	
Caryophyllaceae	*Polycarpaea corymbosa*	
Caryophyllaceae	*Polycarpaea longiflora*	
Celastraceae	*Denhamia cunninghamii*	
Cleomaceae	*Cleome viscosa*	
Combretaceae	*Terminalia canescens*	
Commelinaceae	*Murdannia graminea*	
Convolvulaceae	*Bonamia linearis*	
Convolvulaceae	*Evolvulus alsinoides var. decumbens*	
Convolvulaceae	*Ipomoea coptica*	
Convolvulaceae	*Polymeria ambigua*	
Cyperaceae	*Abildgaardia schoenoides*	
Cyperaceae	*Bulbostylis barbata*	
Cyperaceae	*Cyperus conicus*	
Cyperaceae	*Cyperus microcephalus subsp. microcephalus*	
Cyperaceae	*Fimbristylis ammobia*	
Cyperaceae	*Fimbristylis caespitosa*	
Cyperaceae	*Fimbristylis neilsonii*	
Cyperaceae	*Fimbristylis oxystachya*	
Cyperaceae	*Fimbristylis schultzii*	
Cyperaceae	*Fimbristylis sp.*	
Droseraceae	*Drosera derbyensis*	
Euphorbiaceae	*Euphorbia hassallii*	
Euphorbiaceae	*Euphorbia trigonosperma*	
Euphorbiaceae	*Microstachys chamelea*	
Fabaceae	*Acacia colei var. colei*	
Fabaceae	*Acacia colei var. ileocarpa*	
Fabaceae	*Acacia drepanocarpa subsp. drepanocarpa*	
Fabaceae	*Acacia hippuroides*	
Fabaceae	*Acacia monticola*	
Fabaceae	*Acacia platycarpa*	
Fabaceae	*Acacia tumida var. tumida*	
Fabaceae	*Bauhinia cunninghamii*	
Fabaceae	*Chamaecrista moorei*	
Fabaceae	*Crotalaria crispata*	
Fabaceae	*Crotalaria medicaginea var. neglecta*	
Fabaceae	*Crotalaria sp.*	
Fabaceae	*Cullen pustulatum*	
Fabaceae	*Desmodium filiforme*	
Fabaceae	*Erythrophleum chlorostachys*	
Fabaceae	*Galactia tenuiflora*	
Fabaceae	*Glycine tomentella*	
Fabaceae	*Indigofera linifolia*	
Fabaceae	*Senna costata*	
Fabaceae	*Senna oligoclada*	
Fabaceae	*Tephrosia crocea*	
Fabaceae	*Tephrosia leptoclada*	
Fabaceae	*Tephrosia remotiflora*	
Fabaceae	*Tephrosia sp. C Kimberley Flora (K.F. Kenneally 5599)*	
Fabaceae	*Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)*	
Fabaceae	*Zornia chaetophora*	
Fabaceae	*Zornia prostrata*	
Fabaceae	*Zornia prostrata var. prostrata*	
Fabaceae	**Stylosanthes hamata*	Weed
Fabaceae	**Stylosanthes scabra*	Weed
Goodeniaceae	*Goodenia armitiana*	
Goodeniaceae	*Goodenia sepalosa var. sepalosa*	
Lamiaceae	*Clerodendrum tomentosum var. tomentosum*	
Lamiaceae	*Cyanostegia cyanocalyx*	
Lauraceae	*Cassytha capillaris*	
Loganiaceae	*Mitrasacme exserta*	
Loganiaceae	*Mitrasacme lutea*	
Loranthaceae	*Amyema sanguinea var. sanguinea*	
Malvaceae	*Brachychiton diversifolius subsp. diversifolius*	
Malvaceae	*Corchorus sidoides*	
Malvaceae	*Corchorus tridens*	
Malvaceae	*Gossypium australe*	
Malvaceae	*Triumfetta albida*	
Malvaceae	*Waltheria indica*	
Malvaceae	**Malvastrum americanum*	Weed
Menispermaceae	*Tinospora smilacina*	
Moraceae	*Ficus aculeata var. indecora*	
Myrtaceae	*Calytrix exstipulata*	
Myrtaceae	*Corymbia flavescens*	
Myrtaceae	*Corymbia greeniana*	
Myrtaceae	*Corymbia zygophylla*	
Myrtaceae	*Eucalyptus zygophylla*	
Myrtaceae	*Melaleuca alsophila*	
Myrtaceae	*Melaleuca viridiflora*	
Orobanchaceae	*Buchnera asperata*	
Orobanchaceae	*Buchnera linearis*	
Orobanchaceae	*Buchnera ramosissima*	
Orobanchaceae	*Buchnera urticifolia*	
Orobanchaceae	*Striga curviflora*	
Orobanchaceae	*Striga squamigera*	
Phyllanthaceae	*Sauropus trachyspermus*	
Plantaginaceae	*Stemodia lythrifolia*	
Poaceae	*Aristida aff. nitidula*	
Poaceae	*Aristida holathera var. holathera*	
Poaceae	*Aristida hygrometrica*	
Poaceae	*Aristida inaequiglumis*	
Poaceae	*Aristida sp.*	
Poaceae	*Bothriochloa sp.*	
Poaceae	*Chloris lobata*	
Poaceae	*Chrysopogon fallax*	
Poaceae	*Chrysopogon pallidus*	
Poaceae	*Digitaria brownii*	
Poaceae	*Ectrosia schultzii var. schultzii*	
Poaceae	*Eragrostis cumingii*	
Poaceae	*Eragrostis eriopoda*	
Poaceae	*Eragrostis sp.*	
Poaceae	*Eriachne ciliata*	
Poaceae	*Eriachne melicacea*	
Poaceae	*Eriachne obtusa*	
Poaceae	*Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)*	
Poaceae	*Heteropogon contortus*	
Poaceae	*Schizachyrium fragile*	
Poaceae	*Setaria surgens*	
Poaceae	*Sorghum plumosum*	
Poaceae	*Sorghum timorense*	
Poaceae	*Sporobolus australasicus*	
Poaceae	*Triodia schinzii* (Broome variant)	
Poaceae	*Triodia caelestialis*	P3
Poaceae	*Urochloa praetervisa*	
Poaceae	*Xerochloa imberbis*	
Poaceae	*Yakirra australiensis var. australiensis*	
Poaceae	*Yakirra australiensis var. intermedia*	
Poaceae	*Yakirra pauciflora*	
Polygalaceae	*Polygala tepperi*	
Portulacaceae	*Calandrinia quadrivalvis*	
Portulacaceae	*Calandrinia strophiolata*	
Portulacaceae	*Calandrinia translucens*	
Proteaceae	*Grevillea pyramidalis subsp. pyramidalis*	
Proteaceae	*Grevillea refracta subsp. refracta*	
Proteaceae	*Grevillea striata*	
Proteaceae	*Hakea arborescens*	
Proteaceae	*Hakea macrocarpa*	
Proteaceae	*Persoonia falcata*	
Pteridaceae	*Cheilanthes brownii*	
Rubiaceae	*Spermacoce occidentalis*	
Sapindaceae	*Atalaya hemiglauca*	
Sapindaceae	*Dodonaea hispidula var. arida*	
Solanaceae	*Solanum cleistogamum*	
Solanaceae	*Solanum cunninghamii*	
Solanaceae	*Solanum dioicum*	
Thymelaeaceae	*Thecanthes punicea*	
Violaceae	*Hybanthus aurantiacus*	

APPENDIX F QUADRAT DATA

Site:	**1**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0505039 8064598
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Brown;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia monticola
Acacia tumida var. tumida
Aristida sp.
Atalaya hemiglauca
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera ramosissima
Calandrinia quadrivalvis
Chrysopogon pallidus
Corchorus sidoides
Corymbia flavescens
Crotalaria medicaginea var. neglecta
Denhamia cunninghamii
Dolichandrone heterophylla
Ectrosia schultzii var. schultzii
Eragrostis cumingii
Eriachne melicacea
Eriachne obtusa
Galactia tenuiflora
Gomphrena canescens subsp. canescens
Goodenia sepalosa var. sepalosa
Gossypium australe
Grevillea pyramidalis subsp. pyramidalis
Grevillea refracta subsp. refracta
Heteropogon contortus
Hybanthus aurantiacus
Indigofera linifolia
Malvastrum americanum
Microstachys chamelea
Mitrasacme lutea
Pterocaulon paradoxum
Ptilotus corymbosus
Ptilotus polystachyus
Schizachyrium fragile
Solanum cunninghamii
Tephrosia remotiflora
Terminalia canescens
Trianthema pilosum
Waltheria indica

Site:	**2**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0505634 8064081
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Yellow;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	25%

Taxa:

Acacia colei var. colei
Acacia platycarpa
Bauhinia cunninghamii
Bothriochloa sp.
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Chrysopogon pallidus
Corymbia greeniana
Dolichandrone heterophylla
Eriachne obtusa
Erythrophleum chlorostachys
Evolvulus alsinoides var. decumbens
Galactia tenuiflora
Gossypium australe
Grevillea pyramidalis subsp. pyramidalis
Pterocaulon paradoxum
Sauropus trachyspermus
Sorghum timorense
Striga curviflora
Stylosanthes scabra
Terminalia canescens
Trichodesma zeylanicum var. latisepalum

Site:	**3**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0506044 8062635
Habitat:	Rocky Outcrop
Slope:	Gentle; Moderate;
Surface Layer:	Rocky/Stony;
Soil Colour:	Brown;
Soil Texture:	Loam;
Rock Type:	Other/Unsure;
Rock Size:	Stones (can pick up); Boulders (can't pick up); Surface Plates;
Rock Abundance:	Continuous (>70%)
Vegetation Condition:	Excellent (no obvious disturbance)
Disturbance Type:	No Disturbance;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Buchnera ramosissima
Calytrix exstipulata
Cassytha capillaris
Cheilanthes brownii
Chrysopogon pallidus
Cleome viscosa
Corchorus tridens
Corymbia flavescens
Cyperus microcephalus subsp. microcephalus
Desmodium filiforme
Dicliptera armata
Eriachne ciliata
Euphorbia trigonosperma
Galactia tenuiflora
Glycine tomentella
Gomphrena leptoclada
Heteropogon contortus
Indigofera linifolia
Persoonia falcata
Polycarpaea longiflora
Ptilotus corymbosus
Striga curviflora
Tephrosia remotiflora
Terminalia canescens
Tinospora smilacina
Triodia schinzii (Broome variant)
Triumfetta albida
Wrightia saligna

Site:	**4**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0506772 8059862
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sand;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	1-2 years;
Leaf Litter Cover:	2%

Taxa:

Acacia platycarpa
Acacia tumida var. tumida
Aristida inaequiglumis
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Bulbostylis barbata
Calandrinia quadrivalvis
Chrysopogon pallidus
Corymbia greeniana
Denhamia cunninghamii
Dolichandrone heterophylla
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis oxystachya
Galactia tenuiflora
Goodenia sepalosa var. sepalosa
Grevillea refracta subsp. refracta
Heteropogon contortus
Microstachys chamelea
Mitrasacme lutea
Persoonia falcata
Ptilotus polystachyus
Senna oligoclada
Terminalia canescens
Wrightia saligna

Site:	**5**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0508913 8056904
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sand; Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	1-2 years;
Leaf Litter Cover:	2%

