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Consolidation of Regional Fauna Habitat Mapping

BHP Billiton Iron Ore Pilbara Tenure

BHP Billiton Iron Ore Pty Ltd

May 2014

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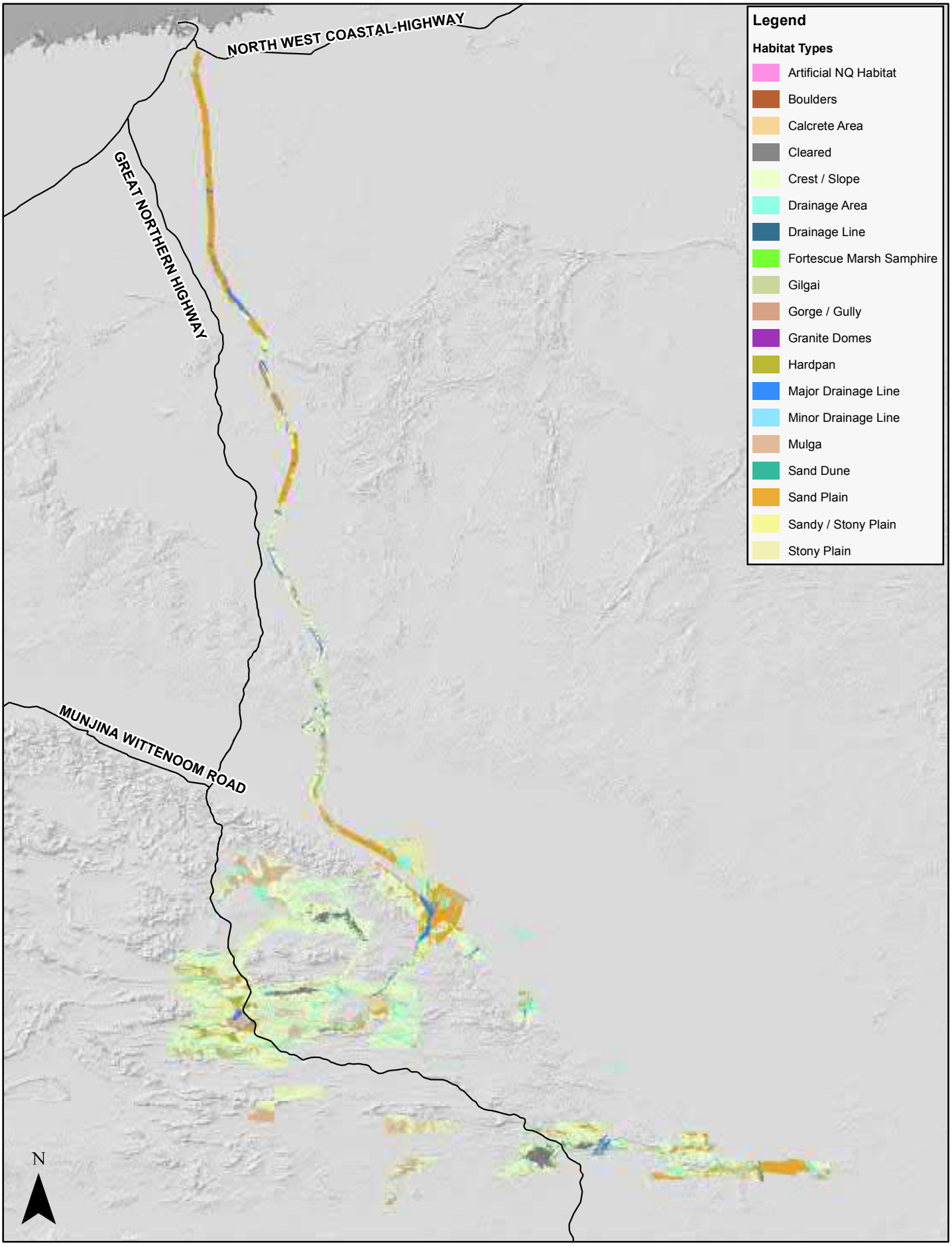
EXECUTIVE SUMMARY

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) has been undertaking baseline biological surveys in the Pilbara since the 1990s. In the past five years, these surveys have involved the preparation of fauna habitat maps, developed using different techniques and/or nomenclature; but based on generally similar field assessments. This report combines all available and relevant fauna habitat mapping into one consolidated regional dataset that provides consistency in naming across BHP Billiton Iron Ore Pilbara tenure.

A combination of landform, vegetation and soils (substrate) were used to delineate and describe fauna habitats. Vegetation mapping (Onshore, 2014) from Onshore Environmental Consultants not only included the vegetation types of the Study Area but also the substrate and landform associated with each vegetation type. The habitat mapping undertaken for this project was largely derived from this dataset and utilised the boundaries of each vegetation association category delineated by Onshore. After considering aerial photography, site visit information, Land System mapping and the vegetation mapping, the vegetation types were grouped into fauna habitat types and mapped accordingly. Where the vegetation types and their boundaries did not correlate with the habitat type (e.g. Gorge/Gully and some areas of Sand Plain), boundaries were redrawn using aerial photography and data from previous surveys conducted by Biologic and other consultants where available.

The following habitats occur within the Study Area; Stony plain, Sandy/Stony Plain, Sand Plain, Sand Dune, Mulga, Minor Drainage Line, Major Drainage Line, Hardpan Plain, Granite domes & boulders (tors), Gorge/Gully, Gilgai (cracking clay), Fortescue Marsh samphire, Drainage Line, Drainage Area, Crest/Slope, Calcrete Areas and Artificial Habitats (see figure below). Each habitat type was also assessed for species diversity and records of conservation significant fauna. Sand Plain, Sand Dune, Major Drainage Line, Granite Dome & Boulder Piles, Fortescue Marsh Samphire, Gilgai and Gorge/Gully habitats had higher species diversity and conservation significant species records.



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PILBARA HABITAT
CONSOLIDATION PROJECT

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1 INTRODUCTION

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) has commissioned baseline biological surveys across its Pilbara tenure since the 1990s. In the past five years, these surveys have involved the preparation of fauna habitat maps, developed using different techniques and/or nomenclature; however have generally utilised similar field methods. This report combines all available and relevant fauna habitat mapping into one consolidated regional dataset that provides consistency in naming across BHP Billiton Iron Ore tenure.

The scope of work included an initial gap analysis that identified leases that had no previous habitat mapping. In most cases, areas that did not have vegetation mapping, or the mapping was at a poor resolution, did not have reliable fauna habitat mapping. This allowed the fauna habitat field investigations to be undertaken in conjunction with a similar project to consolidate the vegetation mapping across BHP Billiton Iron Ore tenure, being undertaken by Onshore Environmental Consultants Pty Ltd (Onshore).

With the use of aerial photography, previous fauna habitat mapping, Onshore's consolidated vegetation mapping and information gathered during site visits, a regional dataset was created which allowed the mapping of a consistent set of habitat types across BHP Billiton Iron Ore Pilbara tenure. A description of the Pilbara environment, the methodology used to delineate, describe and map habitat types, as well as an analysis of habitats types that have recorded higher species diversity and/or conservation significant species is provided in this report. Figure 1.1 shows the Study Area for this consolidated habitat mapping.

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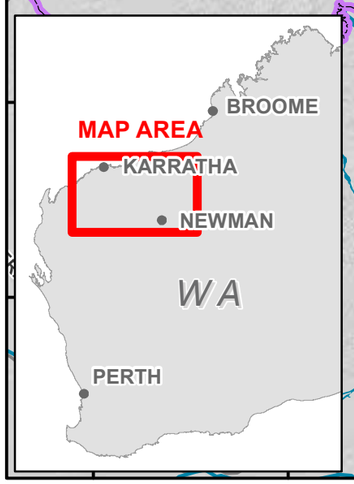
PORT HEDLAND
POINT SAMSON
DAMPIER
WICKHAM
KARRATHA
ROEBOURNE
MARBLE BAR
PANNAWONICA
TOM PRICE
NEWMAN

DE GREY RIVER
PIPPINGARRA ROAD
YULE RIVER
WOODIE WOODIE ROAD
MARBLE BAR ROAD
NORTH WEST COASTAL HIGHWAY
GREAT NORTHERN HIGHWAY
FORTESCUE RIVER
MUNJINA WITTENOOM ROAD
NANUTARRA WITTENOOM ROAD
KARIJINI DRIVE
PARABURDOO TOM PRICE ROAD
ASHBURTON RIVER
SPEARHOLE CREEK
WESTERN CREEK
SAVORY CREEK
FORTESCUE MARSH

Great Sandy Island Nature Reserve
Barrow Island Marine Management Area
Mardie
Millstream Chichester National Park
Yandeyarra Aboriginal Reserve
Mungaroona Range Nature Reserve
Woodstock/Abydos Aboriginal Reserve
Meentheena
Jigalong Aboriginal Reserve
Mt Minnie
Cane River Conservation Park
Nanutarra
Mt Florence
Karijini National Park

Pilbara IBRA
Gascoyne IBRA



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Regional Location

FIGURE 1.1

Legend

- Study Area
- Pilbara & Gascoyne IBRA
- IndigenousReserve
- NatureConservationReserve
- Rail
- Roads
- Watercourse

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2 ENVIRONMENT

2.1 Biogeography

The majority of the Study Area is situated in the Pilbara biogeographical region, with a small section within the north eastern Gascoyne Region, as defined by the Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway and Cresswell 1995).

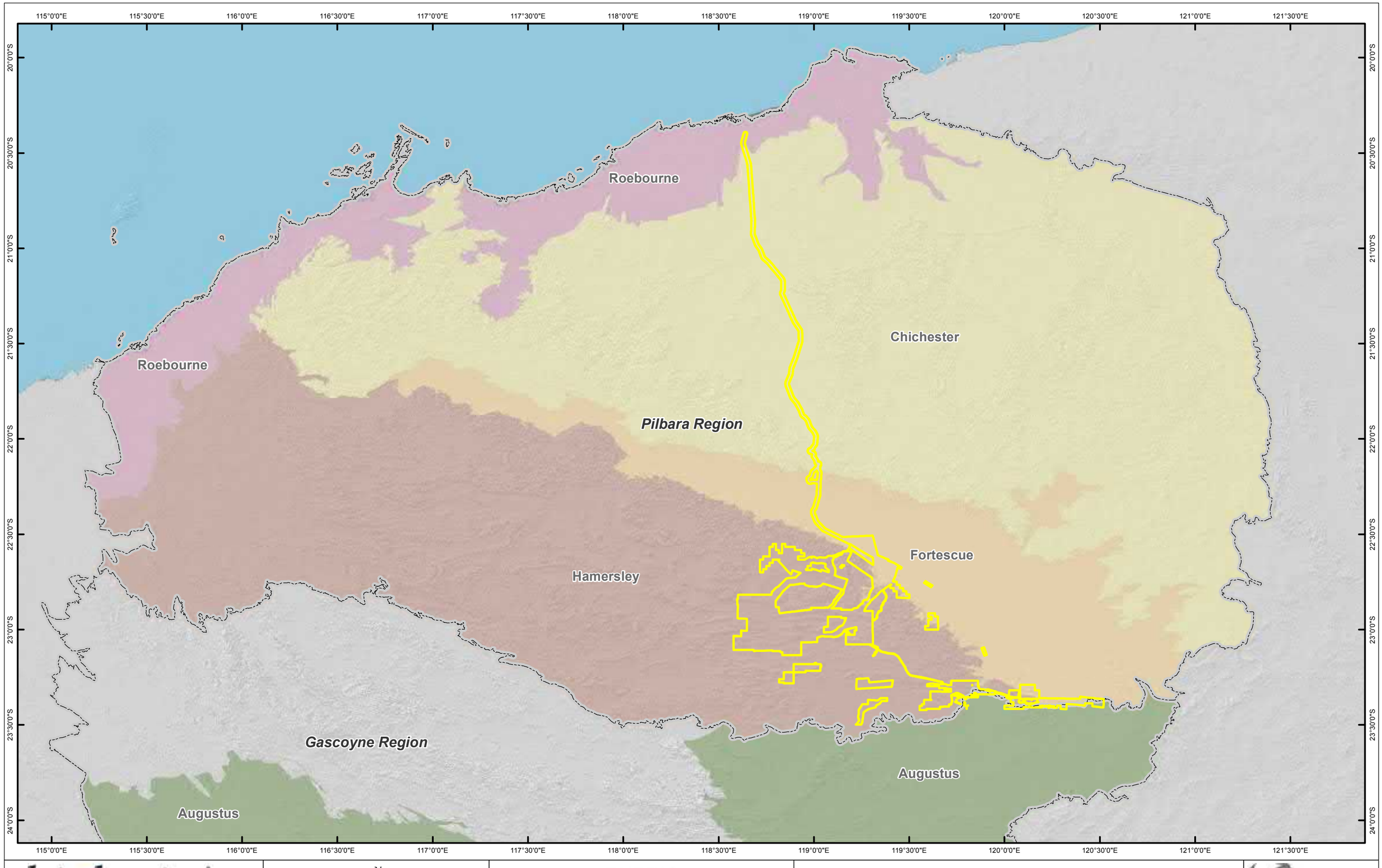
The Pilbara bioregion is subdivided into four subregions: the Chichester, Fortescue Plains, Hamersley and Roebourne of which the Study Area covers each of these (Figure 2.1). The Gascoyne bioregion is subdivided into three subregions: the Ashburton, Carnegie and Augustus, with the Study Area covering less than 1% the Augustus subregion (Figure 2.1).

The majority of the Study Area is situated in the Hamersley subregion (Figure 2.1). The Hamersley subregion is a mountainous area of Proterozoic sedimentary ranges and plateaux, dissected by gorges (Kendrick 2001a). The principal vegetation community comprises Mulga low woodland over bunch grasses in valley floors, while *Eucalyptus leucophloia* over *Triodia brizoides* is dominant on the ranges.