Taxa:

Acacia tumida var. tumida
Aristida inaequiglumis
Bonamia linearis
Brachychiton diversifolius subsp. diversifolius
Chrysopogon pallidus
Corchorus sidoides
Corymbia greeniana
Corymbia zygophylla
Crotalaria crispata
Dodonaea hispidula var. arida
Dolichandrone heterophylla
Ehretia saligna var. saligna
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis oxystachya
Galactia tenuiflora
Grevillea refracta subsp. refracta
Heliotropium leptaleum
Microstachys chamelea
Mitrasacme lutea
Polygala tepperi
Pterocaulon intermedium
Pterocaulon sphacelatum
Ptilotus corymbosus
Terminalia canescens
Tinospora smilacina
Trichodesma zeylanicum var. latisepalum
Triodia caelestialis
Waltheria indica

Site:	**6**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0511410 8054256
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Brown;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Aristida holathera var. holathera
Atalaya hemiglauca
Bauhinia cunninghamii
Buchnera asperata
Chrysopogon pallidus
Clerodendrum tomentosum var. tomentosum
Corymbia greeniana
Crotalaria crispata
Dolichandrone heterophylla
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Eucalyptus zygophylla
Fimbristylis oxystachya
Galactia tenuiflora
Hakea macrocarpa
Mitrasacme lutea
Sorghum plumosum
Terminalia canescens
Triodia caelestialis
Urochloa praetervisa
Waltheria indica
Wrightia saligna
Yakirra australiensis var. australiensis

Site:	**7**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0512194 8053067
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia platycarpa
Acacia tumida var. tumida
Amyema sanguinea var. sanguinea
Aristida holathera var. holathera
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Calandrinia quadrivalvis
Chrysopogon pallidus
Corymbia greeniana
Crotalaria crispata
Dolichandrone heterophylla
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Evolvulus alsinoides var. decumbens
Galactia tenuiflora
Grevillea refracta subsp. refracta
Heteropogon contortus
Microstachys chamelea
Persoonia falcata
Polycarpaea corymbosa
Pterocaulon intermedium
Pterocaulon paradoxum
Schizachyrium fragile
Solanum cunninghamii
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)
Terminalia canescens
Trichodesma zeylanicum var. latisepalum
Triodia caelestialis
Yakirra australiensis var. australiensis

Site:	**8**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0513299 8051669
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Brown;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia platycarpa
Acacia tumida var. tumida
Aristida holathera var. holathera
Aristida inaequiglumis
Atalaya hemiglauca
Brachychiton diversifolius subsp. diversifolius
Buchnera asperata
Chrysopogon pallidus
Corymbia flavescens
Corymbia greeniana
Crotalaria crispata
Crotalaria sp.
Dolichandrone heterophylla
Drosera derbyensis
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Fimbristylis sp.
Glycine tomentella
Gomphrena flaccida
Goodenia armitiana
Goodenia sepalosa var. sepalosa
Grevillea pyramidalis subsp. pyramidalis
Heliotropium cunninghamii
Heteropogon contortus
Indigofera linifolia
Polycarpaea corymbosa
Pterocaulon intermedium
Pterocaulon serrulatum var. velutinum
Sorghum plumosum
Stylosanthes hamata
Tephrosia leptoclada
Tephrosia remotiflora
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra pauciflora

Site:	**9**
Date:	12/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0513903 8051197
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Loose;
Soil Colour:	Other;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia colei var. colei
Acacia drepanocarpa subsp. drepanocarpa
Aristida aff. nitidula
Aristida hygrometrica
Aristida inaequiglumis
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera ramosissima
Corymbia greeniana
Crotalaria crispata
Cyperus microcephalus subsp. microcephalus
Dolichandrone heterophylla
Eragrostis cumingii
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Evolvulus alsinoides var. decumbens
Galactia tenuiflora
Gomphrena canescens subsp. canescens
Hakea macrocarpa
Heteropogon contortus
Indigofera linifolia
Pterocaulon intermedium
Schizachyrium fragile
Solanum dioicum
Sporobolus australasicus
Striga squamigera
Stylosanthes scabra
Tephrosia leptoclada
Triodia schinzii (Broome variant)
Zornia prostrata var. prostrata

Site:	**10**
Date:	11/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0515171 8049722
Habitat:	Floodplain
Slope:	Gentle;
Surface Layer:	Crust;
Soil Colour:	Yellow; White;
Soil Texture:	Sand; Sandy-Clay;
Rock Type:	Other/Unsure;
Rock Size:	Boulders (can't pick up);
Rock Abundance:	Few (<10%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Weeds; Animal Tracks; Grazing; Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia colei var. colei
Aristida hygrometrica
Bauhinia cunninghamii
Buchnera ramosissima
Buchnera urticifolia
Bulbostylis barbata
Calandrinia strophiolata
Carissa lanceolata
Chloris lobata
Chrysopogon fallax
Corchorus tridens
Corymbia greeniana
Cyperus conicus
Digitaria brownii
Eragrostis cumingii
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis caespitosa
Fimbristylis schultzii
Gomphrena canescens subsp. canescens
Grevillea striata
Ipomoea coptica
Melaleuca alsophila
Pluchea rubelliflora
Polycarpaea corymbosa
Pterocaulon intermedium
Setaria surgens
Solanum dioicum
Sorghum plumosum
Sporobolus australasicus
Stylosanthes hamata
Tridax procumbens
Waltheria indica
Xerochloa imberbis

Site:	**11**
Date:	11/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0515243 8049399
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange; Yellow;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia colei var. colei
Acacia drepanocarpa subsp. drepanocarpa
Aristida holathera var. holathera
Bauhinia cunninghamii
Buchnera ramosissima
Chrysopogon pallidus
Corymbia greeniana
Crotalaria crispata
Cyperus conicus
Desmodium filiforme
Dolichandrone heterophylla
Drosera derbyensis
Ehretia saligna var. saligna
Eragrostis eriopoda
Glycine tomentella
Gomphrena canescens subsp. canescens
Goodenia sepalosa var. sepalosa
Hakea macrocarpa
Heliotropium sp.
Heteropogon contortus
Indigofera linifolia
Polygala tepperi
Ptilotus polystachyus
Sorghum plumosum
Stylosanthes hamata
Stylosanthes scabra
Yakirra australiensis var. australiensis

Site:	**12**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0515924 8048995
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Amyema sanguinea var. sanguinea
Aristida holathera var. holathera
Aristida hygrometrica
Aristida inaequiglumis
Bauhinia cunninghamii
Brachychiton diversifolius subsp. diversifolius
Buchnera linearis
Calandrinia quadrivalvis
Calandrinia translucens
Chrysopogon pallidus
Corchorus sidoides
Corymbia greeniana
Corymbia zygophylla
Crotalaria crispata
Dolichandrone heterophylla
Eragrostis eriopoda
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Ficus aculeata var. indecora
Fimbristylis oxystachya
Grevillea pyramidalis subsp. pyramidalis
Polycarpaea corymbosa
Solanum dioicum
Sorghum plumosum
Spermacoce occidentalis
Trianthema pilosum
Yakirra australiensis var. australiensis

Site:	**13**
Date:	15/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0512144 8050058
Habitat:	Undulating Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Brown;
Soil Texture:	Sandy-Clay; Clay-Loam; Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Weeds; Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	2%

Taxa:

Acacia colei var. colei
Acacia colei var. ileocarpa
Acacia tumida var. tumida
Aristida aff. nitidula
Aristida inaequiglumis
Aristida sp.
Bauhinia cunninghamii
Chrysopogon pallidus
Corymbia greeniana
Crotalaria crispata
Cullen pustulatum
Dolichandrone heterophylla
Eragrostis sp.
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Gomphrena canescens subsp. canescens
Hakea arborescens
Heliotropium cunninghamii
Heliotropium sp.
Heteropogon contortus
Indigofera linifolia
Polycarpaea corymbosa
Pterocaulon paradoxum
Pterocaulon sp.
Spermacoce occidentalis
Stylosanthes hamata
Tephrosia sp. D Kimberley Flora (R.D. Royce 1848)
Tinospora smilacina
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra australiensis var. australiensis
Zornia prostrata

Site:	**16**
Date:	15/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0512281 8047660
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	> 5 years;
Leaf Litter Cover:	5%

Taxa:

Acacia tumida var. tumida
Aristida aff. nitidula
Aristida holathera var. holathera
Bauhinia cunninghamii
Bonamia linearis
Brachychiton diversifolius subsp. diversifolius
Bulbostylis barbata
Calandrinia quadrivalvis
Chrysopogon pallidus
Corchorus sidoides
Corymbia greeniana
Crotalaria crispata
Dolichandrone heterophylla
Eriachne obtusa
Eriachne sp. Dampier Peninsula (K.F.Kenneally 5946)
Erythrophleum chlorostachys
Euphorbia hassallii
Goodenia sepalosa var. sepalosa
Grevillea pyramidalis subsp. pyramidalis
Grevillea refracta subsp. refracta
Heliotropium cunninghamii
Microstachys chamelea
Mitrasacme exserta
Polycarpaea corymbosa
Polygala tepperi
Polymeria ambigua
Senna costata
Solanum cunninghamii
Spermacoce occidentalis
Tephrosia sp. C Kimberley Flora (K.F. Kenneally 5599)
Trichodesma zeylanicum var. latisepalum
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra pauciflora

Site:	**17**
Date:	13/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0501476 8070456
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Crust;
Soil Colour:	Orange;
Soil Texture:	Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	Common (10-30%)
Vegetation Condition:	Very Good (slight disturbance)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	< 1 year;
Leaf Litter Cover:	2%

Taxa:

Abildgaardia schoenoides
Acacia tumida var. tumida
Aristida holathera var. holathera
Aristida hygrometrica
Bonamia linearis
Buchnera asperata
Calandrinia quadrivalvis
Chamaecrista moorei
Corchorus sidoides
Crotalaria crispata
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Euphorbia hassallii
Fimbristylis ammobia
Fimbristylis neilsonii
Goodenia sepalosa var. sepalosa
Grevillea refracta subsp. refracta
Heteropogon contortus
Microstachys chamelea
Persoonia falcata
Ptilotus polystachyus
Spermacoce occidentalis
Striga squamigera
Tephrosia crocea
Trachymene oleracea subsp. oleracea
Trianthema pilosum
Triodia schinzii (Broome variant)
Zornia chaetophora

Site:	**18**
Date:	14/05/2015
Botanist:	Matthew Macdonald (MJM)
Quadrat Size:	50 x 50 m
North-west Corner:	51K 0503734 8066043
Habitat:	Plain
Slope:	Negligible;
Surface Layer:	Loose;
Soil Colour:	Orange;
Soil Texture:	Sand; Sandy-Clay;
Rock Type:	No Rocks;
Rock Size:	No Rocks;
Rock Abundance:	None (0%)
Vegetation Condition:	Good (low grazing, few weeds)
Disturbance Type:	Animal Tracks; Grazing; Faeces;
Time Since Fire:	2-5 years;
Leaf Litter Cover:	10%

Taxa:

Abildgaardia schoenoides
Acacia tumida var. tumida
Aristida inaequiglumis
Bonamia linearis
Buchnera ramosissima
Byblis filifolia
Calandrinia quadrivalvis
Crotalaria crispata
Eragrostis eriopoda
Eriachne obtusa
Erythrophleum chlorostachys
Fimbristylis ammobia
Goodenia sepalosa var. sepalosa
Grevillea refracta subsp. refracta
Heliotropium leptaleum
Heteropogon contortus
Microstachys chamelea
Polygala tepperi
Pterocaulon paradoxum
Schizachyrium fragile
Solanum cleistogamum
Spermacoce occidentalis
Tephrosia crocea
Triodia schinzii (Broome variant)
Waltheria indica
Yakirra australiensis var. intermedia

Site:	**0**
Date:	0/01/1900
Botanist:	0
Quadrat Size:	0
North-west Corner:	0
Habitat:	0
Slope:	0
Surface Layer:	0
Soil Colour:	0
Soil Texture:	0
Rock Type:	0
Rock Size:	0
Rock Abundance:	0
Vegetation Condition:	0
Disturbance Type:	0
Time Since Fire:	0
Leaf Litter Cover:	%

Taxa:

APPENDIX G SIGNFICANT FLORA AND WEED LOCATIONS

Priority Flora Records

Taxon	Status	Date	Collector	Count	Easting	Northing
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	499972	8069648
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	500041	8069802
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	499540	8069960
Pterocaulon intermedium	P3	15-MAY-15	Matthew Macdonald	1	512043	8053129
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	504309	8065397
Pterocaulon intermedium	P3	11-MAY-15	Matthew Macdonald	1	515172	8049723
Pterocaulon intermedium	P3	12-MAY-15	Matthew Macdonald	1	508905	8056914
Pterocaulon intermedium	P3	13-MAY-15	Matthew Macdonald	1	513902	8051201
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	504489	8065127
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	512185	8053074
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	512185	8053074
Pterocaulon intermedium	P3	13-MAY-15	Matthew Macdonald	1	513285	8051678
Pterocaulon intermedium	P3	14-MAY-15	Matthew Macdonald	1	503365	8066681
Pterocaulon intermedium	P3	13-MAY-15	Matthew Macdonald	1	501697	8069412
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	300	512037	8053110
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1500	499689	8069847
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	501015	8069032
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	50	502678	8067418
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	200	512322	8051853
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	512324	8051958
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	50	512185	8053074
Triodia caelestialis	P3	12-MAY-15	Matthew Macdonald	1	505982	8062571
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	20	511403	8054250
Triodia caelestialis	P3	12-MAY-15	Matthew Macdonald	50	508905	8056914
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	100	503921	8066082
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	200	500946	8069120
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	500798	8069186
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	500656	8069273
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	50	500373	8069441
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	500273	8069488
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	499926	8069682
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	499834	8069766
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	512216	8052028
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	100	499512	8069908
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	500	499685	8069931
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	1000	499908	8069827
Triodia caelestialis	P3	15-MAY-15	Matthew Macdonald	500	500036	8069802
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	50	502526	8067594
Triodia caelestialis	P3	14-MAY-15	Matthew Macdonald	100	502306	8067938

Introduced Flora Records

Taxon	Status	Date	Collector	Count	Easting	Northing
**Malvastrum americanum*	Weed	12-MAY-15	Matthew Macdonald	1	505038	8064608
**Stylosanthes hamata*	Weed	15-MAY-15	Matthew Macdonald	1	512132	8050056
**Stylosanthes hamata*	Weed	13-MAY-15	Matthew Macdonald	1	513285	8051678
**Stylosanthes hamata*	Weed	11-MAY-15	Matthew Macdonald	20	515244	8049400
**Stylosanthes hamata*	Weed	11-MAY-15	Matthew Macdonald	10	515172	8049723
**Stylosanthes scabra*	Weed	11-MAY-15	Matthew Macdonald	1	515244	8049400
**Stylosanthes scabra*	Weed	12-MAY-15	Matthew Macdonald	1	505637	8064082
**Stylosanthes scabra*	Weed	13-MAY-15	Matthew Macdonald	10	513902	8051201
**Tridax procumbens*	Weed	11-MAY-15	Matthew Macdonald	1	515172	8049723

Datum: GDA 1994 MGA Zone 50

APPENDIX H SHEFFIELD RESOURCES THUNDERBIRD PROJECT *VARANUS SPARNUS* MEMO

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Thunderbird Project

Sheffield Resources

***Varanus sparnus* Memo**

Attention: Wayne Groeneveld

MEMO

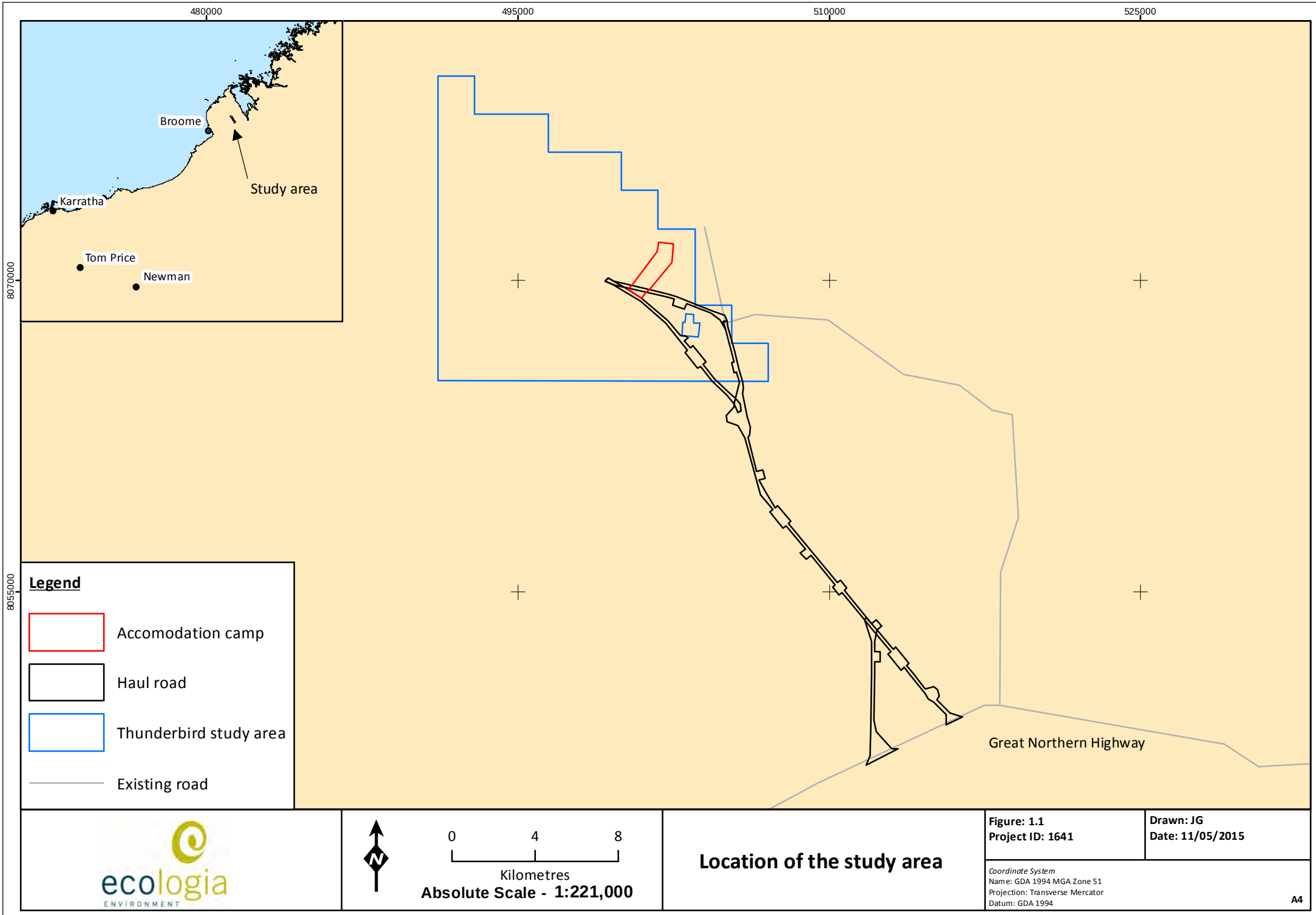
Introduction

Sheffield Resources Limited (Sheffield) is a rapidly emerging mineral sands company with significant additional nickel, talc and iron assets, all located within the state of Western Australia. Sheffield are currently validating extensive historical work and undertaking biological surveys at an early stage to aid their project pathway.

In 2014 Sheffield commissioned *ecologia* Environment (*ecologia*) to undertake a two-phase Level 2 terrestrial (vertebrate and SRE invertebrate) and subterranean fauna survey of its Thunderbird Project (study area), located 70 kilometres west of Derby on the Dampier Peninsula (Figure 1.1). Level 2 assessments were completed in 2014.

Following the completion of the Level 2 assessments, Doughty *et. al.* (2014) identified a new species of Goanna from the Dampier Peninsula; Dampier Peninsula Goanna (*Varanus sparnus*) (Appendix A). One of the individuals used in the morphological and DNA analysis for the new species description was an individual collected during phase 1 of the Level 2 fauna assessment at Thunderbird, which was vouchered at the Western Australian Museum (WAM) at a request of WAM.

Given the interest and potential implications of a newly described species within the study area, this memo has been developed to clarify *Varunus sparnus* occurrence within the Thunderbird study area.



Location of the study area

Figure: 1.1
Project ID: 1641

Drawn: JG
Date: 11/05/2015

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

A4

***Varanus sparnus* study area records**

The newly described *Varanus sparnus* has been split from the similar looking and widely distributed Short-tailed Pygmy Monitor (*Varanus brevicauda*), on the grounds of both distinct morphological and DNA characteristics (Doughty *et. al.* 2014). However, based on current knowledge, both species occur sympatrically, and could both therefore occur within the study area. As the species was described following the field assessments, the only confirmed record within the study area exists as the vouchered individual, with the remaining individuals potentially being either species.