The Fortescue Plains subregion, comprises the next largest portion of the Study Area. This subregion contains the Fortescue Marsh, which is listed as a nationally important wetland (Environment Australia 2001). Outside the Fortescue Marsh, this subregion is characterised by River Red Gum (*E. camaldulensis*) woodlands fringing drainage lines and deeply incised gorge systems (Kendrick 2001b).

Smaller proportions of the Study Area lie within the Chichester, Augustus and Roebourne subregions. The Chichester subregion is situated within the northern section of the Pilbara Craton. It contains undulating Archaean granite and basalt plains and significant areas of basaltic ranges. The plains support shrub steppe, which is characterised by *Acacia inaequilatera* over *Triodia wiseana* hummock grasslands. *Eucalyptus leucophloia* tree steppes occur on the ranges (Kendrick and McKenzie 2001).

Rugged low Proterozoic sedimentary and granite ranges divided by broad flat valleys characterise the Augustus subregion (Desmond *et al.* 2001). The Gascoyne River system is the main drainage for the subregion. The subregion contains extensive areas of alluvial valley-fill deposits. The shallow stony loams on the rises support Mulga woodland with areas



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IBRA SUBREGIONS WITHIN THE STUDY AREA

FIGURE 2.1

Legend

- Study_Area
- Pilbara and Gascoyne Regions

IBRA Sub Regions

- Augustus
- Chichester
- Fortescue
- Hamersley
- Roebourne

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of *Triodia* while the shallow earthy loams over hardpan on the plains are covered by Mulga parkland (Desmond *et al.* 2001).

The Roebourne subregion comprises Quaternary alluvial and Aeolian coastal and sub-coastal plains. The plains are covered by a grass savannah of mixed bunch (*Aristida* spp., *Enneapogon* spp.), and hummock grasses (*Triodia* spp.) and dwarf shrubland of *Acacia stellaticeps* or *A. pyrifolia* and *A. inaequilatera*. *Triodia* hummock grasslands dominate the uplands. Ephemeral drainage lines support *Eucalyptus victrix* or *Corymbia hamersleyana* woodlands (Kendrick and Stanley 2001).

2.2 Climate

The majority of the Study Area is within the Pilbara Region, which experiences high temperatures and low, irregular rainfall following tropical cyclones in summer. The majority of the rainfall occurs in summer, often linked with thunderstorms and occasional tropical cyclones. Average annual rainfall for the Pilbara is 290 mm, with January, February and March being the wettest months. A minimum of one tropical cyclone moves through or along the coast of the region during a regular summer season, supplying half the annual rainfall (McKenzie *et al.* 2009).

The climate of the Study Area is characterised into three climatic sub-types (Figure 2.2) following the Köppen classification system (Stern *et al*. 2001). This classification system uses native vegetation as an expression of climate, combining factors such as average annual temperatures and precipitation, monthly temperatures and precipitation, and the dominant seasonality of precipitation. The climatic groups and classes for the Study Area include:

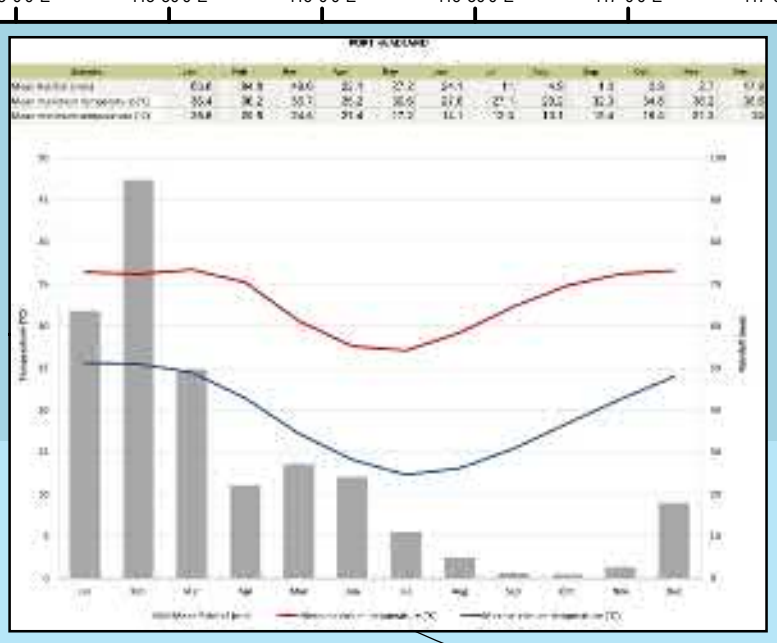
Desert

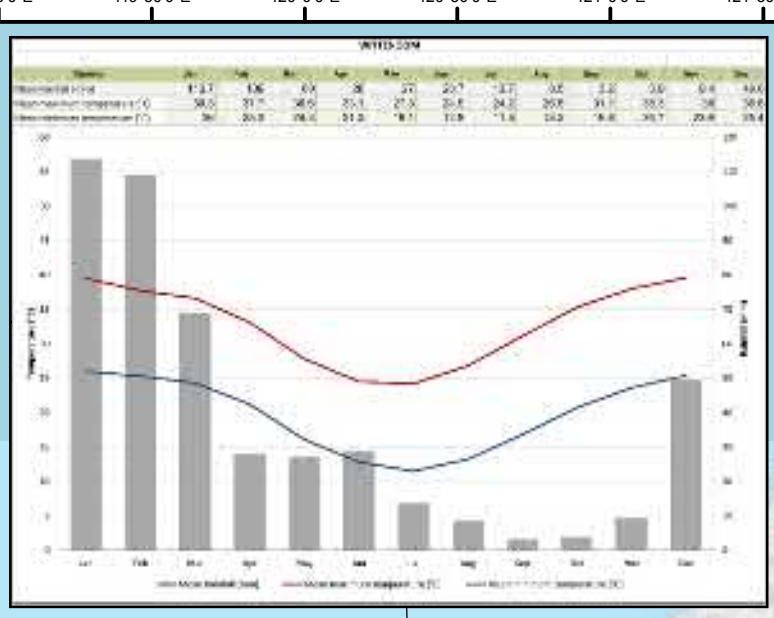
- hot (persistently dry);
- hot (winter drought); and

Grassland

- hot (persistently dry).

Due to the size of the Study Area, climatic conditions vary throughout. Three weather stations located in proximity to the Study Area provide an indication of temperature and rainfall patterns: Port Hedland post office; Wittenoom; and Newman (Figure 2.2, Table 2.1).

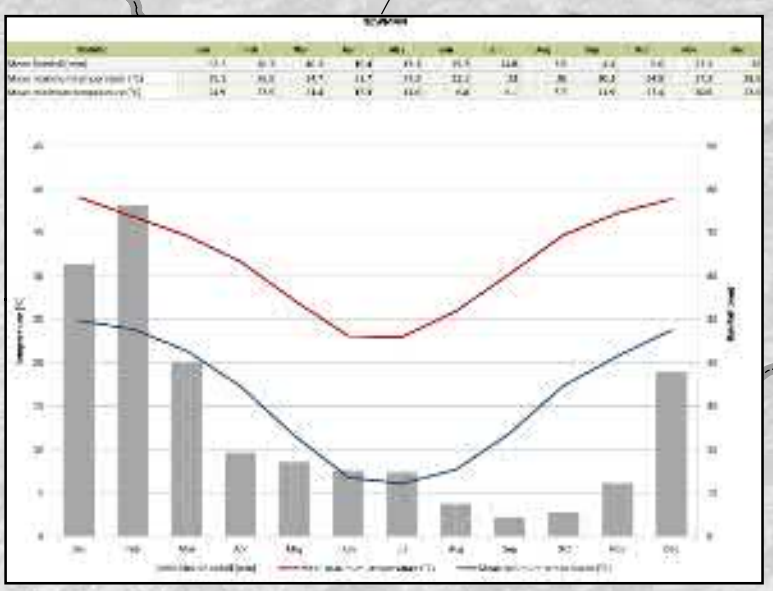




PORT HEDLAND

WITTENOOM

NEWMAN



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Average Monthly Temperature And Rainfall Observations At Port Hedland (Post Office), Wittenoom And Newman Airport (Bom 2013).

FIGURE 2.2

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- Study_Area
- IBRA Pilbra & Gascoyne

Climate Classifications

- Desert, Hot, Persistently Dry
- Desert, Hot, Winter Drought
- Grassland, Hot, Persistently Dry
- Grassland, Hot, Summer Drought

Table 2.1: Average weather conditions within the Study Area (BoM 2013).

Weather station location	Average Annual rainfall (mm)	Average monthly temperature (°C)
Port Hedland post office	329.3 mm	31.8°C
Wittenoom	463.7 mm	32.8°C
Newman airport	310.2 mm	31.4°C

2.3 Substrate

Geology

The regional geology of the Study Area is dominated by the Archaean hard-rock landscapes of the Pilbara craton (Figure 2.3). The base rock of the northern regions of the Pilbara Craton is the most exposed and oldest Archaean granite and greenstone terrane in Australia (Griffin 1990). This granite-greenstone terrane was formed between 3,500 and 2,800 million years ago as a result of four major phases of complex deformation and associated metamorphism (Griffin 1990).

In the south, the base rock is overlain with rugged sedimentary strata, volcanic flows and lateritised caps (Archaean and Proterozoic) of the Hamersley Basin. This Basin is the younger (2,760 to 1,700 million years old) of the two major components of the Pilbara Craton, and forms a relatively undisturbed cover over the older granite-greenstone terrane (SL Johnson In: Van Vreeswyk *et al.* 2004). In the north of the Hamersley Basin are the Archaean basalt, shale, sandstone, conglomerate, tuff and carbonate formations of the Northwest and Northeast Pilbara Sub-basins. These rocks are collectively known as the Fortescue Group and, with a narrow strip of banded iron formation, they make up the Chichester Ranges (Tille 2006). To the south, the Hamersley Range has formed on the late Archaean-Palaeoproterozoic metamorphosed banded iron formations, shales, dolerite, carbonate, chert and rhyolite of the South Pilbara Sub-basin. These rocks belong to the Hamersley Group and make up part of the Ophthalmia Fold Belt. The Hamersley Basin in its entirety is also referred to as the Mount Bruce Supergroup and comprises the Turee Creek, Hamersley and Fortescue Groups (Powell and Horwitz 1994).

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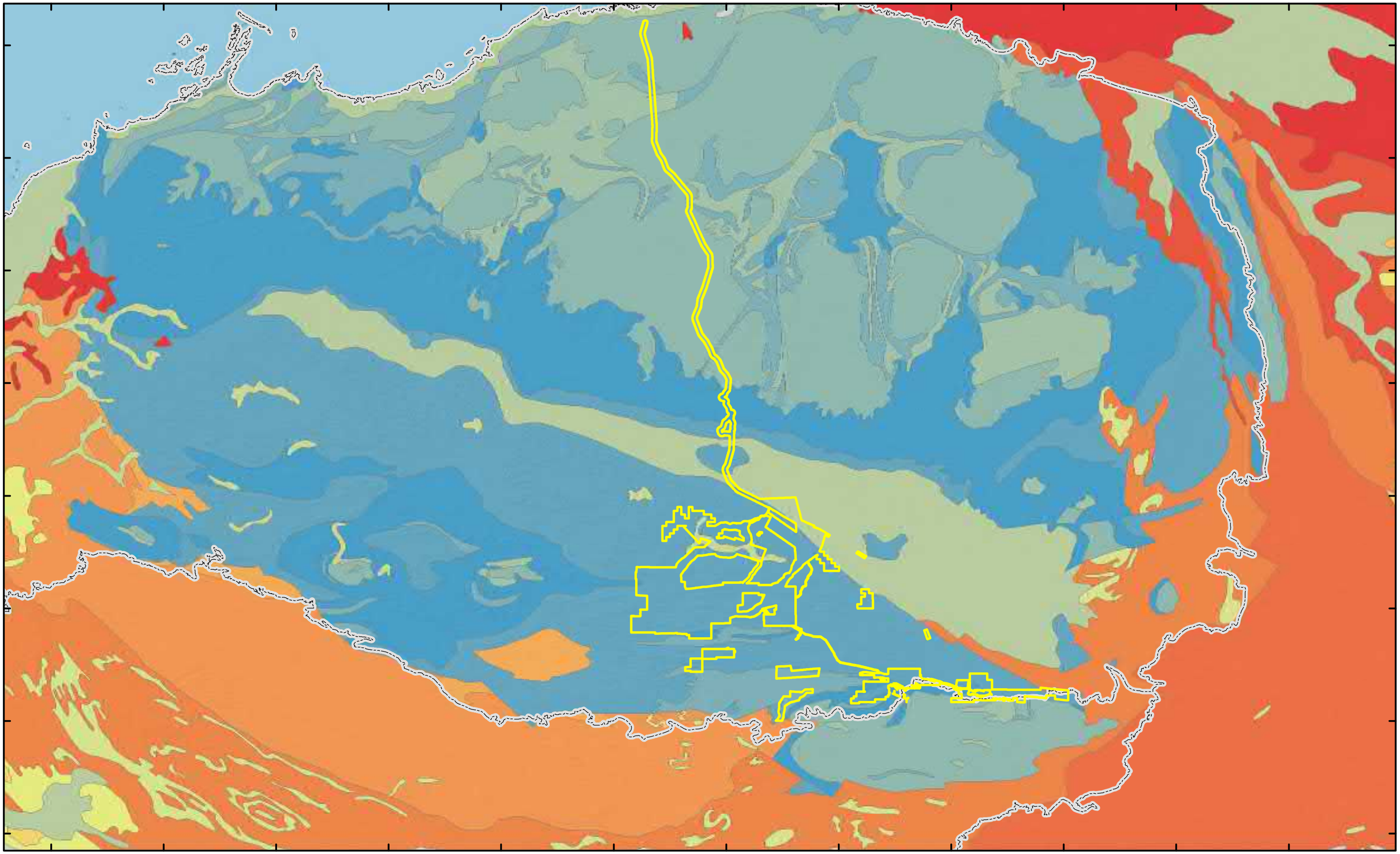