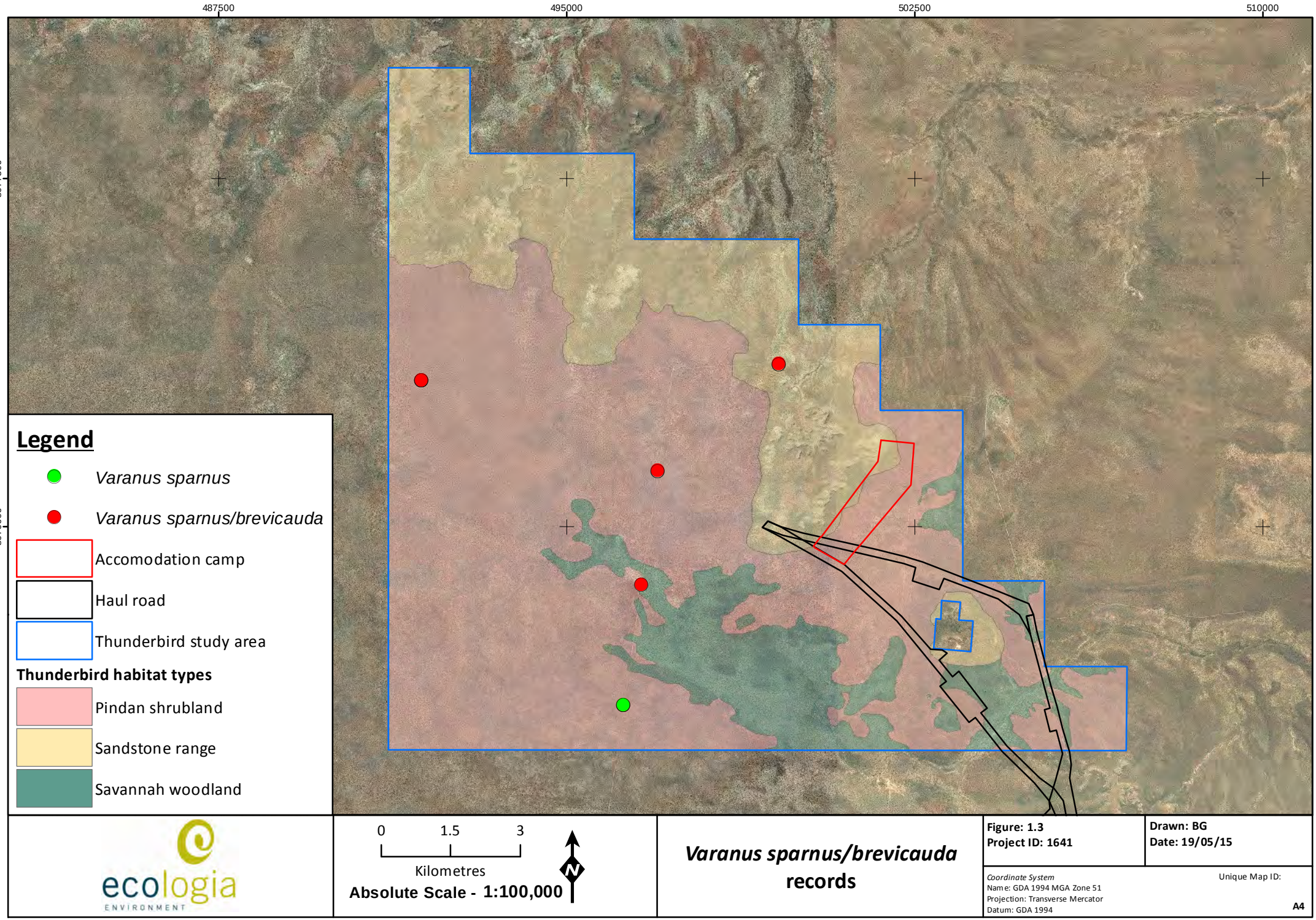
A total of 12 individuals were recorded, including seven during Phase 1 and five during Phase 2 (Table 1.1, Figure 1.3). One individual was vouchered from Phase 1 (WAM voucher number R173115, Figure 1.2), and confirmed as *Varanus sparnus*. Individuals were recorded from a total of five of the seven trapping sites installed. All individuals were trapped from systematic trapping sites in pitfall or funnel traps. Individuals were recorded from all three broad fauna habitat types identified from the study area (Figure 1.3).

Figure 1.2 *Varanus sparnus* WAM vouchered individual from Thunderbird study area

Table 1.1 – *Varanus sparnus/brevicauda* records from the study area.

	Site	Count	Easting	Northing	Date
Phase 1					
Varanus sparnus/brevicauda	TB S4	1	491858	8073144	11/04/2013
Varanus sparnus/brevicauda	TB S4	1	491858	8073144	12/04/2013
Varanus sparnus/brevicauda	TB S5	1	496965	8071200	7/04/2013
Varanus sparnus/brevicauda	TB S6	1	496603	8068741	13/04/2013
Varanus sparnus/brevicauda	TB S7	1	496226	8066143	12/04/2013
Varanus sparnus/brevicauda	TB S7	1	496226	8066143	13/04/2013
*Varanus sparnus**	TB S7	1	496226	8066143	13/04/2013
Phase 2					
Varanus sparnus/brevicauda	TBS1	1	499584	8073492	19/10/2013
Varanus sparnus/brevicauda	TBS1	1	499584	8073492	21/10/2013
Varanus sparnus/brevicauda	TBS4	1	491858	8073144	22/10/2013
Varanus sparnus/brevicauda	TBS4	1	491858	8073144	22/10/2013
Varanus sparnus/brevicauda	TBS5	1	496965	8071200	19/10/2013

GDA94 Zone 51K
*Vouchered individual confirmed as *Varanus sparnus*



ecologia ENVIRONMENT

Varanus sparnus/brevicauda records

Figure: 1.3
Project ID: 1641

Drawn: BG
Date: 19/05/15

Coordinate System
Name: GDA 1994 MGA Zone 51
Projection: Transverse Mercator
Datum: GDA 1994

Unique Map ID:

A4

Regional context

To date, a total of four individuals have been identified as *Varanus sparnus*, these individuals were those utilised for the description of the species based on morphology and DNA characteristics (Doughty *et. al.* 2014). Details of these individuals are provided in Table 1.2, adapted from Doughty *et. al.* 2014, and shown in Figure 1.4.

Figure 1.4 shows relatively few *Varanus brevicauda/sparnus* records on the Dampier Peninsular, with previous records restricted to the Thunderbird study area, and in the surrounding region of the James Price Point precinct (DPaW 2015). The lack of records is likely attributed to a lack of biological survey work utilising pitfall and funnel trap methods on Dampier Peninsular.

Current habitat associated with *V.sparnus* is broadly described as pindan shrubland (Doughty *et. al.* 2014). Given *Varanus brevicauda* is known to excavate and live in burrows (Wilson and Swan 2013), and observations of *Varanus sparnus* in captivity are that this species also regularly excavates and burrows (Doughty *et. al.* 2014), any soil substrate on the Dampier Peninsular able to be excavated could currently be considered as potential suitable habitat. Presence of spinifex (*Triodia* spp.) is also a likely component of this habitat association.

Given two disjunct location records exist approximately 85 km apart, it is likely *Varanus sparnus* occurs throughout the Dampier Peninsula, wherever suitable sandy substrate habitat exists. There is no conservation status currently assigned to *Varanus sparnus*.

Table 1.2 – Vertebrate fauna species recorded

WAM voucher number	Locality	Sex	Easting	Northing
WAM R168486	Coulomb Point	M	409970	8072930
WAM R168474	Coulomb Point	-	411859	8056795
WAM R168475	Coulomb Point	F	410010	8069268
WAM R173115	Thunderbird Study area	F	496284	8066624

GDA 94 Zone 51K

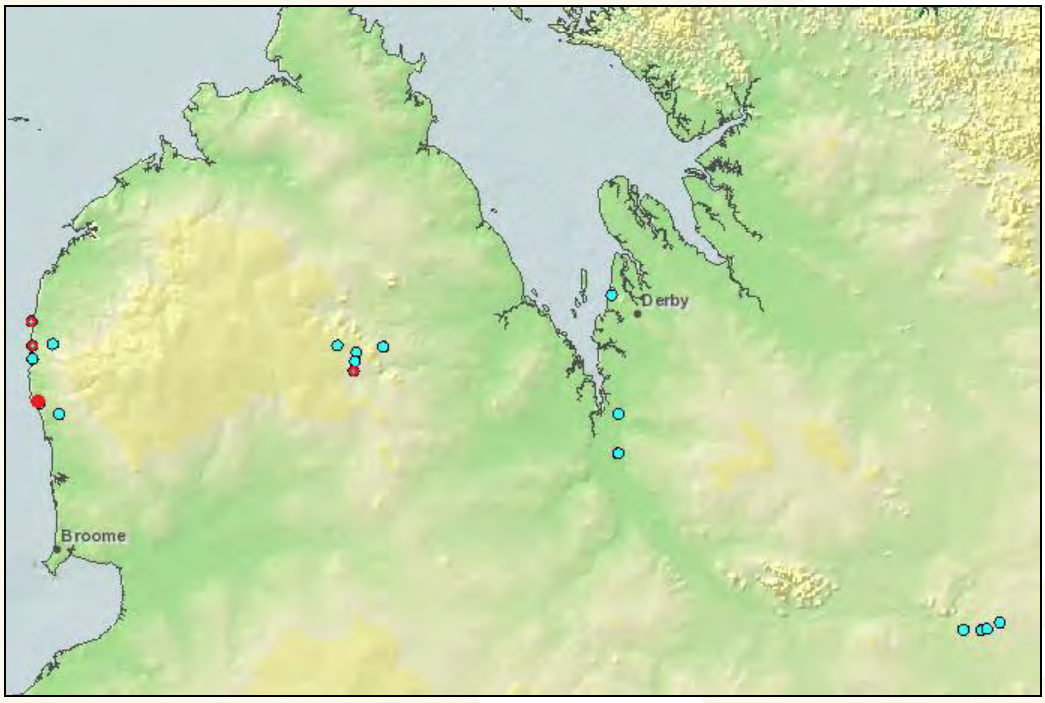


Figure 1.4 – NatureMap *Varanus brevicauda/sparnus* and *Varanus sparnus* (red dots)records

Please feel free to contact myself or Bruce Greatwich to discuss any aspect of this memo.

Best regards,
Shaun Grein
Managing Director

2 June 2015

References

Doughty, P., Kealley, L., Fitch, A. and Donnellan, S., 2014. *A new diminutive species of Varanusfrom the Dampier Peninsula, western Kimberley region, Western Australia*. Records of the Western Australian Museum, **(29)**, Pg 128-140.

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APPENDIX A – Doughty *et. al.* 2014, A new diminutive species of *Varanus* from the Dampier Peninsula, western Kimberley region, Western Australia

RECORDS OF THE WESTERN AUSTRALIAN MUSEUM 29 128–140 (2014)

A new diminutive species of *Varanus* from the Dampier Peninsula, western Kimberley region, Western Australia

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ABSTRACT – *Varanus* lizards in Australia are moderately diverse and include a radiation of small-bodied species that occur in arid or tropical environments. *Varanus brevicauda* is the smallest species, with an elongate body and short prehensile tail and is associated with spinifex clumps in arid environments. Recently collected unusual specimens at the north-western edge of the range of *V. brevicauda* on the Dampier Peninsula, Western Australia, had an even more elongate body and also co-occurred with typical *V. brevicauda*. This led us to conduct a morphological and molecular genetic systematic appraisal of the two morphotypes. We found that the more elongate specimens were highly divergent genetically from both typical *V. brevicauda* and another related species, *V. eremius*, with the three lineages forming a polytomy. Morphologically, the elongate specimens are most similar to *V. brevicauda*, but possess a more elongate body, less robust head and limbs, distinctive scales on the front of the arms that are large, squarish and lacking surrounding granules and a plainer pattern and colouration. The co-occurrence of both forms on the Dampier Peninsula in combination with the extent and pattern of genetic divergence and presence of key morphologically diagnostic traits unequivocally demonstrates that more elongate form is a new species, which we describe here. The new species may be of conservation concern owing to the small range of the only known specimens and development proposals in the area.

KEYWORDS: Goanna, monitor lizard, *Varanus brevicauda*, *Varanus sparnus* sp. nov.

INTRODUCTION

Lizards of the genus *Varanus* Merrem, 1820, commonly referred to as goannas or monitors, are a moderately diverse group with over 70 species from Australia, south-east Asia, India, the Middle East and Africa. Australia is the most species-rich region with 31 species, including a radiation of small to very small-bodied species within the subgenus *Odatria* Gray, 1838 (Pianka et al. 2004). *Varanus* show strong conservatism in body shape, with most species having long, pointed heads and tails (King and Green 1999). Body proportions, however, can differ substantially among species, with relative head and tail lengths differing widely in association with differences in ecology (Thompson and Withers 1997; Openshaw and Keogh 2014).

Within the small-bodied Australian *Odatria* group there are three widely-distributed arid zone species: *V. brevicauda* Boulenger, 1898, *V. acanthurus* Boulenger, 1885 and *V. eremius* Lucas & Frost, 1895. *Varanus brevicauda* is the smallest species of *Varanus*, with a snout-vent length of around 120 mm and a total length of about 250 mm owing to its short tail (hence the specific name) (Storr et al. 1983; Pianka 2004). It occurs along the west coast and extends eastwards and inland through the sandy deserts as far as the Simpson Desert in western Queensland (Wilson and Swan 2010). This species is an active burrower, with relatively straight claws on the hands, capable of digging their own tunnels and foraging for food among *Triodia* clumps and along sand dunes (Pianka 2004).

Recently, several unusual specimens assignable to *V. brevicauda* have been collected from the extreme north-west of the species' range, from near Coulomb Point on the Dampier Peninsula, north of Broome in the western Kimberley region (Figure 1). This area is characterised by sandy soils and pindan vegetation communities (McKenzie 1983). The specimens have a more elongate and gracile appearance than typical *V. brevicauda* and a more subdued pattern. We carried out

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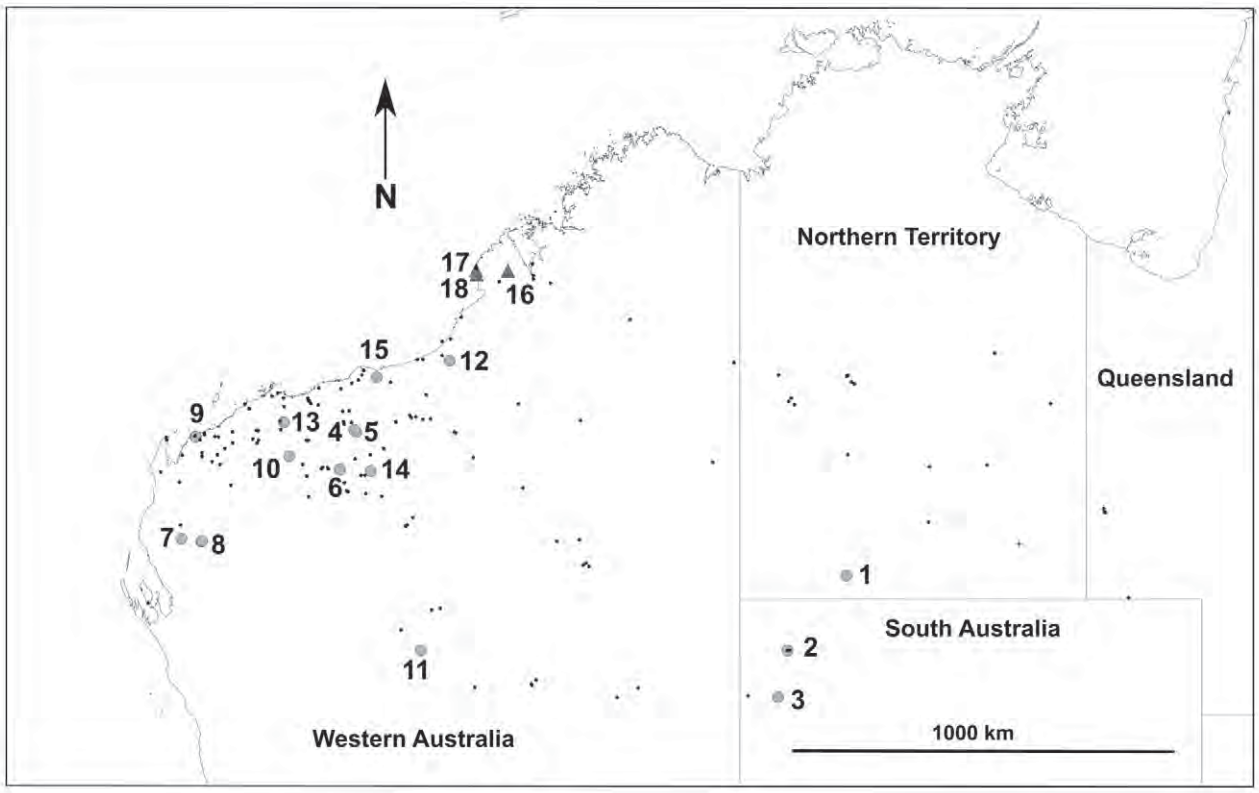

FIGURE 1 Map showing the distribution of *Varanus brevicauda* (dots) and *V. sparnus* sp. nov. (triangles) based on Atlas of Living Australia voucher records (small dots) and locations from which molecular genetic data were obtained (large symbols).

a molecular genetic analysis to assess the distinctiveness of these specimens from 'typical' *V. brevicauda* sampled throughout its range. This genetic evidence indicated that the elongate specimens are equally distant genetically to *V. brevicauda* and *V. eremius*. Examination of specimens also revealed a suite of morphological characters to distinguish the new form. Here we describe this population as a new species of *Varanus*.

METHODS

MORPHOLOGY

Specimens were examined from the collections of the Western Australian Museum (WAM; where new type material is deposited). We examined three preserved specimens of the elongate form, plus one live captive specimen, and compared these with 20 *V. brevicauda* from throughout the rest of its range in Western Australia, including from the Dampier Peninsula (Appendix 1). We compared the two forms qualitatively and measured and counted other characters. Table 1 presents the morphological variables assessed and how they were measured. Measurements were made with electronic callipers to the nearest 0.1 mm, with SVL, TailL and TrunkL to 0.5 mm (broken tails were excluded). Individuals were sexed on the basis of everted hemipenes in males or of conspicuous gravidity in females, or by direct examination of the gonads.

MOLECULAR GENETICS

Frozen or alcohol preserved tissues were available from 31 *Varanus* vouchers (Appendix 1). DNA was extracted from using a Puregene DNA isolation kit (Gentra Systems, Minneapolis, U.S.A.) following the manufacturer's protocol for DNA purification from solid tissue. An ~886 bp fragment of the mitochondrial genome, including the 3′ end of the *NADH dehydrogenase* subunit *4* (*ND4*) gene (710 bp) and the tRNA genes *tRNAHis*, *tRNASer* and the 5′ end of *tRNALeu* (176 bp), hereafter referred to as *ND4*, was amplified and sequenced using the forward primers *ND4*: 5′-TGACTACCAAAAGCTCATGTAGAAGC-3′ or *ND4*: 5′-ACCTATGACTACCAAAAGCTCATGTAGA AGC-3′ with the reverse primer Leu1: 5′-CATTACTTT TTACTTGGATTTGCACCA-3′. Each PCR was carried out in a volume of 25 ml with a final concentration of 1X GeneAmp PCR Gold buffer, 2–4 mM MgCl2, 200 M of each dNTP, 0.2 mM of each primer and 0.5 U of AmpliTaq Gold DNA polymerase (Applied Biosystems, Foster City, CA, U.S.A.). Amplifications consisted of an initial denaturation step of 94°C for 9 min, followed by 34 cycles of PCR with the following temperature profile: denaturation at 94°C for 45 s, annealing at 55°C for 45 s, and extension at 72°C for

TABLE 1 Morphological characters measured.

Character	Description
SVL	Snout-vent length
LegL	Leg length, measured from the knee patella to the tip of the 4th toe including claw
HeadL	Head length, measured obliquely from tip of snout to anterior margin of tympanum
HeadW	Head width, measured at the widest point
HeadD	Head depth, measured level with centre of the tympanum, at the highest point
SupLab	Number of supralabial scales
InfLab	Number of infralabial scales, ending with the last small scale in contact with the posterior margin of the last upper labial
MBSR	Number of midbody scale rows, counted midway between axilla and groin
4TLam	Number of enlarged subdigital lamellae under fourth toe, counted from toe junction to base of claw
PCP	Number of pre-cloacal pores
TailL	Tail length, measured from the base of the cloaca to the tip of the tail
CloSpu	Number of cloacal spurs present
ILL	Inter-limb length, measured between the forelimb and hindlimb
UArmL	Upper arm length, measured from the lower side of the axilla to the outside of the elbow
LArmL	Lower arm length, measured from the outside of the elbow to the inside of the wrist
HandL	Hand length, measured from the inside of the wrist to the tip of the 4th toe, excluding the nail
ULegL	Upper leg length, measured from the lower side of the groin to the outside of the knee
LLegL	Lower leg length, measured from the outside of the knee to the inside of the ankle
FootL	Foot length, measured from the inside of the ankle to the 4th toe, excluding the nail

1 min, with an additional final extension at 72°C for 6 min. The double-stranded amplification products were visualised on 1.5% agarose gels and purified using an UltraClean PCR clean-up DNA purification kit (Mo Bio Laboratories Inc., CA, U.S.A.) before cycle-sequencing using the BigDye Terminator v3.1 cycle-sequencing kit (Applied Biosystems). The cycling protocol consisted of 25 cycles of denaturation at 96°C for 30 s, annealing at 50°C for 15 s, and extension at 60°C for 4 min. All samples were sequenced on an Applied Biosystems 3700 DNA sequencer. These sequences were aligned with previously published *Varanus ND4* sequences, including species from clades related to *V. brevicauda* as identified by Fitch et al. (2006) and Vidal et al. (2012) (Appendix 1) with MAFFT v6.814b (Katoh et al. 2005) implemented in Geneious Pro v5.5.2.

Bayes factors were used to assess all possible alternative partitioning strategies for four data subsets: 1st, 2nd and 3rd codon positions and the tRNA in PartitionFinder v1.0.0 (Lanfear et al. 2012). The Akaike Information Criterion (AIC) and Bayes Information Criterion (BIC) were used to assess the best fit partition strategy and nucleotide substitution model for each data subset in the selected partition strategy. Sequences were analysed phylogenetically using Bayesian and maximum likelihood methods. Bayesian analysis was conducted using MrBayes v3.1.2 (Ronquist and Huelsenbeck 2003). The analysis was run with model parameters unlinked using default priors for two million generations with two independent runs and two chains sampling every 1000 generations. The first 25% of sampled trees were discarded as burn-in and convergence was assessed by examining effective sample sizes (ESS values), split frequencies of clades across runs and likelihood plots through time in TRACER v1.4.1 (Rambaut and Drummond 2007).

Net average sequence divergence between lineages (*dA*) was calculated in MEGA v5 (Tamura et al. 2011) as: $dA = dXY - (dX + dY)/2$, where, dXY is the average distance between groups X and Y, and dX and dY are the within-group means. Net average sequence divergence between taxa was calculated from our data and the data of Fitch et al. (2006), Smith et al. (2007), Smissen et al. (2013), Maryan et al. (2014) and GenBank accessions for *V. komodoensis* Ouwens, 1912 for sister species pairs of *Varanus* where more than one sequence was available for each member of the pair.