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GEOLOGY OF THE STUDY AREA

FIGURE 2.3

SEE LEGEND SEPARATE SHEET

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Legend

- Study Area
- **IBRA Pilbra & Gascoyne**

Geology 2500K Generalised

CODE, NARRATIVE, AGE

- AP_b:Basalt, dacite, and sandstone:Archaean
- AP_i:Iron-formation and shale:Archaean
- Ab:Metamorphosed basic and ultrabasic volcanic and intrusive rocks:Archaean
- Agn:Granite and Gneiss:Archaean
- Asf:Metamorphosed sedimentary and acid volcanic rocks:Archaean
- Cza:Alluvial, shoreline, and eolian deposits:Phanerozoic
- Czsl:Marine limestone, sandstone, and valley-fill deposits:Phanerozoic
- P-d:Basic and ultrabasic intrusive rocks:Proterozoic - Phanerozoic
- P_gn1:Granite and gneiss:Proterozoic
- P_gn2:Granite and gneiss:Proterozoic
- P_s1:Metasedimentary rocks:Proterozoic
- P_s2:Metasedimentary rocks:Proterozoic
- P_ss1:Sandstone and shale:Proterozoic
- P_ss2:Sandstone and shale:Proterozoic
- P_st1:Sandstone:Proterozoic
- P_st2:Sandstone:Proterozoic
- Ps:Marine and continental sedimentary rocks:Phanerozoic
- TRKs:Marine and continental sedimentary rocks:Phanerozoic

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GEOLOGY OF THE STUDY AREA

FIGURE 2.3

LEGEND

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The Study Area south of the Hamersley Basin lies within the Ashburton Basin. The geology of the Ashburton Basin is characterised by Palaeoproterozoic sandstone, carbonate, basalt, shale and conglomerate (Tille 2006).

Small southern sections of the survey area fall within the Bangemall Proterozoic sedimentary basins and the Archaean granitic rocks of the Sylvania Inlier. A small section in the north of the Study Area is situated in the Carnarvon sedimentary basin.

Soils

The soils of the Pilbara region are generally skeletal, shallow and stony with the colours reflecting the underlying parent material. Texturally, soils are stony loams, with clays and silts toward the bottom of the ranges (McKenzie *et al*. 2009). Soils are generally of low fertility and slightly acidic, except for clays associated with basalts, and alluvial and colluvial valley floors, which are more alkaline and fertile (McKenzie *et al*. 2009).

Van Vreeswyk *et al.* (2004) identified 21 broad soil groups from the Pilbara and interpreted their occurrence according to the region's geomorphology. A general overview of the soils of the Pilbara is as follows.

More than a third of the Pilbara consists of rugged hills and ranges. The soils on the ranges are predominately stony with minor red shallow loams and some red shallow sands. Calcareous shallow loams are mostly common on basalt-based hills, whilst soils of the granitic terrain are mostly red shallow sands. Within the hill systems and valleys the soils are shallow red/brown non-cracking clays, which occur as isolated pockets of soil. Downslope from the ranges soils become deeper in the form of stony-surfaced, red loamy earths with some areas of deep red/brown non-cracking clay. The lowest landscape units (i.e. alluvial plains) have self-mulching cracking clays with areas of deep red/brown non-cracking clays or red deep loamy duplexes. The broad, gently sloping plains are composed of red sandy earths, red deep sands and red loamy earths (Van Vreeswyk *et al.* 2004).

Tille (2006) provided a hierarchy of soil-landscape mapping units of Western Australia's Rangelands and Arid Interior. The state has been divided into a number of the soil-landscape regions, provinces and zones. The updated maps and descriptions form part of Western Australia's contribution to the Australian Soil Resource Information System (ASRIS).

The Study Area contains nine soil-landscape zones, predominantly within the Fortescue Province and one within the Ashburton Province (Table 2.2; Figure 2.4). Tille (2006) describes the Fortescue Province as follows.

'*Hills and ranges (with stony plains and some alluvial plains and sandplains) on the volcanic, granitic and sedimentary rocks of the Pilbara Craton. Stony soils with Red loamy earths and Red shallow loams (and some Red/brown non-cracking clays, Red deep sandy duplexes and Red deep sands).'*

Table 2.2: Soil-landscape zones included in the Study Area (Tille (2006)

Zone	Code	Characteristics
Fortescue Province		
Nullagine Hills Zone	280	Hills and ranges (with some stony plains) on volcanic and sedimentary rocks of the Pilbara Craton (including the Hamersley Basin). Stony soils with Red shallow loams and sands. Spinifex grasslands with kanji and snappy gum.
De Grey-Roebourne Lowlands Zone	281	Alluvial plains and sandplains (and some floodplains and stony plains) on alluvial and marine deposits over rocks of the northern Pilbara Craton. Red deep sandy duplexes with Red loamy earths and some Red/brown non- cracking clays, Cracking clays, Red sandy earths and Red deep loamy duplexes. Spinifex grasslands with kanji and tussock grasslands.
Chichester Ranges Zone	282	Hills and dissected plateaux (with some stony plains) on basalt and sedimentary rocks of the Hamersley Basin. Stony soils with some Red shallow loams and Hard cracking clays. Spinifex grasslands with kanji and snappy gum (and some tussock grasslands).
Abydos Plains and Hills Zone	283	Stony plains (with some hills) on granitic rocks of the Pilbara Craton (East Pilbara Terrane). Red deep sandy duplexes and Red shallow loams with Stony soils, Red sandy earths and Red loamy earths. Spinifex grasslands with kanji (and some tussock grasslands).
Fortescue Valley Zone	284	Alluvial plains, hardpan wash plains and sandplains (with stony plains, floodplains and some salt lakes) on alluvial deposits over sedimentary rocks of the Hamersley Basin. Red deep sands, Red loamy earths and Red/brown non-cracking clays with some Red shallow loams and Hard cracking clays. Mulga shrublands and spinifex grasslands with some tussock grasslands and halophytic shrublands.
Hamersley Plateaux Zone	285	Hills and dissected plateaux (with some stony plains and hardpan wash plains) on sedimentary and volcanic rocks of the Hamersley Basin (Opthalmia Fold Belt). Stony soils with Red shallow loams and some Red/brown non-cracking clays and Red loamy earths. Spinifex grasslands with snappy gum and kanji (and some mulga shrublands).

Zone	Code	Characteristics
Jigalong Plains Zone	288	Alluvial plains, sandplains, hills and ranges (with floodplains and hardpan wash plains) on sedimentary rocks of the Manganese Group (with some basalt and granite). Red deep sands with Red/brown non-cracking clays, Red loamy earths, Red deep sandy and loamy duplexes, Stony soils and Red shallow loams. Mulga woodlands/shrublands with spinifex and tussock grasslands.
Harding Hills and Plains Zone	289	Hills and ranges with (stony plains and some alluvial and flood plains) on sedimentary, granitic and volcanic rocks of the northern Pilbara Craton. Stony soils with Red/brown non-cracking clays and Red shallow loams and some Hard cracking clays. Spinifex grasslands with kanji and snappy gum (and some tussock grasslands).
Ashburton Province		
Bulloo Plains and Hills Zone	290	Hardpan wash plains, stony plains, hills and ranges (with some sandplains) on sandstone and shale of parts of the Collier and Bresnahan Basins and granite of the Sylvania Inlier. Red shallow loams (often with hardpans), Red loamy earths, Stony soils and Red deep sands with some Red shallow sands. Mulga shrublands (with some spinifex grasslands).

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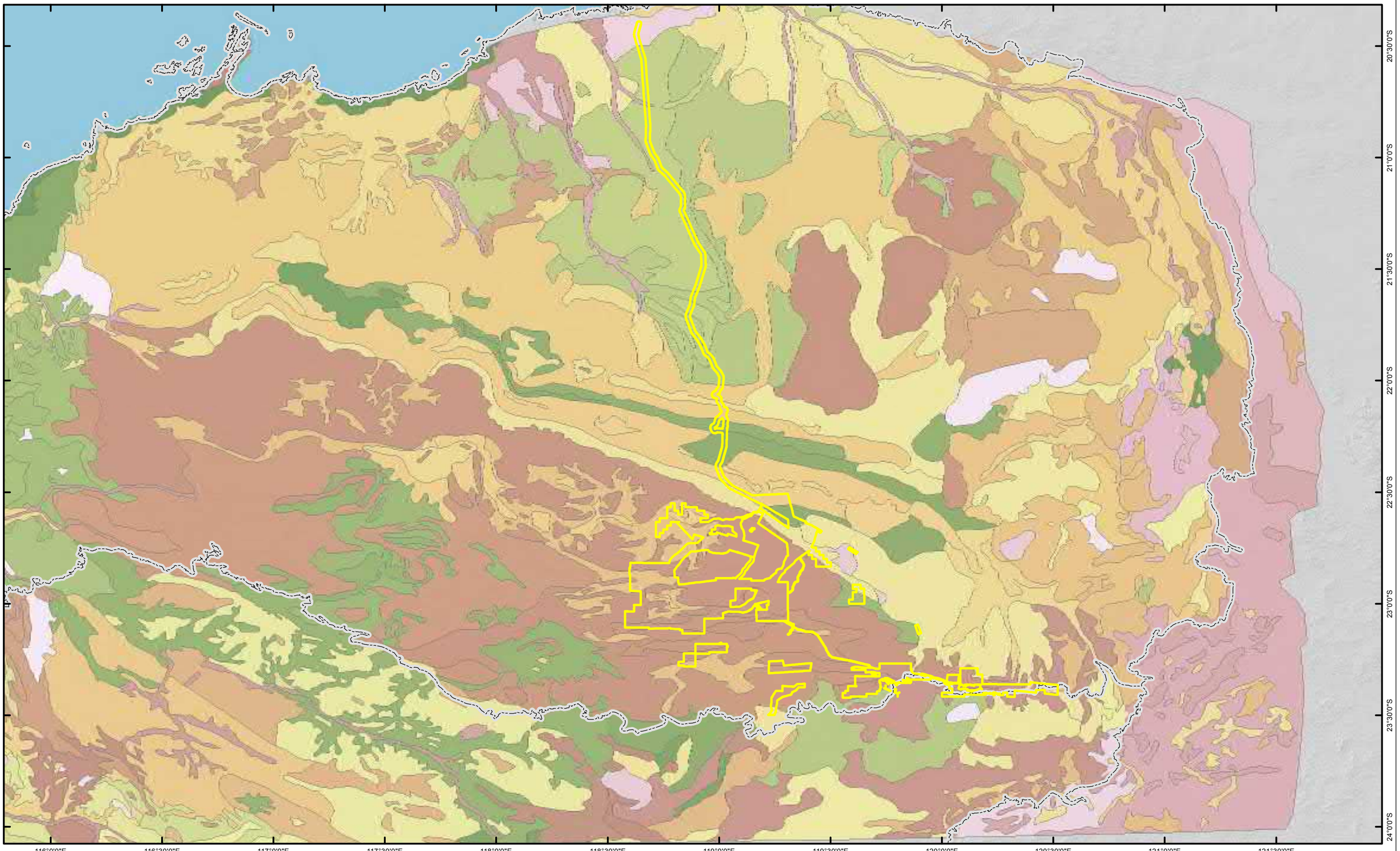

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BHPBIO

BHPBIO Consolidation of Regional Fauna Habitat Mapping

SOILS AND THE STUDY AREA (CSIRO SOILS)

FIGURE 2.4

See Legend Separate Sheet

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Legend

Study Area

IBRA Pilbra & Gascoyne

CSIRO Soils

Mapping Unit / Description

AA11, Ranges of conglomerates

AA12, Ranges on conglomerate; extensive areas without soil cover and when present

AA16, Low ranges and steep hills on granites

AA7, Stony hills on granite--often with little soil cover: shallow stony sands (Uc5.11) are dominant but small areas of (Dr2.32) soils also occur. Occurs on sheet(s): 6

AA9, Stony hills on gneiss with frequent bare rock areas: shallow stony sands (Uc5.11) are dominant. Other soils include (Um5.41) as well as (Dr2.33 and Dr2.32). Occurs on sheet(s): 6

AB14, Upland sand plains with occasional dunes and minor inclusions of associated plains units: chief soils are red earthy sands (Uc5.21) with red sands (Uc5.11) and (Uc1) on the dunes; both (Gn) and (Um) soils of associated units occur. Occurs on sheet(s): 6

AB19, Extensive sandy plains: chief soils are red earthy sands (Uc5.21) with extensive areas of red earths (Gn2.12) and with some hard red soils (Dr) along creek lines. Similar to unit AB21 but without sandstone residuals. Occurs on sheet(s): 6

AB20, Isolated sand plains and dune fields: chief soils are red earthy sands (Uc5.21) with loose red sands (Uc1.23) on the dunes. Occurs on sheet(s): 6

AB21, Pindan country--gently undulating sand plain with a few small rocky sandstone residuals; no external drainage: chief soils are red earthy sands (Uc5.21)

AB39, Gently undulating plain dominated by longitudinal dunes of varying frequency; some exposures of ironstone gravels on low rises occur in the dune swales: chief soils are red earthy sands (Uc5.21) on dune slopes

AB41, Undulating areas on chert breccia with frequent rock outcrops; these areas are elevated above the main drainage-ways but are lower relatively than adjacent ranges: chief soils are shallow red earthy sands (Uc5.21). Occurs on sheet(s): 10

AB42, Upland sand plain associated with extensive areas of unit AB41: chief soils are red earthy sands (Uc5.21). Occurs on sheet(s): 10

AB43, Pediplains on granite with some granitic residuals

AB44, Plains with a variable

B27, Low terrace associated with main stream channels: chief soils are loose sands (Uc1.22) with some (Um5.11) soils on patches of calcrete (kunkar). Occurs on sheet(s): 6

BA17, Flat-topped but sometimes steep-sided hills with extensive areas of bare rock--sandstones and other sedimentary rocks

BB11, Flat-topped residuals capped by calcrete (kunkar) and opaline silica of the Oakover formation: chief soils are shallow alkaline loams (Um5.11) along with red earths (Gn2.12). Occurs on sheet(s): 6

BD1, Plains and levees

BD2, Terraces and levees flanking the main rivers: dominant soils are (Um5.2) but other soils of some importance are (Uc5.32) and (Gn2.13); while (Uc1.22) soils occur on the youngest terraces and there are limited areas of (Dr) soils. Occurs on sheet(s): 6

BE10, Plains with clay pans: earthy loams (Um5.3) are dominant along with areas of (Gn2.12) and (Uc5.21) soils on red-brown hardpan; and (Uf6.71) soils are associated with the clay pans. Occurs on sheet(s): 6

BE6, Extensive flat and gently sloping plains

BE9, Plains dominated by earthy loams (Um5.3) with red-brown hardpan at shallow depth: there are also large areas of (Uf6.71) and (Ug5.37) soils in lower situations. Narrow zones of (Um5.11) soils on calcrete (kunkar) are adjacent to many of the creek lines.

Bz15, Rocky hills and offshore islands of acid intrusive rock. Largely bare rock outcrop with pockets of shallow siliceous sands (Uc1.2) and loams (Um1). Occurs on sheet(s): 6

Fa10, Steep ranges comprising sandstones

Fa11, Stony hills with some steeply dissected pediments on sandstones

Fa12, Gently undulating plain with frequent low granite tors and coalescing pediplain: chief soils are earthy loams (Um5.51)

Fa13, Ranges of banded jaspilite and chert along with shales

Fa14, Steep hills and steeply dissected pediments on areas of banded jaspilite and chert along with shales

Fa15, Ranges of basalt along with shale

Fa16, Hills and steep dissected pediments in areas of basalt

Fa17, Ranges comprising basic intrusive rocks

Fa18, Low stony hills and steeply dissected pediments on areas of basic intrusive rocks

Fa19, Steep stony hills and ranges on metamorphosed basic and ultrabasic rocks

Fa28, Steep hills and low ranges associated with various rocks including dolomite and some chert breccia; exposures of rock are extensive and soils are shallow and stony: chief soils are shallow stony earthy loams (Um5.51). Other soils include shallow stony fo

Fa29, Steep stony hills and low ranges on highly folded quartzites

Fa30, Ranges on metamorphosed sandstones

Fa32, Low ranges and hills largely on metamorphics and granites but with some inclusions of sandstones and conglomerates; extensive areas of bare rock; transgressed by dunes in places and flanked by small plains: chief soils are probably shallow stony earthy l

Fa5, Ranges in areas of shales and greywacke along with some dolomites and volcanic rocks; there may be some narrow valley plains and steep dissected pediments: stony shallow earthy loams (Um5.51) are dominant but there are extensive areas without soil cover;

Fa6, Low ranges and stony hills often capped by red-brown hardpan and fringed by breakaways and dissected pediments; dominant soils are shallow stony earthy loams (Um5.51)

Fa8, Steep ranges comprising fine-grained sedimentary rocks along with basic dykes; extensive portions of this unit are without soil cover: chief soils are shallow stony earthy loams (Um5.51) on the steep slopes while shallow stony (Uc1.43) and (Uc5.11) soils

Fa9, Stony hills with some steeply dissected pediments on fine-grained sedimentary rocks and basic dykes; some small valley plains may occur: shallow stony earthy loams (Um5.51) dominate along with small areas of shallow stony (Uc1.43) soils on steeper slopes

Fb3, High-level valley plains set in extensive areas of unit Fa13. There are extensive areas of pisolitic limonite deposits: principal soils are deep earthy loams (Um5.52) along with small areas of (Gn2.12) soils. Occurs on sheet(s): 6

Fb8, Plains: chief soils are deep earthy loams (Um5.52) together with some areas of clay soils (Uf6.71) and (Ug5.37). Occurs on sheet(s): 10

Fy1, Steep ranges on dolomites and sandstones

Gf1, Steep ranges on basic lavas along with dolomites

Ja1, Extensive valley plains largely associated with the Fortescue River: chief soils are earthy clays (Uf6.71) along with some (Ug5.38)

Ja2, This unit occupies the central position within the high-level valley plains represented by unit Fb3: chief soils are earthy clays (Uf6.71) along with extensive areas of (Ug5.38) soils. Occurs on sheet(s): 6

Ja3, Gently undulating pediplains and alluvial plains associated with Permian sediments: chief soils are earthy clays (Uf6.71)

LAKE, Lake

Lb12, Valley flats along major drainage lines

Lh1, Coastal plains mainly beyond marine flooding influence: main soils are pedal calcareous earths (Gc2.22) with some associated highly calcareous earths (Gc1.12). On the seaward side are firstly samphire flats (Gc1.1) and then bare saline mud (Uf). Calcareo

MM16, Alluvial plains dominated by deep cracking clays (Ug5.38) along with some areas of (Uf6.71) soils

MM17, Alluvial plains with occasional stony residuals of basic and ultrabasic rocks: chief soils are deep cracking clays (Ug5.38) but extensive areas of (Dr2.33) and (Uf6.71) soils occur. (Uc5.32) and (Uc1.22) soils occur as narrow bands along stream channels.

MM18, This unit comprises a complex pattern of steep stony hills and valley plains along with some steep pediments. The hills are largely formed by metamorphosed basic and ultrabasic rocks as well as basic lavas

MM19, High-level gently undulating plain flanked by areas of basaltic ranges of unit Gfl: chief soils are cracking clays (Ug5.37). Areas of (Uf6.71) and (Dr2.33) soils occur also. Occurs on sheet(s): 6

MY1, Gently undulating plateau elements sometimes sharply incised by narrow valleys. The boundary of this unit is frequently formed by breakaways but it may at times merge beneath the adjacent plain. These areas are capped by the Robe pisolite iron ore format

MY4, Low lateritic residuals: chief soils are probably ironstone gravels in a red earth matrix (KS-Gn2.11

My53, Extensive plains dominated by neutral red earths (Gn2.12) with areas of acid and alkaline red earths (Gn2.11

My54, Broad very gently undulating plains with scattered rock outcrops occurring as mesas: chief soils are neutral and acid red earths (Gn2.12

My55, Gently sloping outwash plains generally flanking the northern face of the Hamersley Range; coarse surface gravels are extensive: chief soils are neutral red earths (Gn2.12) with some (Gn2.11) and (Dr2.33) soils. Occurs on sheet(s): 6

Mz23, Extensive flat and gently sloping plains with a scatter of surface gravels

Mz25, Plains associated with the Fortescue valley; there is a surface cover of stony gravels close to the ranges and hills: chief soils are acid red earths (Gn2.11) with some neutral red earths (Gn2.12); red-brown hardpan is absent. Associated are areas of cal

Mz36, Pediments with some steep hills on granites; granitic residuals; bosses and tors: chief soils are acid red earths (Gn2.11) overlying a red-brown hardpan. Other soils include (Uc5.11) and (Dr2.32). Occurs on sheet(s): 10

Oa11, Dissected stony pediments and hills occurring at foot of unit Gfl; some residuals of more resistant rocks occur as mesas. On deeply dissected areas lime is released from weathering of more basic rocks: chief soils are hard alkaline red soils (Dr2.13) and

Oc40, Alluvial

Oc48, Partly dissected pediments and breakaways capped by red-brown hardpan

Oc49, Partially dissected pediments with some low stony hills on fine-grained sedimentary rocks and basic dykes

Oc50, Dissected pediplain with occasional small steep stony hills frequently flanking areas of unit Fa5. Shales and greywackes along with some volcanics and dolomites form the country rock: hard alkaline red soils (Dr2.33) are dominant. Associated are areas of

Oc51, Gently undulating pediplain on granite with occasional low granite bosses and tors: hard alkaline red soils (Dr2.33) are dominant. (Dr2.32) soils also occur along with (Gn2.12) soils while (Um5.1) soils overlie calcrete (kunkar) zones adjacent to creeks.

Oc54, Partially dissected pediplains on gneiss. Low stony ridges associated with quartz dykes occur and there are minor occurrences of breakaways and mesas. Surface quartz gravels are extensive. Hard alkaline red soils (Dr2.33) are dominant along with (Dr2.32)

Oc55, Alluvial plains dominated by hard alkaline red soils (Dr2.33): narrow zones of (Um5.12) (Uc5.32)

Oc56, Plains dominated by hard alkaline red soils (Dr2.33) but with quite large areas of (Ug5.37) soils in lower situations. Other soils include (Um5.12)

Oc59, Foothill pediments with occasional rock outcrops and extensive stony gravel deposits: chief soils are hard alkaline red soils (Dr)

Oc61, Dissected pediments and steep residual hills with iron formations: chief soils are hard alkaline red soils

Oc62, Very gently undulating pediplain with low granite outcrops and tors; occasional basic dykes occur as low elongate ridges: chief soils are hard alkaline red soils (Dr2.33) and (Dr2.43) having coarse-textured A horizons up to 18 in. thick. Associated are o

Oc63, Pediplains on granite; more dissected than unit Oc62 and usually occurring as a zone flanking the main stream courses: chief soils are hard alkaline red soils (Dr2.33) and (Dr2.43). There are more areas of (Um5.11) soils on calcrete (kunkar) than in unit

Oc64, Low stony hills and dissected pediments on granite with occasional basic dykes: chief soils are hard

Oc65, Low stony hills and steeply dissected pediments in areas of fine-grained sandstone

Oc66, Gently undulating pediplains extending out from breakaways capped by Robe pisolite deposits and other related formations. There may be a few small flat-topped residuals rising above the pediplains: chief soils are hard alkaline red soils (Dr2.33). Small

Oc67, Plains: dominant soils are hard alkaline red soils (Dr2.33). Associated are extensive areas of (Um5.52) soils with (Ug5.38) soils in central landscape positions. Small areas of (Gn2.12) soils also occur as well as (Um5.11) on calcrete (kunkar). Occurs o

Oc68, Dissected stony pediments with some steep stony hills: chief soils are hard alkaline red soils (Dr2.33) but quite large areas of hard neutral red soils (Dr2.32) occur too. There are also significant areas of (Um5.5) soils. Occurs on sheet(s): 6

Oc69, Valley plains with occasional low flat-topped residuals that are often capped by iron ore formations but sometimes by calcrete (kunkar): hard alkaline red soils (Dr2.33) are dominant with some areas of (Dr2.32) soils. Significant areas of (Uf6.71) and (U

Oc70, Dissected pediments and low stony hills associated with cherts

Oc71, Outwash plains with much coarse surface gravel: chief soils are hard alkaline red soils (Dr2.33) but (Uf6.71)

Oc72, Plains dominated by hard alkaline red soils (Dr2.33) with some areas of (Gn2.12)

Oc73, Partially dissected pediments with some low stony hills. This unit usually flanks areas of unit Fa1O or unit Fa11: chief soils are hard alkaline red soils (Dr2.33) along with some areas of (Dr2.32) soils. Shallow stony (Uc5.11) soils occur on the steeper

Oc74, Dissected pediments with low stony hills as in unit Oc70

Oc75, Dissected pediments associated with dolomites and some chert breccias: chief soils are shallow and stony varieties of hard alkaline red soils (Dr2.33) along with some (Um5.51) soils. Occurs on sheet(s): 10

SV8, Salt flats

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BHPBIO

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SOILS AND THE STUDY AREA (CSIRO SOILS)

FIGURE 2.4

LEGEND

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2.4 Land Systems

Land Systems are units of landforms incorporating soils, vegetation types and geology. The Land Systems within the Pilbara and Gascoyne bioregions have been described and mapped, and soil and vegetation condition assessed following Van Vreeswyk *et al.* (2004), and Payne *et al.* (1988), respectively

The Study Area overlaps with 45 Land systems (Figure 2.5). The Newman land system (Hills and ranges with spinifex grasslands) covers the greatest area within the Study Area with Boolgeeda (Stony plains with spinifex grasslands) and Rocklea (Hills and ranges with spinifex grasslands) covering the next greatest area Land Systems.

Three Land Systems within the Study Area, Marsh (Fortescue), Wannamunna and Wona, contain Priority Ecological Communities (PEC) as identified by the DPaW (DPaW 2013a).

The Land Systems of the Pilbara bioregion are grouped into 20 land types according to landforms, soils, drainage patterns and vegetation. Seventeen of these land types occur within the Study Area (Table 2.3).