RESULTS

MOLECULAR GENETICS

The partioning scheme and models of nucleotide substitution for the *ND4* alignment of 460 bp chosen in Partition Finder were first codon position with HKY+G, second codon position with HKY+G and third codon position with TIM+G. Figure 2 shows a Neighbor-Joining phylogram showing relationship among mitochondrial *ND4* sequences from *V. brevicauda* and near relatives. This topology was also recovered with the Bayesian analysis. Specimens resembling *V. brevicauda* fell into two highly divergent groups: the first is widespread across the arid zone, while the second appears to be geographically restricted to the Dampier Peninsula at the north-western edge of the range of *V. brevicauda sensu lato* (Figures 1, 2). The relationships of these two groups with *V. eremius* are unresolved by our data but net average sequence divergence (*dA*) between the three exceeds that between many other sister species pairs of varanids (Table 2).

MORPHOLOGY

Table 3 presents a summary of the morphological differences between *V. brevicauda* from across its range and the elongate individuals from the Dampier Peninsula (Figure 3). The two taxa had similar dorsal patterning, although *V. brevicauda* tended to have more pronounced ocelli than the elongate specimens, giving it a bolder pattern (Figure 4). Morphologically, the elongate specimens had a more gracile appearance (Figure 4), with longer inter-limb lengths (Table 3). We also found that head depth was shallower in the elongate individuals as well (Figure 5).

FIGURE 2 Neighbour-Joining (NJ) phylogram of relationships among mitochondrial *ND4* sequences of *Varanus brevicauda* and near relatives. Numbers at nodes are NJ bootstrap proportions (left) and Bayesian posterior probabilities (right).

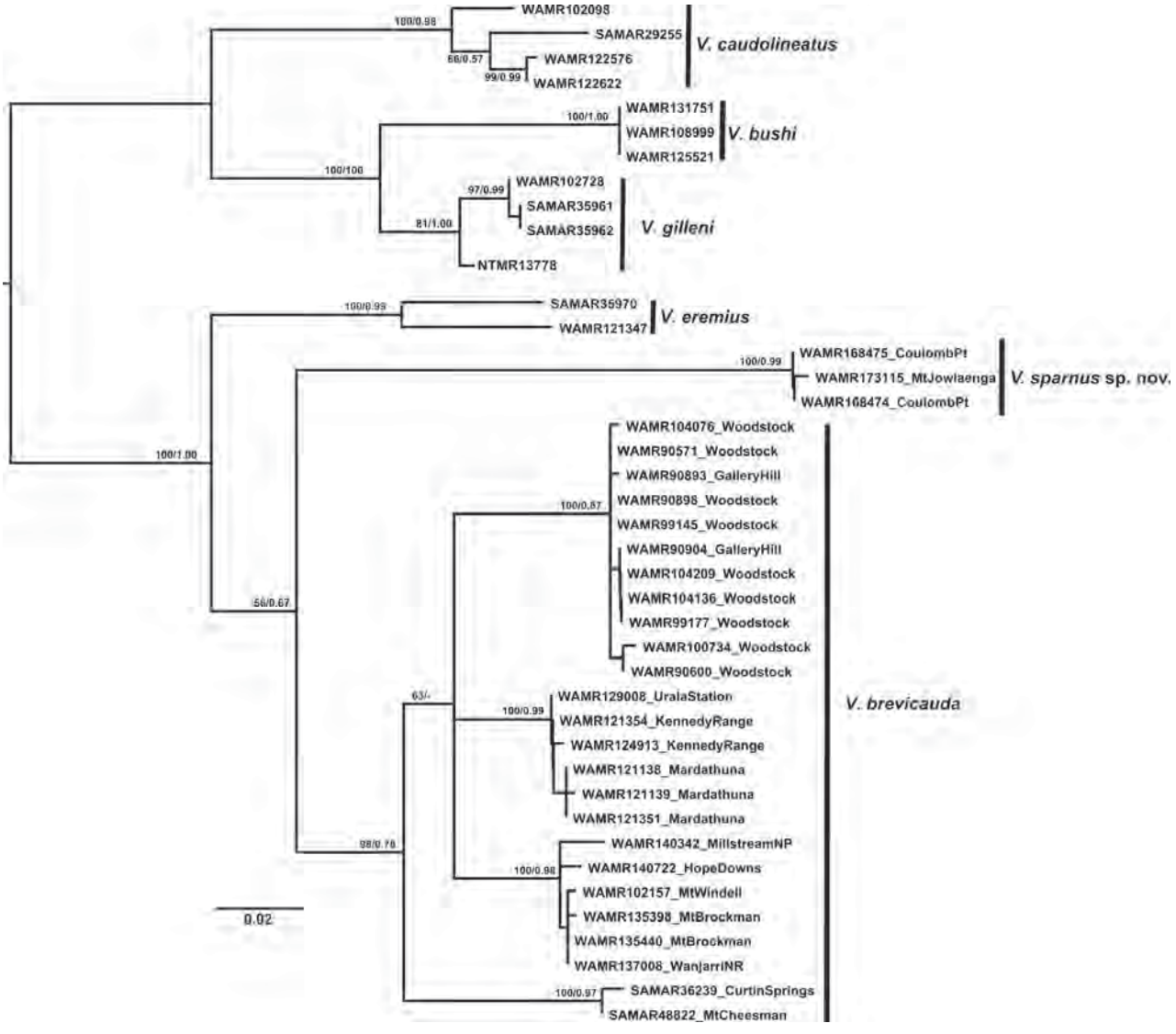

TABLE 2 Net average sequence divergence (*dA*) between sister species pairs of varanids and among *Varanus brevicauda*, *V. sparnus* sp. nov., *V. eremius* and other more distantly-related species pairs.

Sister species pair	*dA*
V. brevicauda-sparnus sp. nov.	0.134
V. eremius-sparnus sp. nov.	0.143
V. brevicauda-eremius	0.085
V. komdoensis-varius	0.125
V. mitchelli-semiremex	0.121
V. gouldii-rosenbergi	0.112
V. bushi-gilleni	0.066
V. pilbarensis-hamersleyensis	0.063
V. acanthurus insulanicus-baritji	0.019

A key difference between the two taxa observed was the appearance of the scales on the front and leading edge of the arms. The scales on the arms of *V. brevicauda senso stricto* are oval in shape and possess a ring of granules around them (Figure 6), similar to scales elsewhere on the body. In contrast, the elongate individuals had large, squarish scales on the front and leading edge of the arms, and the scales lacked small granules at their periphery (Figure 6). A further difference is that, in ventral view, the transition from the large squarish scales on the elongate individuals is quite abrupt, whereas in *V. brevicauda* the scales encircling the arm are similar in appearance with no abrupt transition (Figure 6).

TAXONOMIC CONCLUSIONS

The molecular genetic evidence strongly supported the existence of two independently evolving lineages within *V. brevicauda senso lato* (including the elongate specimens) based on reciprocal monophyly in the mitochondrial nucleotide sequence data and the extent of net average sequence divergence between the lineages relative to other recognised sister species pairs of *Varanus* (Table 2). Furthermore, nuclear gene sequence data from more than 300 loci produced from an anchored enrichment phylogenomic approach (Lemmon and Lemmon 2012) supports the highly divergent nature of the two lineages (Donnellan, Keogh, Lemmon and Lemmon, unpublished data).

The morphological evidence also supports the existence of two species, with the new species more elongate and gracile than *V. brevicauda*, and differences in scalation on the arms. Patterning and colouration differences were less apparent, although there was a trend for specimens of the elongate form to be less well-marked and to be a darker reddish-brown (at least in the two adults). Significantly, the two species are in sympatry on the Dampier Peninsula, where typical *V. brevicauda* specimens (WAM R40273, R40274, R44329) were collected 7 km to the north of the holotype of the new species. There was no evidence of individuals demonstrating intermediate morphological states, indicating a lack of gene flow between the two species.

Taken together, morphology, molecular genetics and the overlapping distributions of the two forms strongly demonstrate that the more elongate Dampier Peninsula specimens represent a new species distinct from *V. brevicauda*, which we describe below.

TAXONOMY

Family Varanidae Merrem, 1820

Genus *Varanus* Merrem, 1820

TYPE SPECIES

Lacerta varia (= *Varanus varius*) White, 1790, by subsequent designation.

***Varanus sparnus* sp. nov.**

Dampier Peninsula Goanna

Figures 3–6

http://www.zoobank.org/urn:lsid:zoobank.org:act:039C783D-5A6C-4B79-9069-94E1C51E77C7

MATERIAL EXAMINED

Holotype

Australia: *Western Australia*: WAM R168486, adult male collected by R.J. Teale and G. Harold on 10 March 2009, from Coloumb Point, Dampier Peninsula (-17.4277ºS, 122.1522ºE).

Paratypes

Australia: *Western Australia*: WAM R168475, adult female from Coloumb Point, Dampier Peninsula, collected on 14 March 2009 (-17.4608ºS, 122.1525ºE); WAM R168474, subadult, from Coloumb Point, Dampier Peninsula (-17.5736ºS, 122.1694ºE).

Additional material

Australia: *Western Australia*: WAM R173115, live subadult female from 9 km south-west of Mt Jowlaenga, Dampier Peninsula (-17.4865ºS, 122.9650ºE).

DIAGNOSIS

A very small *Varanus* (< 120 mm SVL) with short limbs, elongate body, ridged, circular and short prehensile tail (TailL/SVL: 0.92–0.99), and relatively plain reddish-brown dorsum with widely scattered small black spots. Further distinguished from *V. brevicauda* by having a more elongate body, shorter limbs, less robust head, body and tail, and presence of enlarged squarish scales not encircled by granules on front of the arms.

TABLE 3 Summaries of characters and ratios measured for *Varanus brevicauda* and *V. sparnus* sp. nov. Means±S.D and ranges on the second line for each character are presented. See Table 1 for abbreviations. Sample sizes are listed in column headings, unless noted for individual characters below.

	V. brevicauda	*V. sparnus* sp. nov.			
Character:	N = 20 (8♀, 12♂)	R168486 (♂)	R168475 (♀)	R168474 (J)	R173115 (♀)
SVL	102.0±8.2	116.0	116.4	72.1	110.0
	90.5–120.5				
TailL	98.1±10.9	111.5	108.4	69.0	101.0
	79–117				
HeadL	18.2±1.2	20.1	17.9	13.6	15.9
	16.0–20.5				
HeadW	10.8±0.8	10.5	9.5	6.9	9.5
	9.4–12.6				
HeadD	8.1±0.9	7.6	7.0	5.0	7.5
	6.0–9.7				
SupLab	17.5±1.5	16	17	16	18
	15–21				
InfLab	17.1±1.1	16	16	15	18
	15–19				
MBSR	88.4±6.8	79	86	66	
	80–103				
4TLam	16.1±1.6	15	16	14	
	14–19				
PCP	0.4±1.4	0	0	0	0
	0–6				
ILL	58.2±5.7	66.6	74.1	40.2	79.7
	49.2–69.1				
UArmL	8.4±0.8	8.3	8.7	6.2	6.3
	7.0–9.8				
LArmL	6.8±0.7	6.9	7.0	4.9	7.6
	4.7–7.8				
HandL	9.3±0.6	10.1	8.9	6.0	8.4
	8.4–10.3				
ULegL	9.7±0.8	10.0	9.0	6.1	8.0
	7.8–11.0				
LLegL	8.7±1.0	7.6	7.8	5.6	7.3
	6.6–10.2				
FootL	10.5±1.2	9.9	9.6	7.2	8.6
	7.4–12.3				

DESCRIPTION OF HOLOTYPE (WAM R168486)

Head short (HeadL/SVL – 0.173), narrow (HeadW/SVL – 0.091) and shallow (HeadD/SVL – 0.066); snout slightly concave dorsally, narrowing to broadly rounded tip when viewed dorsally; in lateral view, snout gradually narrows to nostrils, then angles downwards to tip of snout; upper jaw protrudes slightly beyond lower jaw; eyes relatively large; nares large and directed posteriorly, posterior edge straight and defined by ridge, narrowing anteriorly; nostril opening small and positioned anteriorly and ventrally within narial opening; external ear opening large (~1.5 times width of eye), ventral portion angled forwards, anterior edge curved slightly and posterior edge straight for uppermost 1/3, then angled anteriorly; line of mouth gradually rising from snout tip to below posterior edge of eye, then straight to ventral edge of ear opening. Longitudinally oriented scales on top of head behind eyes with pronounced, straight keels; scales on top of snout protruding and irregular, lacking keels; scales above eyes with short keels; keels at back of head angled outwards.

Mental two times longer than wide, sides gradually narrowing then angling at 45º to meet at posterior terminal point; first, second and third infralabials enlarged, gradually decreasing in size from mental until the size of surrounding scales. Gular scales near edge of jaw flattened and elongate, gradually rounding towards gular fold; gular fold strong, with underlying granular scales underneath fold.

FIGURE 3 Images in life of *Varanus sparnus* sp. nov. Upper image – WAM R173115 (image by R. Ellis); lower image – holotype WAM R168486 (image by G. Harold).

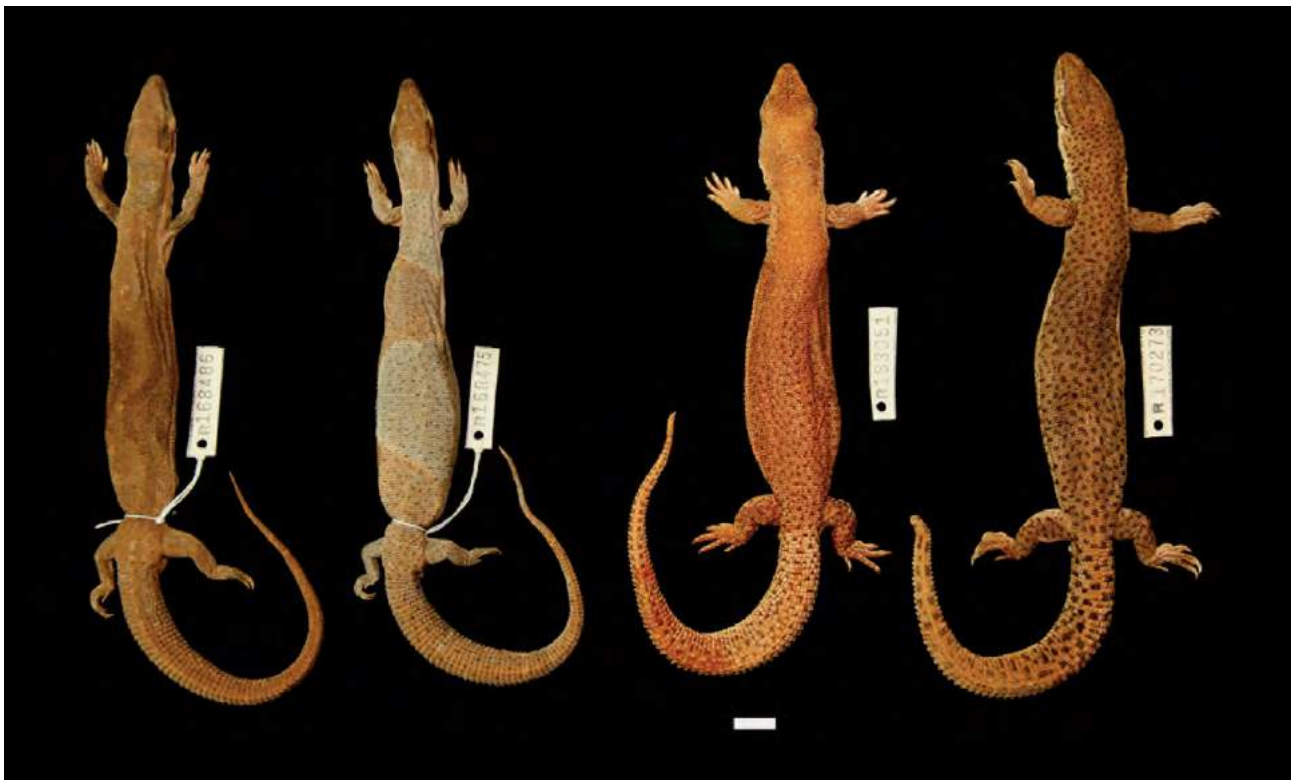

FIGURE 4 Preserved specimens of *Varanus sparnus* sp. nov. (holotype – WAM R168486; paratype – 168475), and *V. brevicauda* (WAM R163051, WAM R170273). Scale bar = 1 cm.

Torso extremely elongate (ILL/SVL – 0.57); covered in rows of small scales; dorsal scales non-overlapping and oblong with low keels bordered by 8–12 small granules (except for anterior edge); scales on sides lack keels and are rounder (less oblong); ventral scales non-overlapping, smooth (i.e. no perforation visible) and rectangular with slightly rounded posterior edge.

Limbs extremely short (UArmL/SVL – 0.072; LArmL/SVL – 0.059; ULegL/SVL – 0.086 LLegL/SVL – 0.066), with relatively large hands (HandL/SVL – 0.087) and feet (FootL/SVL – 0.085); absolute lengths: hand length > lower arm > upper arm, upper leg > foot length > lower leg. Lower arm compressed; scales on dorsal surface of lower and upper arm large, squarish and flattened, lacking surrounding granules; scales on ventral surface small; abrupt transition of scale size at leading edge of lower arm: from rows of large scales of inner lower arm to smaller scales on ventral surfaces. Scales on upper and lower surfaces of legs similar to dorsal scales on body, but smaller; scales on anterior surface enlarged and flattened, lacking surrounding granules; scales on posterior edge very small, almost granular; medial rows of scales on dorsal surfaces of hands and feet enlarged and with tightly grouped non-overlapping flat scales; palmar and plantar surfaces with small rounded scales. Fingers long with long recurved claws; toes moderately long with long recurved claws.

Cloacal spurs to either side of vent, each with 20–25 spurs arranged in 3 or 4 irregular rows; spurs flattened at base and curve upwards to fine point. Tail short and covered in regular rows of scales; dorsal scales strongly keeled and angled dorsally at posterior edge; ventral scales strongly keeled and flat; tail tip gradually tapering to a fine point; tail tip very flexible and prehensile. Measurements of the holotype and all other specimens are presented in Table 3.

Colouration

In life, ground colour of dorsum and lateral surfaces light reddish-brown; freckled with fine black spots (no ocelli present) that occupy a single scale; ventral surfaces dull yellowy-white; head with a dark blackish streak from the eye to the dorsal portion of ear opening; upper labials and scales below eye pale with light grey stippling (Figure 3). In preservative, ground colour darker reddish-brown and lower surfaces dull yellowy-white; otherwise similar to life (Figure 4).

VARIATION

The adult female (WAM R168475) is similar in most respects to the male holotype, however, this specimen has a longer torso and more gracile proportions (including slender head and neck, and thinner tail). The patterning also differs in that 1–4 scales comprise the black spots scattered on the dorsum, giving them a darker appearance. Cloacal spurs in the same position as for the male, but much shorter and without sharp tips. The juvenile (WAM R168474) is more heavily spotted in appearance than the adult female, with the black spots comprised of 4–6 scales. Otherwise, the colouration is similar in most respect to the adults. The live specimen (WAM R173115) is a subadult female, with a very subdued pattern (Figure 3).

FIGURE 5 Comparison of lateral view of heads of *Varanus sparnus* sp. nov. (top two images) and *V. brevicauda* (bottom two images). From top to bottom: WAM R168475, WAM R168486, WAM R163051, WAM R170273. Scale bar = 1 cm.

HABITAT

The three Coloumb Point specimens were collected in areas with alluvial or sandstone deposits, and broadly classed as 'pindan shrubland'. A detailed vegetation assessment for the three type specimens is provided below (M. Maier, Biota Environmental Consultants, pers. comm.). The holotype, WAM R168486, occurred with *Corymbia* sp. low trees over *Acacia monticola, A. colei, A. eriopoda* tall open scrub over mixed open grassland, on pindan soil on plain. The paratype WAM R168474 was associated with *Corymbia dampieri* and *C. polycarpa* scattered low trees over *Acacia*