Table 2.3: Land Systems of the Study Area (Van Vreeswyk *et al*. 2004)

Land System	Landforms and Vegetation	Area (ha)
1. Hills and ranges with spinifex grassland.		
Boolaloo	Granite hills, domes and tor fields and sandy plains with shrubby spinifex grasslands.	49577.2
Capricorn	Hills and ridges of sandstone and dolomite supporting shrubby hard and soft spinifex grasslands.	76585.2
Granitic	Rugged granitic hills supporting shrubby hard and soft spinifex grasslands.	43421.3
McKay	Hills, ridges, plateaux remnants and breakaways of meta sedimentary and sedimentary rocks supporting hard spinifex grasslands.	153286.2
Newman	Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands.	1141628.5
Robertson	Hills and ranges of sedimentary rocks supporting hard spinifex grasslands.	14957.8

Land System	Landforms and Vegetation	Area (ha)
Rocklea	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.	496528.7
Ruth	Hills and ridges of volcanic and other rocks supporting hard spinifex (occasionally soft spinifex) grasslands.	1910.8
Talga	Hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands.	41716.7
2. Plateaux, mesas and breakaways with spinifex grasslands		
Oakover	Breakaways, mesas, plateaux and stony plains of calcrete supporting hard spinifex grasslands.	4414.5
Robe	Low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands.	31404.2
3. Plateaux, mesas and breakaways with *Acacia* shrublands		
Laterite	Laterite mesas and gravelly rises and plains supporting mulga shrublands.	6074.8
Table	Low calcrete plateaux, mesas and lower plains supporting mulga and cassia shrublands and minor spinifex grasslands.	20088.5
4. Dissected plains with spinifex grasslands		
Egerton	Dissected hardpan plains supporting mulga shrublands and hard spinifex hummock grasslands.	87032.3
Platform	Dissected slopes and raised plains supporting hard spinifex grasslands.	188829.5
5. Stony plains and hills with spinifex grasslands		
Adrian	Stony plains and low silcrete hills supporting hard spinifex grasslands.	16093.7
6. Stony plains and low hills with *Acacia* shrublands		
Prairie	Gently undulating stony plains and granite hills supporting *Acacia- Eremophila- Senna* shrublands and minor soft spinifex grasslands.	190141.1

Land System	Landforms and Vegetation	Area (ha)
7. Stony plains with spinifex grasslands		
Boolgeeda	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands and mulga shrublands.	511442.3
Macroy	Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands.	325086.3
8. Stony gilgai plains with tussock grasslands and spinifex grasslands		
Wona	Basalt upland gilgai plains supporting tussock grasslands and minor hard spinifex grasslands.	39108.4
9. Stony plains with *Acacia* shrublands		
Elimunna	Stony plains on basalt supporting sparse *Acacia* and *Senna* shrublands and patchy tussock grasslands.	21921.7
Sylvania	Gritty surfaced plains and low rises on granite supporting *Acacia- Eremophila- Senna* shrublands.	107818.1
10. Sandplains with spinifex grasslands		
Divide	Sandplains and occasional dunes supporting shrubby hard spinifex grasslands.	296452.1
Uaroo	Broad sandy plains supporting shrubby hard and soft spinifex grasslands.	85642.7
11. Wash plains on hardpan with groved mulga shrublands (sometimes with spinifex understorey)		
Cadgie	Hardpan plains with thin sand cover and sandy banks supporting mulga shrublands with soft and hard spinifex.	47982.1
Fan	Washplains and gilgai plains supporting groved mulga shrublands and minor tussock grasslands.	148205.3
Jamindie	Stony hardpan plains and rises supporting groved mulga shrublands, occasionally with spinifex understorey.	250960.3
Nooingnin	Hardpan plains with very large groves supporting mulga shrublands.	77265

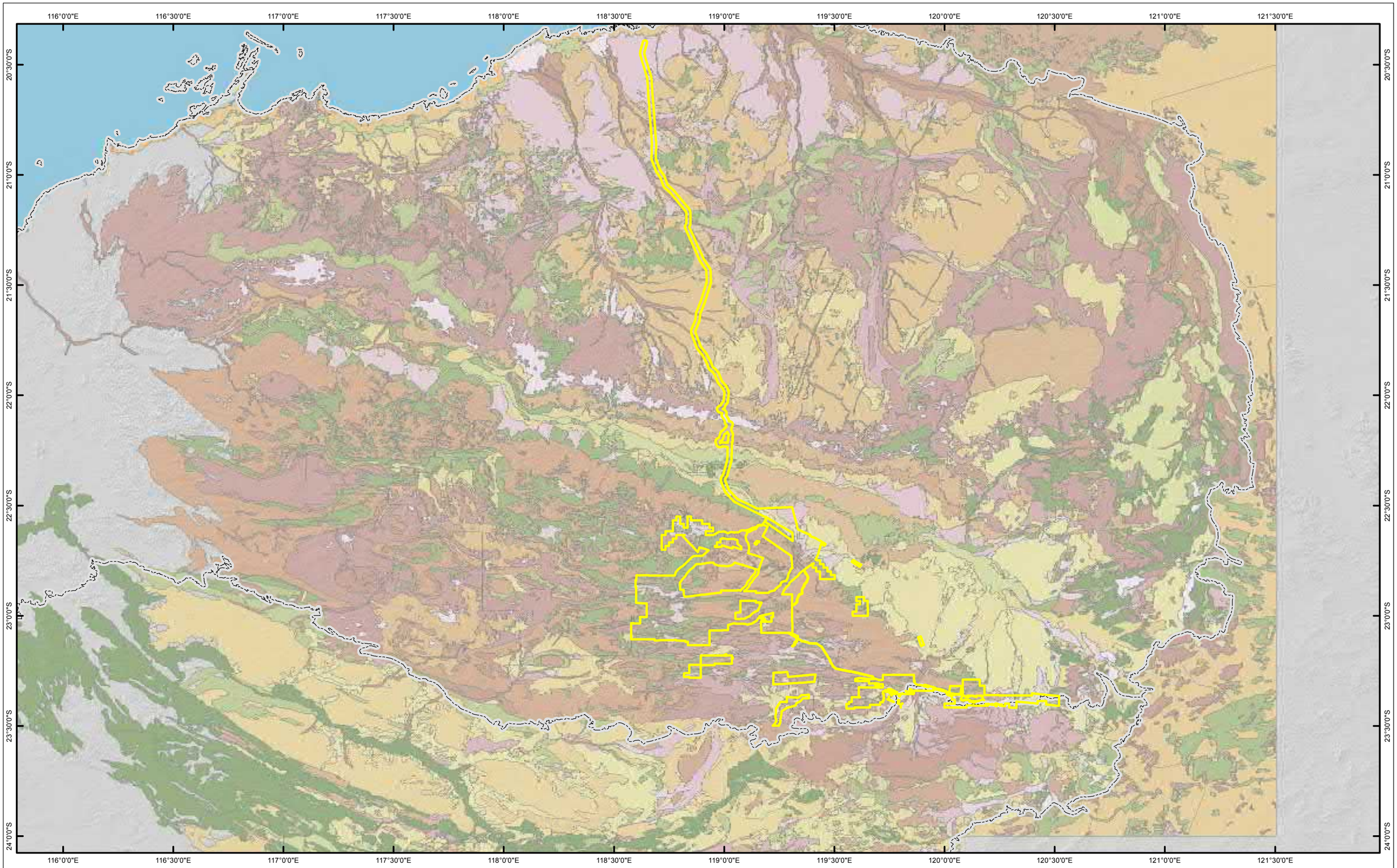
Land System	Landforms and Vegetation	Area (ha)
Pindering	Gravelly hardpan plains supporting groved mulga shrublands with hard and soft spinifex.	26317.5
Spearhole	Gently undulating hardpan plains supporting groved mulga shrublands and hard spinifex.	107710.2
Wannamunna	Hardpan plains and internal drainage tracts supporting mulga shrublands and woodlands (and occasionally eucalypt woodlands).	62648.1
Washplain	Hardpan plains supporting groved mulga shrublands.	45112.1
Zebra	Hardpan plains with large linear gravelly sand banks supporting acacia shrublands with soft and hard spinifex.	2644.1
12. Alluvial plains with soft spinifex grasslands		
Mallina	Sandy surfaced alluvial plains supporting soft spinifex (and occasionally hard spinifex) grasslands.	43242.5
Urandy	Stony plains, alluvial plains and drainage lines supporting shrubby soft spinifex grasslands.	43261.6
13. Alluvial plains with tussock grasslands or grassy shrublands		
Brockman	Alluvial plains with cracking clay soils supporting tussock grasslands.	32869.7
Turee	Stony alluvial plains with gilgaied and non-gilgaied surfaces supporting tussock grasslands and grassy shrublands.	58921.3
14. Alluvial plains with snakewood shrublands		
Christmas	Stony alluvial plains supporting snakewood and mulga shrublands with sparse tussock grasses.	23185.9
Cowra	Plains fringing the Marsh land system and supporting snakewood and mulga shrublands with some halophytic undershrubs.	20293.6
Marillana	Gravelly plains with large drainage foci and unchannelled drainage tracts supporting snakewood shrublands and grassy mulga shrublands.	41862.5

Land System	Landforms and Vegetation	Area (ha)
15. River plains with grassy woodlands and shrublands, and tussock grasslands		
Coolibah	Flood plains with weakly gilgaied clay soils supporting coolibah woodlands with tussock grass understorey.	88488.4
Fortescue	Alluvial plains and flood plains supporting patchy grassy woodlands and shrublands and tussock grasslands.	50417.1
River	Active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands.	89577.6
16. Calcreted drainage plains with shrublands or spinifex grasslands		
Calcrete	Low calcrete platforms and plains supporting shrubby hard spinifex grasslands.	65428.9
17. Salt lakes and fringing alluvial plains with halophytic shrublands		
Marsh	Lakebeds and flood plains subject to regular inundation, supporting samphire shrublands, salt water couch grasslands and halophytic shrublands.	97668.1

2.5 Vegetation

Beard (1975) classified and mapped the pre-European vegetation associations throughout Western Australia. Within this framework, the Study Area is situated in the Eremaean Botanical Province. The section of the Study Area within the Pilbara Region (Fortescue Botanical District), encompasses the Abydos Plain, George Ranges, Chichester Plateau, Fortescue Valley and the Hamersley Plateau vegetation systems; and the Ashburton Valley and Kumarina Hills vegetation systems within the Gascoyne Region (Ashburton Botanical District) (Table 2.4).

Baseline biological surveys commissioned by BHP Billiton Iron Ore have almost always included mapping of vegetation. Mapping has been undertaken at different scales and using different classification systems. A concurrent project has been undertaken by Onshore to consolidation vegetation mapping across all of BHP Billiton Iron Ore's tenements. This work has been utilised to develop the fauna habitat maps in this report and is discussed in in Section 3.



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BHPBIO

BHPBIO Consolidation of Regional Fauna Habitat Mapping

LAND SYSTEMS WITHIN THE STUDY AREA

FIGURE 2.5

Legend

- Study Area
- IBRA Pilbra & Gascoyne

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Legend

- Study Area
- IBRA Pilbra & Gascoyne

Land Systems

- Adrian
- Ashburton
- Augustus
- Balfour
- Billygoat
- Black
- Bonney
- Boolaloo
- Boolgeeda
- Brockman
- Bryah
- Buckshot
- Cadgie
- Calcrete
- Callawa
- Capricorn
- Charley
- Cheela
- Cheerawarra
- Christmas
- Collier
- Coolibah
- Coongimah
- Cowra
- Cundelbar
- Disturbed Land
- Divide
- Dollar
- Edward
- Egerton
- Eighty Mile
- Elimunna
- Ethel
- Fan
- Ford
- Fortescue
- George
- Granitic
- Gregory
- Hooley
- Horseflat
- Jamindie
- Jigalong
- Jurrawarrina
- Kanjenjie
- Kooline
- Kumina
- Kunderong
- Kurubuka
- Lake Bed
- Laterite
- Little Sandy
- Littoral
- Lochinvar
- Macroy
- Mallina
- Marandoo
- Marillana
- Marsh
- McKay
- Mosquito
- Mulgul
- Nadarra
- Narbung
- Newman
- Nirran
- Nita
- Nooingnin
- Oakover
- Paraburdoo
- Paradise
- Paterson
- Pindering
- Platform
- Prairie
- Pullgarah
- Pyramid
- River
- River Channel
- Robe
- Robertson
- Rocklea
- Ruth
- Satirist
- Scoop
- Sherlock
- Spearhole
- Sylvania
- Table
- Talga
- Tallawuna
- Taylor
- Three Rivers
- Turee
- Uaroo
- Urandy
- Wannamunna
- Warri
- Washplain
- Weelarrana
- White Springs
- Wona
- Yamerina
- Zebra

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Figure:	2.5	Date:	19 Nov 2013
Sheet Size:	A3	Status:	FINAL
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Regional Fauna Habitat Mapping
LAND SYSTEMS