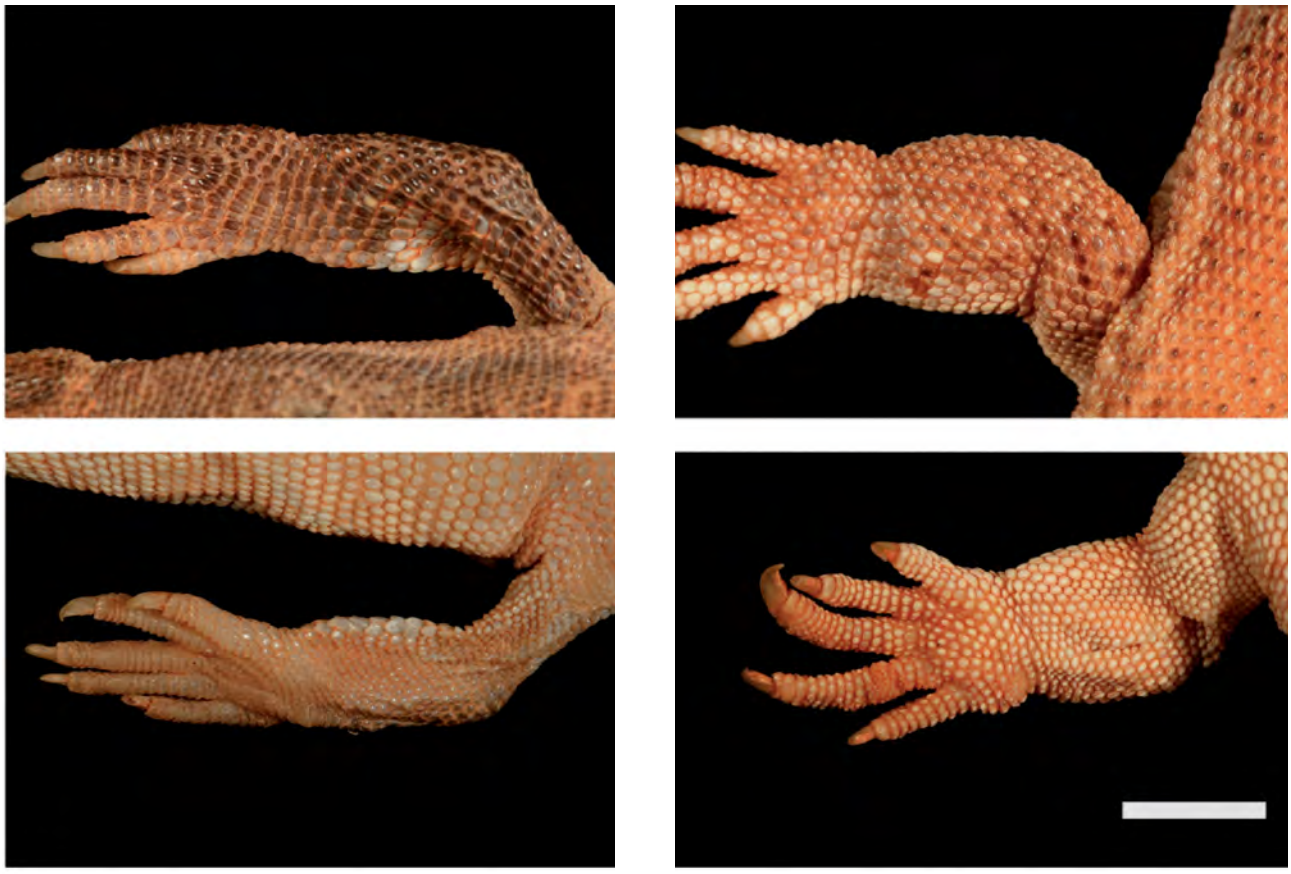

FIGURE 6 Close up comparison of the difference in arm scalation between *Varanus sparnus* sp. nov. (upper left – dorsal view; lower left – ventral view; WAM R168486) and *V. brevicauda* (upper right – dorsal view; lower right – ventral view; WAM R163051). Scale bar = 0.5 cm.

FIGURE 7 Habitat shots from the type series of *Varanus sparnus* sp. nov. from near Coloumb Point, Dampier Peninsula, Western Australia. Collection locations of paratypes WAM R168474 (left) and WAM R168475 (right).

eriopoda open shrubland; on pindan soil on plain. The paratype WAM R168475 was found amongst *Eucalyptus miniata, Terminalia ferdinandiana* low open woodland over *Acacia tumida* var. *kulparn* low closed heath over *Triodia schinzii* very open hummock grassland on exposed coastal fringe; on coastal sand in dune swale (Figure 7). The Mt Jowelaenga individual (WAM R173115) was collected in a funnel trap in pindan woodland with dense shrubs of *Acacia tumida*, scattered *Triodia caelestialis* and *Sorghum timorense* and soil consisting of red-brown sandy loam (N. Jackett, Ecologia Environment, pers. comm.).

BEHAVIOUR

Observations of the captive individual (WAM R173115) indicate that this species is a highly active burrower, excavating underneath all hard structures, such as flat pieces of wood and a heating stone (L. Umbrello, pers. comm.). This specimen readily consumed both live food (*Tenebrio* larvae, crickets) and wet cat food. Attempts to photograph this species in life were difficult, as the animals were constantly moving and rarely paused (G. Harold, R. Ellis, pers. comm.). The tail is highly prehensile, similar to that of *V. brevicauda*, possibly functioning to assist in navigating through *Triodia* clumps and shrubs.

DISTRIBUTION

The four individuals were collected from two locations approximately 90 km apart in the central portion of the Dampier Peninsula in the western Kimberley (Figure 1). This species is likely to be restricted to the peninsula (~15,000 km^2). No specimens from outside of the Dampier Peninsula (i.e. the western deserts and Pilbara region) were detected when sorting through the *V. brevicauda* specimens in the WAM collections.

ETYMOLOGY

sparnos is Greek for ‘rare’ or ‘scarce’, in reference to this species’ isolation and small range on the Dampier Peninsula. Latinised to *sparnus*, and used as an adjective.

REMARKS

Descriptions of new Australian goanna species in the past 10 years have all come from Western Australia: two from the southern Pilbara region (Aplin et al. 2006; Maryan et al. 2014), and now *V. sparnus* from the south-western Kimberley, approximately 700 km to the north. The description of *V. sparnus* further establishes Australia’s status as the most species-rich region for *Varanus* globally, with approximately 32 of 75 species (Uetz 2014).

Varanus sparnus has an apparently extremely restricted distribution, completely confined to the relatively small Dampier Peninsula area. This is in contrast to its two closest relatives, *V. brevicauda* and *V. eremius*, which nearly range across the entire arid zone that comprises the majority of the Australian continent (Pianka et al. 2004). All three species occupy sandy substrates, so other factors would explain the distributional patterns of these taxa. The sandy arid regions of the west coast of Australia has a disproportionately high number of endemics with small ranges (McKenzie et al. 2000; How and Cowan 2006; Doughty et al. 2011). Although most of these species occur further south in the mid-west and Pilbara regions, the same processes (e.g. changes in sea level that affect sand-associated taxa) may affect taxa in the Dampierland region as well. As the distribution of *V. sparnus* appears to be extremely restricted, it would be prudent for wildlife and conservation agencies to consider this species for some kind of protected status until more is known about its true range and biology.

Varanus sparnus is slightly smaller than *V. brevicauda* in maximum body size, making it the smallest known *Varanus*. In contrast, the largest member of the genus, *V. komodoensis*, reaches sizes of over 1.5 m in SVL, 3.0 m in total length and 80 kg (Jessop et al. 2006), compared to *V. sparnus* with an SVL of 116 mm, total length of 227.5 mm and mass of only 16.3 g, a remarkable size difference within a single genus of reptiles (e.g. King and Green 1999; Pianka et al. 2004; Openshaw and Keogh 2014).

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APPENDIX 1 Specimens examined for morphological[M] and molecular genetic analyses. Numbers in bold preceding localities refer localities from which genetic data were obtained (see Figure 1). *Short sequences that we did not include in Figure 2, but fall within the *V. brevicauda* clade (sequences not on GenBank but available from the authors).

Registration Number	Locality	State	Sex	GenBank	Declat	Declong
Varanus brevicauda						
SAMA R36239	**(1)** Curtin Springs	NT		KP076412	-25.392	131.767
SAMA R48822	**(2)** Mt Cheesman	SA		KP076413	-27.337	130.237
SAMA R62377*	**(3)** 166 km SSE Watarru	SA		*	-28.549	129.998
WAM R13837[M]	Derby	WA	♀	-	-17.300	123.617
WAM R20350[M]	32 km S Derby	WA	♂	-	-17.600	123.633
WAM R28029[M]	La Grange	WA	♀	-	-18.683	121.767
WAM R40274[M]	Coloumb Point	WA	♂	-	-17.367	122.150
WAM R44329[M]	Coloumb Point	WA	♂	-	-17.367	122.150
WAM R46168[M]	Anna Plains	WA	♀	-	-19.250	121.483
WAM R90571	**(4)** Woodstock	WA		KP076403	-21.6097	118.9878
WAM R90600[M]	**(4)** Woodstock	WA	♀	KP076409	-21.6116	118.9556
WAM R90893[M]	**(5)** 200 m S Gallery Hill	WA	♂	KP076410	-21.6677	119.0408
WAM R90898[M]	**(4)** Woodstock	WA	♂	DQ525115	-21.6116	118.9556
WAM R90904[M]	**(5)** 200 m S Gallery Hill	WA	♂	KP076411	-21.6677	119.0408
WAM R99145[M]	**(5)** 200 m S Gallery Hill	WA	♀	KP076402	-21.6677	119.0408
WAM R99177	**(5)** 200 m S Gallery Hill	WA		KP076408	-21.6677	119.0408
WAM R100734	**(4)** Woodstock	WA		KP076407	-21.6094	118.9878
WAM R102157	**(6)** Mt Windell	WA		DQ525116	-22.6300	118.6139
WAM R104076	**(4)** Woodstock	WA		KP076404	-21.6166	118.9500
WAM R104136	**(4)** Woodstock	WA		KP076405	-21.6166	118.9500
WAM R104209	**(4)** Woodstock	WA		KP076406	-21.6166	118.9500
WAM R121138[M]	**(7)** 8 km NW Mardathuna Homestead	WA	♂	KP076419	-24.4288	114.5000
WAM R121139[M]	**(7)** 8 km NW Mardathuna Homestead	WA	♂	KP076417	-24.4288	114.5000
WAM R121351[M]	**(7)** 8 km NW Mardathuna Homestead	WA	♀	KP076418	-24.4288	114.5000
WAM R121354[M]	**(8)** Kennedy Range National Park	WA	♂	KP076416	-24.4930	115.0306
WAM R124913	**(8)** Kennedy Range	WA		KP076414	-24.5008	115.0175
WAM R129008	**(9)** Urala Station	WA		KP076420	-21.7836	114.8633
WAM R135398[M]	**(10)** Mt Brockman	WA	♂	KP076399	-22.3000	117.3000
WAM R135440[M]	**(10)** Mt Brockman	WA	♀	KP076398	-22.2919	117.2989
WAM R137008[M]	**(11)** Wanjarri NR	WA	♀	KP076415	-27.3333	120.7167
WAM R139065*	**(12)** Mandora	WA		*	-19.8083	121.4639
WAM R140342[M]	**(13)** Millstream-Chichester	WA	♂	KP076401	-21.4116	117.1561
WAM R140722	**(14)** Hope Downs	WA		KP076400	-22.6736	119.4161
WAM R140985*[M]	**(9)** Urala Station	WA	♂	*	-21.7827	114.8697
WAM R161599*	**(15)** Goldsworthy	WA		*	-20.2419	119.5740

Registration Number	Locality	State	Sex	GenBank	Declat	Declong
Varanus sparnus sp. nov.						
WAM R168486[M]	Coulomb Point	WA	♂		-17.4277	122.1522
WAM R168474[M]	**(18)** Coulomb Point	WA	-	KP076422	-17.5736	122.1694
WAM R168475[M]	**(17)** Coulomb Point	WA	♀	KP076423	-17.4608	122.1525
WAM R173115[M]	**(16)** 9 km SW Mt Jowlaenga	WA	♀	KP076421	-17.4865	122.9650
Varanus eremius						
SAMA R35970	2 km W Purni Bore	SA	-	DQ525114	-26.28	136.08
WAM R121347	30 km S Carnarvon	WA	-	DQ525113	-25.1313	113.7681
Varanus caudolineatus						
SAMA R29255	57 km S Leonara	WA	-	DQ525139	-29.37	121.27
WAM R102098	Wongida, Barlee Range	WA	-	DQ631874	-22.9666	115.8500
WAM R122622	18.5 km SE Wooramel	WA	-	DQ631876	-25.7105	114.5994
WAM R122576	18 km SE Wooramel	WA	-	DQ631875	-25.6805	114.6217
Varanus bushi						
WAM R131751	Hamersley Station	WA	-	DQ631883	-22.4452	117.8797
WAM R125521	North Pilbara	WA	-	DQ631882	-21.5000	117.5000
WAM R129912	West Angelas iron ore mine	WA	-	DQ631877	-23.1858	118.7544
Varanus gilleni						
WAM R102728	Little Sandy Desert	WA	-	DQ631872	-24.5925	120.2631
SAMA R35961	Alka Seltzer Bore	SA	-	DQ525138	-26.33	136.01
NTM R13778	no locality data	-	-	DQ525137	-	-