FIGURE 2.5

LEGEND

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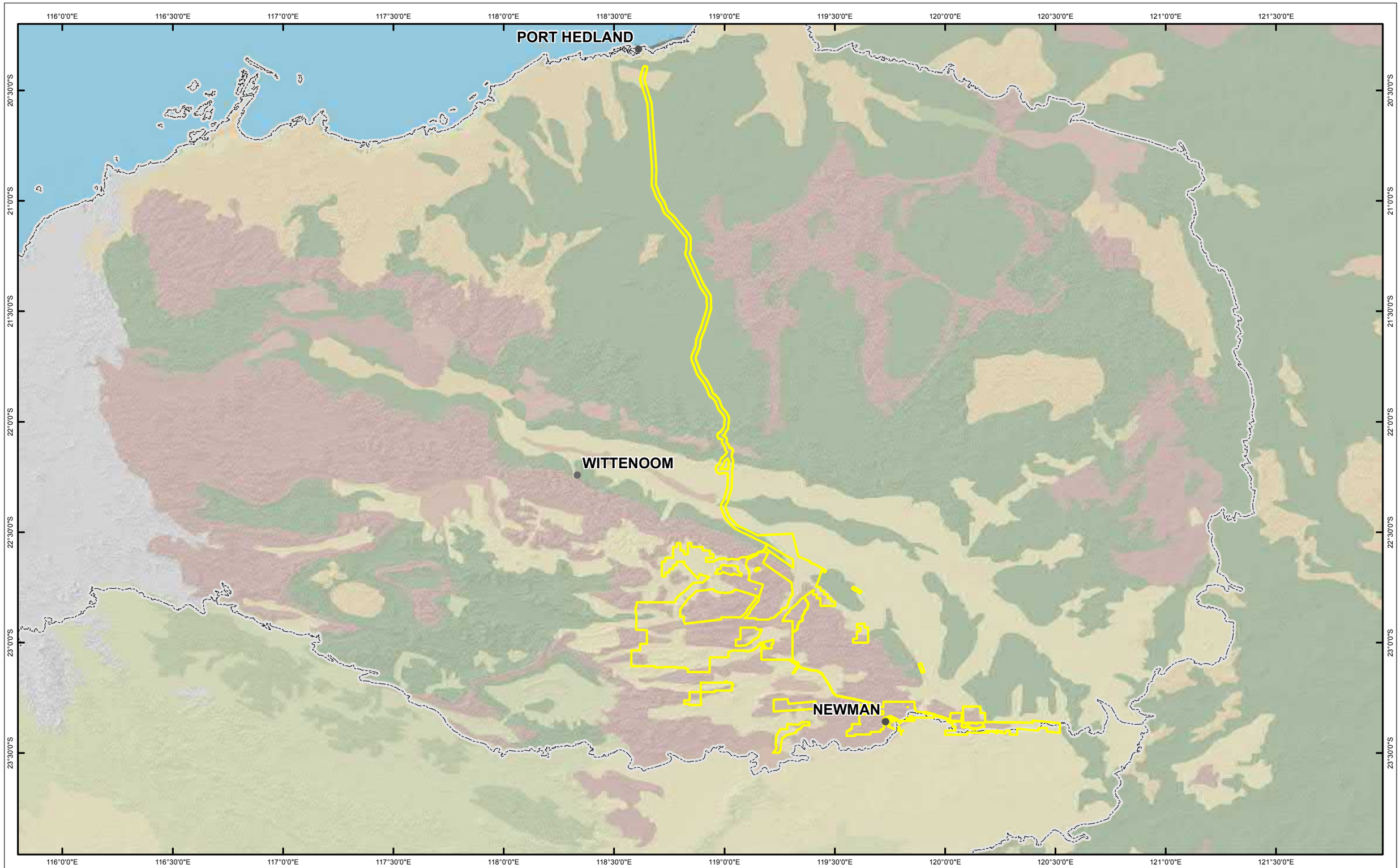

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Figure:	2.6	Date:	12 FEB. 2014
Sheet Size:	A3	Status:	Final
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BHPBIO Consolidation of Regional Fauna Habitat Mapping

BEARD'S VEGETATION TYPES AND THE STUDY

FIGURE 2.6

Legend

- Study Area
- IBRA Pilbra & Gascoyne

Beards Vegetation Systems

- Acacia shrubland
- Acacia woodland
- Eucalyptus forest
- Eucalyptus woodland
- Melaleuca woodland
- Mixed shrubland
- Sedgeland
- Short-Bunch Grassland: Treeless
- Spinifex Grassland: Tree steppe

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Table 2.4: Vegetation systems within the Study Area (Beard 1975)

Region/Subregion	Pre-European Vegetation System (Beard 1975)	Description
Pilbara		
Hamersley	Hamersley Plateau	The principal vegetation community in the valley floors of this subregion comprise low Mulga woodland over bunch grasses, while *Eucalyptus leucophloia* over *Triodia brizoides* is dominant on the skeletal soils of the ranges (Kendrick 2001a).
Fortescue Plains	Fortescue Valley	This subregion contains extensive salt marshes, Mulga-bunch grass and short grass communities on the eastern plains. River red gum (*Eucalyptus camaldulensis*) and Coolabah (*E. victrix*) woodlands with soft spinifex and Buffel grass (*Cenchrus ciliaris*) understorey occur along drainage lines and active floodplains. This subregion contains the northern limit of Mulga (*Acacia aneura;* the species formerly known as *A. aneura* is now split into several different species.) in the Pilbara.
Chichester	Abydos Plain	Shrub-steppe of *Acacia pyrifolia-Triodia pungens* association is the dominant community on granite where there is a general cover of hummock grasses with widely spaced shrubs. *Triodia pungens* is the most common species on deeper soils over granite, being replaced by *T. wiseana* var. *brevifolia* on stony ground, by *T. lanigera* on sandy soils and *T. longiceps* or *T. angusta* becoming dominant on calcrete.
Chichester	Chichester Plateau	*Acacia pyrifolia-Triodia* shrub steppe is present on the hard alkaline red soils. This association is similar to that of the Abydos Plain. The shrub steppe changes to grass savannah (dominated by *Aristida latifolia*) on clay soils in the lower regions of the system. The southern flank of the Plateau leading to the Fortescue is chacterised by Mulga in valleys, lower slopes support Mulga with understorey of spinifex *T. pungens* and *Eucalyptus brevifolia-T. wiseana* steppe on upper slopes.
Chichester	George Ranges	Tree steppe cover the high, steep, rocky parts of the Ranges with shrub steppe in the valleys and lower slopes. *Eucalyptus brevifolia* occurs occasionally within the tree steppe and hummock grasses a mixture of *Triodia pungens* and *T. brizoides* in the north. *T. brizoides* is replaced in the south with *T. wiseana* var. *brevifolia.* The

Region/Subregion	Pre-European Vegetation System (Beard 1975)	Description
		shrub-steppe of *Acacia pyrifolia-Triodia pungens* association is similar to that of the Abydos Plain.
Gascoyne		
Augustus	Kumarina Hills	This subregion contains Mulga woodlands with *Triodia* on shallow stony loams on rises and Mulga parklands on shallow earthy loams over hardpan on the plains (Desmond *et al.* 2001).
Ashburton	Ashburton Valley	Low woodlands of Mulga/snakewood occur on shallow earthy loams over hardpan on the plains, with mulga scrub and *Eremophila* shrublands on the shallow stony loams of the ranges. Low mixed shrublands occur on hills with other areas supporting large areas of *Triodia* (Kendrick 2001c).

2.6 Fauna Habitats

A habitat is considered an area where a faunal community or species occurs. In the Pilbara, substrate type (geology and soils) appears to have the main influence on the distribution of mammals and reptiles (Gibson and McKenzie 2009, Doughty *et al*. 2011). Gibson and McKenzie (2009) goes on to state that, with respect to Pilbara mammals, characteristics of substrate are used by species to partition their habitat on a local scale. As such, substrate was a key consideration for the habitat mapping and descriptions, as many animals in the Pilbara are fossorial or seek refuge within burrows, rock crevices, cracks, and boulder piles.

Landform, which incorporates the broad landscape features and topographical characteristics, is also important in determining habitat types and species distribution (noting that the landform and soils are primarily determined by geology). Many species in the Pilbara are restricted to landform features, for example it is rare to encounter a Striated Grasswren or Pebble-mound Mouse outside of a ridge or hill. The same can be said equally for Mulgara, a species that is rarely recorded in locations away from sand plains. It is noted here that landforms are a major predictor of vegetation and substrate.

Some fauna species in the Pilbara appear to have a strong relationship with specific species of plants and vegetation (noting that vegetation is determined primarily by landform). A few examples include *Ctenophorus valens* which is thought to be associated with *Triodia melvillei* (Maryan and Turpin 2012) and Mulga is important for Broad-tailed (Inland) Thornbill, Slaty-

backed Thornbill, Chestnut-rumped Thornbill, Yellow-rumped Thornbill, Grey Honeyeater, Spiny-cheeked Honeyeater, Red-capped Robin, Hooded Robin, Whitebrowed Babbler, Crested Bellbird, White-tailed Fantail and Grey Butcherbird (Johnstone *et al*. 2013), and reptiles such as the Mulga Dragon are also almost exclusively found in this habitat type.

2.7 Land Use

The land use of the Study Area is dominated by mining/exploration leases and pastoral leases. This is indicative of the Pilbara's primary industries of mining and agriculture. The Study Area is also adjacent to Karijini National Park (including areas of future conservation estate) and sections of Woodstock/Abydos and Jigalong Aboriginal Reserves.

3 METHODS

3.1 Literature and Database Review

At the commencement of the project a literature review was undertaken of all vertebrate fauna surveys undertaken within the Study Area (comprising surveys commissioned by BHP Billiton Iron Ore and publically available documents). A preliminary habitat map was developed using existing mapping and a list of fauna habitat descriptions was compiled. Areas where mapping had not been undertaken were identified.

To determine fauna species recorded in the Study Area, a search of available databases was undertaken (Table 3.1). These records were then overlaid on the habitat mapping to determine habitats from which species had been recorded and to determine the habitats which supported conservation significant species and those which supported a higher diversity of species records (diversity indices were not used and records were not standardised to account for survey intensity).

Table 3.1: Databases searched and parameters used

Source	Database	Parameters
Department of Parks and Wildlife (DPaW 2013b)	NatureMap. *Received January 2014*	Study Area Boundary
BHP Billiton Iron Ore	Fauna database. *Received January 2014*	Study Area Boundary

Threatened communities

Information on the presence of Threatened and Priority Ecological Communities (TECs/PECs) within the Study Area was provided by Department of Parks and Wildlife (DEC March 2013, Version 18). Any TECs and PECs occurring within the Study Area were assessed for likelihood of supporting significant species.

3.2 Field Survey

Areas identified during the literature review which had deficient information to inform the habitat mapping were identified for future field investigations. Areas considered to be the highest priority to inform regional habitat mapping for this project were surveyed. These were generally large areas with no mapping, and in particular areas not previously visited by Biologic's zoologists. The following BHP Billiton Iron Ore leases were surveyed between 24 and 30 July 2013 and 20 and 29 August 2013:

- Caramulla;
- Jimblebar;
- Upper Marillana
- Munjina;
- Mindy;
- Coondiner;
- Marillana; and
- Gurinbiddy.

The field survey was undertaken in conjunction with vegetation mapping undertaken by Onshore.

3.3 Development of Habitat Maps

Habitat descriptions and names from various BHP Billiton Iron Ore reports were used for the assessment. Previous consultant work in the Study Area had used different ways to characterise and map habitat. *ecologia* Environment (1998) used a combination of landform, vegetation and soils (substrate) to delineate habitat types and then used statistical analysis to confirm a strong relationship between fauna recorded and habitats described. These habitats types were adopted for previous extensive mapping by Biologic and this information has been used for this mapping project with some minor name changes and additional habitat types.

The habitat mapping undertaken for this project is based primarily on the vegetation mapping undertaken by Onshore. Onshore's vegetation descriptions included details on landform and substrate, and these were grouped together to form fauna habitat units. The grouping of vegetation associations into fauna habitat units was based on the zoologists knowledge of fauna habitat preferences determined from extensive field experience within the Study Area and a review of scientific literature. Where the vegetation types and their boundaries did not correlate with the habitat types (e.g. Gorge/Gully and some areas of Sand Plain) boundaries were redrawn using aerial photography and data collected during the field survey.

3.4 Project Team

The project was undertaken by the following personnel:

- Mr Morgan O'Connell (Principal Zoologist, Project Manager)
- Dr Ruchira Somaweera (Senior Zoologist).

3.5 Limitations

As the development of fauna habitat maps for this project was based primarily on the development of vegetation association maps by Onshore Environmental Consultants, limitations in the development of their work must also be considered. Details of limitations relevant to the development of fauna habitat maps are provided below.

Limitations for development of the fauna habitat and vegetation maps

- The data provided by BHP Billiton Iron Ore from other consultants were assumed to be correct, and were entered into BHP Billiton Iron Ore's existing template.
- Raw data required to fill a number of fields in the current BHP Billiton Iron Ore template were not collected during the earlier surveys, or survey collection methods were slightly different. This resulted in some difficulty comparing between study areas and likely resulted in a reduced accuracy of mapping where information was not consistent with the database.

Limitations for development of the fauna habitat maps

- Not all areas identified for survey during the literature review were able to be surveyed. This was due to budget and access restrictions. Areas identified for survey were those comprising large areas and/or areas where there was no adjacent mapping from which maps could be extrapolated and/or areas where Biologic's zoologists had not undertaken previous surveys.
- Habitat maps for areas that have not had detailed zoological surveys but have had detailed vegetation surveys by Onshore Environmental Consultants are considered to be accurate. Mapping in areas where no detailed biological surveys have been undertaken should be considered indicative. Habitat descriptions and boundaries may change if detailed surveys are undertaken. Future surveys in areas lacking detailed vertebrate fauna and vegetation information will assist in refining the habitat mapping.

- Habitat mapping undertaken for this project has been developed using available fauna data and Biologic's experience undertaking fauna surveys within the Study Area over the last ten years. There is insufficient data to map habitats statistically, and hence the approach described in this document has been used. The approach was consistent across the entire the Study Area; however it is considered subjective.
- The Study Area was very large, making it difficult to visit and investigate all areas and habitats. Many boundaries or conclusions on habitat type are drawn from aerial imagery or from sources of data other than field data. At least 15% of the habitat mapping was completed in this way and include entire areas that were not visited (Ophthalmia) and sections of areas that were not accessed (i.e. Munjina / Upper Marillana, Caramulla, Prairie Downs, Gurinbiddy, Coondiner and Mindy). Future surveys in areas lacking detailed vertebrate fauna and vegetation information will assist in refining the habitat mapping.
- The habitat mapping in this report is primarily based on vegetation mapping supplied by Onshore (2014) to ensure consistency of the mapping across the Study Area. Consequently the accuracy of the habitat mapping relies heavily on the accuracy of the vegetation mapping. The vegetation mapping is considered accurate where detailed vegetation surveys have been undertaken (see Onshore 2014). Where there were differences between the previous habitat mapping (when available) and habitat maps developed from the Onshore (2014) data, the Onshore data has been used.
- Some habitat types from previous mapping have been altered to be consistent with nomenclature used for this report. It is possible that previous mapping may have delineated habitat types at a finer scale than our approach and hence there may be a loss of resolution in some areas when compared with previous data sets.
- Where possible, an attempt was made to ensure mapping of important habitats (Sand Plain, Gorge, Major Drainage Line, Gilgai, Fortescue Marsh Samphire, Boulders and Granite Domes) matches older habitat mapping where it occurs. Small areas of mismatch may exist.

Limitations for development of the vegetation maps (summarised from Onshore 2014)

- Not all areas identified for survey were able to be accessed due to time and access constraints.

- A number of baseline flora and vegetation surveys completed during the late part of 2013 have not been incorporated into the consolidated dataset, e.g Orebody 19, Orebody 31, Ninga, and hence vegetation maps for these areas are not based on the most detailed information available.
- Flora and vegetation surveys conducted post-2010 should be in accordance with BHP Billiton Iron Ore's Guidance for Flora and Vegetation Surveys in the Pilbara (WIN-ENV-LAND NW-008), which wasn't always the case. This resulted in difficulty for some comparisons between study areas.
- Vegetation mapping from existing surveys covered 62 % of the Study Area (including Fortescue Valley tenements where no mapping has currently been completed). Therefore approximately one third of the Study Area had no baseline data and vegetation maps had to be inferred from the field survey and regional data layers (aerial photos, geology and soil mapping).

4 RESULTS

4.1 Habitat Types

Seventeen habitat types were mapped in the Study Area as shown in Table 4.1 and Figure 4.1. Table 4.1 also describes the distinguishing habitat characteristics, occurrence of the habitat within the Study Area, extent of the habitat outside Study Area and a representative photo.

We consider that all of the main habitat types present within the Study Area have been mapped and described. There are a number of habitats in the Pilbara that do not occur in the Study Area, such as lakes, mangroves, and coastal samphire.

Table 4.1 Habitat types and descriptions

Habitat	Distinguishing habitat characteristics	Occurrence of the habitat within the Study Area	Extent of the habitat outside Study Area	Photo
DEGRADED/ CLEARED AREAS				
Artificial Habitats	Artificial habitats are habitats that have being altered by human activity. Within the habitat mapping these areas are called "Cleared" and "Artificial Northern Quoll Habitat". The latter areas are known to support Northern Quoll.	These artificial habitats are scattered throughout the landscape and include areas such as villages, quarries, rubbish dumps and structures such as culverts. The areas marked as "Artificial Northern Quoll Habitat" are abandoned quarries situated along BHP Billiton Iron Ore's Mainline Rail.	Camps are scattered throughout the Pilbara and rail and roads dissect much of the Pilbara. Other disturbance is common in the Pilbara but form a very small percentage of the entire Pilbara.	
PLAINS				
Calcrete Areas	The vegetation occurring on calcrete differs from that of the surroundings, largely due to the differences in soil type. The substrate is white and consists of skeletal soil, gravel and small jagged pebbles. Trees are isolated and the shrub layer tends to be sparse, with a low hummock grassland (*Triodia* sp.) dominant.	This habitat type is mostly low in the landscape and occurs mostly in the central part of the Study Area. This habitat is most common around Jinidi and Mining Area C.	An uncommon habitat type that is found throughout the Pilbara in small isolated areas. Calcrete Areas are small in their total size when compared to other habitats. Not well represented in National Parks in the Pilbara.	
Gilgai (cracking clay)	Often associated with tussock grasses. Cracking clay soils, usually contain weak crabhole (gilgai) microrelief, and which are generally saline at depth. Surface mantles are absent or common to abundant as pebbles and cobbles of ironstone, basalt and other rocks.	This habitat type is low in the landscape and occurs in patches in the north and central areas of the Study Area. There are two distinct locations for this habitat types, they are west of Mining Area C and just north of the Fortescue Marsh in BHP Billiton Iron Ore's Mainline Rail.	An uncommon habitat in the Pilbara. Areas of this habitat occur north of the Marsh and along the coast near Karratha. Not well represented within National Parks in the Pilbara.	

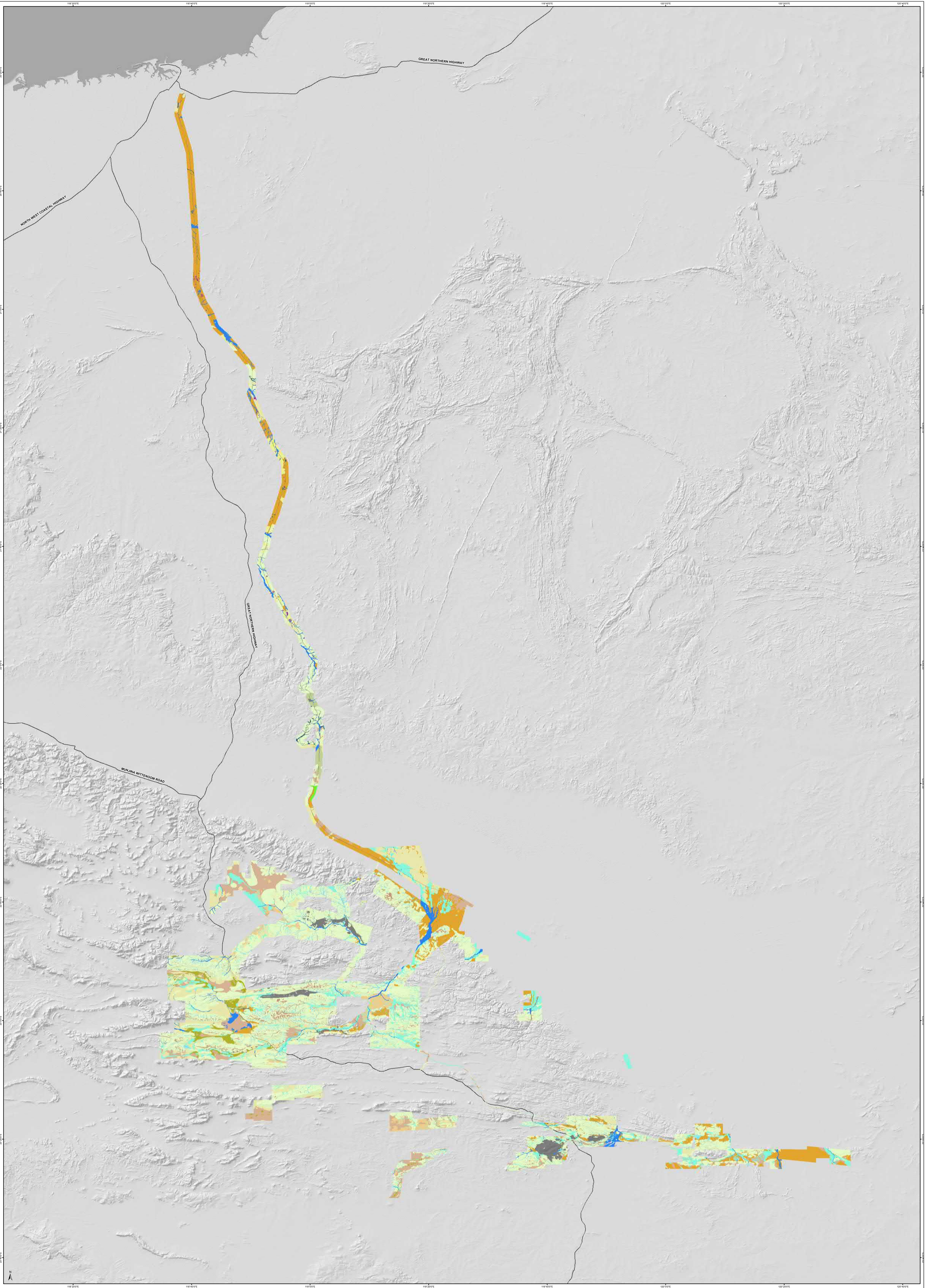
Habitat	Distinguishing habitat characteristics	Occurrence of the habitat within the Study Area	Extent of the habitat outside Study Area	Photo
Granite domes & boulders (tors)	This habitat occurs where the surrounding material has eroded, exposing large domes and boulders. Boulder piles and exfoliating rock on the granite domes provide excellent crevices and cracks for fauna to inhabit. Vegetation is sparse through these areas due to the lack of soil availability. These habitats are mapped separately, but combined together in this table. They are almost always surrounded by sand plains.	This habitat type is high in the relation to the surrounding landscape and occurs in the north of the Study Area. The habitat is common and and occurs mostly in BHP Billiton Iron Ore's Mainline Rail.	A reasonably common habitat, patchily distributed through the northern Pilbara. They tend to be isolated features in the landscape varying in size, height and connectivity thus some patches could be considered more important than others. Not well represented in National Parks in the Pilbara.	
Hardpan Plain	Gently inclined alluvial plains with shallow loams. Typically covered by low scattered woodlands of Mulga in groves arranged at right angles to the direction of sheet water flow. In areas where the hardpan is close to the surface and soil depth is insufficient to support trees, an open scrub may persist.	This habitat type is the low in the landscape and is not a regular feature in the Study Area. This habitat is mostly in BHP Billiton Iron Ore's Mudlark tenement and west of Mining Area C.	Common habitat throughout the Pilbara, particular within and south of the Hamersley Range. Occurs within National Parks in the Pilbara.	
Mulga	This habitat includes woodlands and other ecosystems in which Mulga (*Acacia aneura*) is dominant, either as the principal *Acacia* species or mixed with others. It consists of disintegrating groves on stony soils with spinifex. This habitat type is grouped with other habitat occurring on the plains; however it is noted that small groves of Mulga occur on ridgelines.	Generally low in the landscape and fairly common in the southern half of the Study Area. This habitat is situated in most of the BHP Billiton Iron Ore's leases including around Mining Area C.	Common habitat throughout the central and southern Pilbara. Mulga woodlands cover much of the region and extend south and east across the central arid zone of the continent. Occurs within National Parks in the Pilbara.	
Sand Dune	Sandridges of loose sand supporting similar species to the surrounding sandplain, dominated by *Triodia* spp. grasslands and areas of *Acacia* spp. shrubland occurring in the Study Area just south of the Fortescue Marsh. Linear ridges of raised relief relative to the surrounding Sand Plains.	Generally low in the landscape and uncommon in the Study Area. This habitat is situated in BHP Billiton Iron Ore's Marillana tenement and Mainline Rail.	Limited extent outside of the Study Area and in the Pilbara. A dune field exists to the east of BHP Billiton Iron Ore's Coondiner and Caramulla tenements. Not represented in National Parks in the Pilbara.	

Habitat	Distinguishing habitat characteristics	Occurrence of the habitat within the Study Area	Extent of the habitat outside Study Area	Photo
Sand Plain	Sand Plain habitat is characterised by relatively deep sandy soils supporting dense spinifex grasslands and sparse shrubs. This habitat transitions into patches of Mulga in places. This habitat often occurs as terraces along Major Drainage Lines.	Generally low in the landscape and common in the north of the Study Area, particularly along BHP Billiton Iron Ore's Mainline Rail and south east towards BHP Billiton Iron Ore's Carramulla tenement.	Common habitat throughout the Pilbara, especially in the north. Sand Plain areas are the predominant habitat type within the Chichester subregion. The south east of the Study Area approaches the Little Sandy Desert where areas of Sand Plain are extensive. Not well represented in National Parks in the Pilbara.	
Sandy/Stony Plain	These are predominantly stony plains with localised depositions of sand.	Generally low in the landscape and common in the north of the Study Area, particularly along BHP Billiton Iron Ore's Mainline Rail.	Common habitat throughout the Pilbara, especially in the north. Occurs within National Parks in the Pilbara.	
Stony plain	These are erosional surfaces of gently undulating plains, ridges and associated footslopes. Mainly support hard spinifex (and occasionally soft spinifex) with a mantle of gravel and pebbles.	Generally low in the landscape and common throughout the Study Area, particularly in the north along BHP Billiton Iron Ore's Mainline Rail.	Common habitat throughout the Pilbara, especially in the north. Occurs within National Parks in the Pilbara.	

Habitat	Distinguishing habitat characteristics	Occurrence of the habitat within the Study Area	Extent of the habitat outside Study Area	Photo
RANGES				
Crest/Slope	These fauna habitats tend to be more open and structurally simple due to their recent depositional history than other fauna habitats, and are dominated by varying species of spinifex. A common feature of these habitats is a rocky substrate, often with exposed bedrock, and skeletal red soils. These are usually dominated by *Eucalyptus* woodlands, *Acacia* and *Grevillea* scrublands and *Triodia* spp. low hummock grasslands.	This habitat type is high in the landscape and occurs throughout the Study Area. This habitat is found within most of BHP Billiton Iron Ore's lease when Ranges and hills are present.	Extensive areas of Crest/Slope habitat occur throughout the Pilbara. Occurs within National Parks in the Pilbara.	
Gorge/Gully	Gorges and gullies are rugged, steep-sided valleys incised into the surrounding landscape. Gorges tend to be deeply incised, with vertical cliff faces, while gullies are more open (but not as open as Minor Drainage Lines). Caves and rock pools are most often encountered in this habitat type. Vegetation can be dense and complex in areas of soil deposition or sparse and simple where erosion has occurred.	This habitat type is high in the landscape and occurs throughout the Study Area with the exception of BHP Billiton Iron Ore's Mainline Rail. The habitat occurs in most of BHP Billiton Iron Ore's leases containing large hills and Ranges such as around Mining Area C and Orebody 18 (within Newman mining hub).	A reasonably common habitat in the Pilbara, usually associated with ranges; however, because this habitat type is narrow and linear, they only represent a small proportion of the total land area. Occurs within National Parks in the Pilbara.	
Minor Drainage Line	Located within the minor gullies and depressions, generally through the Crest/Slope habitat. Consists primarily of *Acacia* low shrubland. The understorey generally lacks density and often consists solely of sparse tussock grassland, often including the weed Buffel Grass **Cenchrus ciliaris* where it has been introduced. The substrate can be sandy in places but generally consists of a skeletal loam gravel or stone.	This habitat type is high in the in the landscape, generally running off ridgelines, and fairly common in the Study Area. This habitat is in most of BHP Billiton Iron Ore's leases.	Common habitat throughout the central and southern Pilbara. Mostly associated with the Hamersley and Chichester Ranges. Occurs within National Parks in the Pilbara.	
RIPARIAN ZONES				

Habitat	Distinguishing habitat characteristics	Occurrence of the habitat within the Study Area	Extent of the habitat outside Study Area	Photo
Drainage Area	Characterised by *Eucalyptus xerothermica* and *Corymbia hamersleyana* woodland over broad-leafed *Acacia* shrubland on sandy loam soils sometimes with exposed rocky areas. These can have high vegetation density, complexity and diversity, and because they tend to occur on accretional or depositional areas, and often have deeper and richer soils than other fauna habitats. Grasses tend to be dominated by tussock grasses rather than spinifex, or the weed Buffel Grass **Cenchrus ciliaris*.	This habitat type is low in the landscape and occurs throughout the Study area but mostly in the central areas and to the south. This habitat is located in most of BHP Billiton Iron Ore's leases and in particular around Mining Area C, Whaleback and the ore bodies to the east.	A common habitat in central, south, and eastern parts of the Pilbara. Occurs within National Parks in the Pilbara.	
Drainage Line	Drainage Lines are low lying, linear, gently sloping areas and tend not to support moderately dense Eucalypt forest (unlike Major Drainage Line). This habitat tends not to be associated with ridgelines and hills (unlike Minor Drainage Line).	This habitat type is low in the landscape and occurs mostly in the north of the Study Area. This habitat crosses BHP Billiton Iron Ore's Mainline Rail in numerous locations.	A common habitat in the Pilbara occurring mostly in the north throughout the Chichester subregion. Occurs within National Parks in the Pilbara.	
Fortescue Marsh samphire	Samphire is generally considered a hostile environment with extreme heat and salinity in waterlogged soils. The vegetation consists of members of the family Chenopodiaceae (genus *Tecticornia*).	This habitat type is low in the landscape and occurs in a small patch in the central part of the Study Area. This single patch occurs where BHP Billiton Iron Ore's Mainline Rail passes through the Fortescue Marsh.	An uncommon habitat in the Pilbara but is fairly extensive around the Fortescue Marsh. Samphire are most commonly associated with coastal saline environments and these are quite common and extensive. Not represented within National Parks.	

Habitat	Distinguishing habitat characteristics	Occurrence of the habitat within the Study Area	Extent of the habitat outside Study Area	Photo
Major Drainage Line	Major Drainage Lines comprise mature River Red Gums, Coolibahs and stands of Silver Cadjeput over river pools. Open, sandy or gravelly riverbeds characterise this habitat type. In ungrazed areas, the vegetation adjacent to the main channel or channels is denser, taller and more diverse than adjacent terrain and can include reedbeds around pools.	This habitat type is the lowest in the landscape and fairly common in the Study Area. This habitat is in most of BHP Billiton Iron Ore's leases. Due to its narrow linear nature, this habitat does not represent a large area. *Melaleuca* forest occurs along the Major Drainage Line where the water table is reasonably close to the surface. While not a common habitat in the Pilbara, it does occur at Weeli Wolli Springs, Coondiner Gorge System and Marillana Creek in the Study Area.	Common habitat throughout the Pilbara and are generally associated with the major rivers in the Pilbara, such as the Fortescue, De Grey, Yule and Turner rivers. However, because they tend to be relatively narrow, linear features, they only represent a small proportion of the total land area. These water bodies are, however, significant features in the region, by virtue of their water points. Occurs within National Parks in the Pilbara.	



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BHP PILBARA

PILBARA HABITAT CONSOLIDATION PROJECT

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Kilometers
1:350,000
Projection: MGA Zone 50 Datum: GDA94

Department:	--	Date:	06/03/2014
Figure:	--	Status:	Draft
Drawn by: -	Requested by: -	Internal Reference: Pilbara Habitat	Sheet Size: A0

Legend

Habitat Types

- Artificial NQ Habitat
- Boulders
- Calcrete Area
- Cleared
- Crest / Slope
- Drainage Area
- Drainage Line
- Fortescue Marsh Samphire
- Gilgai
- Gorge / Gully
- Granite Domes
- Hardpan
- Major Drainage Line
- Minor Drainage Line
- Mulga
- Sand Dune
- Sand Plain
- Sandy / Stony Plain
- Stony Plain

4.2 Data Analysis

4.2.1 Database Results

A total of 26,365 records, consisting of 419 vertebrate fauna species have been recorded inthe Study Area. These include 10 records of freshwater fishes, 146 records of amphibians, 7116 records of reptiles, 6226 records of mammals and the rest being birds.

Of these, 12,507 records belonging to 11 species of amphibians, 27 species of reptiles and 116 species of small mammals were selected for analysis based on the species ability to be trapped. Large species with large home ranges (e.g. larger mammals and reptiles) and highly mobile small mammals (e.g. bats) and birds are likely to forage and roam in large areas, thus the location where the record was made may not necessarily be the general habitat the species is associated with. These 154 species included five species listed under the EPBC Act and seven species listed as Priority species under DPaW.

4.2.2 Habitats and Species Communities

The total number of species recorded from each habitat type is provided in Table 4.2 below. Species records have been obtained from BHP Billiton Iron Ore's database and DPaW's databases. Consequently, trapping intensity is not available for each habitat and therefore the data cannot be standardised according to survey effort. Nevertheless, some assumption can be made that a similar level of survey has been undertaken across all habitats, and although geographical coverage of habitats varies greatly within a study, biological surveys almost always target all the major habitats present within a study area (i.e. if crest/slope habitat covers 50 % of a study area it is unlikely that 50 % of trap effort would be expended in it). It is therefore considered that the information provided in Table 4.2 provides a good representation of species diversity for most of the major habitat types, and the percent totals would be similar across most areas.

The most specious habitat was Crest and Slope with 119 species recorded and Sand Plains, Drainage Areas, Stony Plain, Major Drainage Lines and Mulga also had over 80 species each recoded (Table 4.2). The least speciose habitats were Granite Domes and Boulders. The Artificial habitats were only selectively searched for Northern Quoll and are considered under Cleared habitats.

Table 4.2 Diversity of species among habitats.

Habitats	No of Sp	No of individuals
DEGRADED/CLEARED AREAS		
Artificial Habitats	54	439
PLAINS		
Calcrete Area	18	62
Gilgai	34	112
Granite Domes, Boulders	12	32
Hardpan	26	92
Mulga	80	438
Sand Dune	5	9
Sand Plain	97	2461
Sandy / Stony Plain	55	64
Stony Plain	90	1046
RANGES		
Crest/Slope	119	4744
Gorge/Gully	69	534
Minor Drainage Line	81	515
RIPARIAN		
Drainage Area	94	1155
Drainage Line	24	39
Fortescue Marsh Samphire	1	2
Major Drainage Line	78	825

With regard to harbouring conservation significant species, the most important were Crest/Slope (with four species listed under the EPBC Act and six as Priority species by DPaW), Gorge/Gully (with three species listed under EPBC and two as Priority species by DPaW), Major Drainage Lines (with two species each listed under the EPBC Act and DPaW), Minor Drainage Line (with three species each listed under the EPBC Act and as Priority species by DPaW) and Sand Plain (with two species listed under the EPBC Act and three as Priority species by DPaW) (Table 4.3). Given that some species adapt to dwell in artificial habitats, Cleared habitats recorded three species listed under the EPBC Act and two as Priority species by DPaW.

Table 4.3 Conservation status of species within habitats.

Habitat	Status	No of Sp	No of Individuals
DEGRADED/CLEARED			
Cleared	DPaW Priority	2	260
	EPBC	3	42
	None	48	137
PLAINS			
Calcrete Area	DPaW Priority	1	40
	None	17	22
Gilgai	DPaW Priority	1	4
	None	33	108
Granite Domes, Boulders	DPaW Priority	1	1
	EPBC Act	2	13
	None	9	11
Hardpan	None	26	92
Mulga	DPaW Priority	2	26
	EPBC Act	1	1
	None	77	411
Sand Dune	None	5	9
Sand Plain	DPaW Priority	3	206
	EPBC	2	49
	None	93	2206
Sandy / Stony Plain	DPAW	5	14
	EPBC	1	5
	None	55	64
Stony Plain	DPaW Priority	4	97
	None	87	949
RANGES			
Crest/Slope	DPaW Priority	6	2935
	EPBC	4	24
	None	111	1785
Gorge/Gully	DPaW Priority	2	9
	EPBC Act	3	23
	None	64	502
Minor Drainage Line	DPaW Priority	3	58
	EPBC Act	3	3
	None	76	454
RIPARIAN			
Drainage Area	DPaW Priority	3	148
	EPBC	1	2
	None	91	1005
Drainage Line	DPaW Priority	1	12

Habitat	Status	No of Sp	No of Individuals
	EPBC	1	3
	None	22	24
Fortescue Marsh Samphire	DPaW Priority	1	1
	None	2	2
Major Drainage Line	DPaW Priority	2	37
	EPBC Act	2	6
	None	74	782

At a species level, *Carlia munda, Ctenotus helenae, Ctenotus pantherinus, Menetia greyii, Pogona minor, Pseudomys hermannsburgensis, Ctenophorus caudicinctus, Heteronotia binoei, Ctenotus saxatilis* and *Gehyra variegata* stand out as habitat generalists with records from 12 or more types of habitats types (Appendix A). On contrary, 26 species were recorded from only one habitat type each (Appendices A, B). However, caution should be exercised when interpreting the data as the classification of habitats is subjective (though criteria were used) and the restriction of a species to a single habitat could be either due to a true habitat-specificity or due to the fact that a very limited number of specimens (sometimes only one) were recorded from the whole Study Area.

Some of the currently known species-habitat associations of conservation significant species were noticeable in the current analysis. For example, 89% of the records of Mulgara (*Dasycercus blythi*) and Bilby (*Macrotis lagotis*) each were in Sand Plain, 57% of Short-tailed Mouse (*Leggadina lakedownensis*) records were in Gilgai, 40% Pilbara Olive Python (*Liasis olivaceus barroni*) records in Gorge/Gully and 80% Western Pebble-mound Mouse (*Pseudomys chapmani*) records were in Crest/Slope, all values substantially greater than the percentages recorded in other habitats (Appendix D). Other more habitat generalist species like the Pilbara Flat-headed Blindsnake (*Ramphotyphlops ganei*) showed affinities to several habitats (Appendix D).

4.3 Fauna Habitat Value

All fauna habitats in the Pilbara have conservation value. Some of these are recognised as having particular value to flora and fauna and these are listed as Threatened Ecological Communities (TECs) under State and/or Commonwealth Legislation. Some areas are listed as Priority Ecological Communities. These are areas that are considered to be of significance but there is insufficient data on them to enable listing as a TEC.

Within the Study Area, there is one Threatened Ecological Community (TEC) (Ethel Gorge) (DPaW 2013c) and six Priority Ecological Communities as identified by DPaW (DPaW 2013a) (see Table 4.4). The Ethel Gorge TEC (*Ethel Gorge aquifer stygobiont community*) is listed due to the composition of the subterranean invertebrate fauna community, and therefore is not considered further in this report.

Fauna habitats that support conservation significant species or a higher diversity of species are considered to have enhanced conservation value. Most conservation significant species are restricted to particular habitat types and have not been able to adapt to impacts arising from European colonization (e.g. land clearing, introduction of feral species (plants and animals), changed fire regimes etc).

Table 4.5 provides a summary of conservation significant species that have been recorded or may occur in each habitat. Sand Plain, Sand Dune, Major Drainage Line, Granite dome & boulder piles, Fortescue Marsh Samphire, Gilgai and Gorge/Gully habitats have the highest number of conservation significant species records or contain habitat suitable for conservation significant species.

Table 4.4: Priority Ecological Communities located within or close to the Study Area.

# PEC	PEC Name	Community description	Priority Level	Relevance for vertebrate fauna	Habitat type
2	Weeli Wolli Spring Community	Weeli Wolli Spring's riparian woodland and forest associations are unusual as a consequence of the composition of the understorey. The sedge and herbfield communities that fringe many of the pools and associated water bodies along the main channels of Weeli Wolli Creek have not been recorded from any other wetland site in the Pilbara. The spring and creekline are also noted for their relatively high diversity of stygofauna and this is probably attributed to the large-scale calcrete and alluvial aquifer system associated with the creek. The valley of Weeli Wolli Spring also supports a very rich microbat assemblage including a threatened species.	P1	Rich microbat assemblage and significant species.	Major Drainage Line
16	Freshwater claypans of the Fortescue Valley	Important for waterbirds, invertebrates and some poorly collected plants. *Eriachne* spp., *Eragrostis* spp. grasslands. Unique community. Has few Coolabah.	P1	Important for waterbirds.	Not applicable
17	Fortescue Marsh (Marsh Land System)	Fortescue Marsh is an extensive, episodically inundated samphire marsh at the upper terminus of the Fortescue River and the western end of Goodiadarrie Hills. It is regarded as the largest ephemeral wetland in the Pilbara. It is a highly diverse ecosystem with fringing mulga woodlands (on the northern side), samphire shrublands and groundwater dependant riparian ecosystems. It is an arid wetland utilised by waterbirds and supports a rich diversity of restricted aquatic and terrestrial invertebrates. Recorded locality for night parrot and bilby and several other threatened vertebrate fauna. Endemic *Eremophila* species, populations of priority flora and several near endemic and new to science samphires.	P1	Important for waterbirds. Northern limit of Mulga woodland communities.	Fortescue Marsh Samphire and Mulga
20	Coolibah-lignum flats	Woodland or forest of *Eucalyptus victrix* (coolibah) over thicket of *Muehlenbeckia florulenta* (lignum) on red clays in run-on zones. Associated species include *Eriachne benthamii*, *Themeda triandra*, *Aristida latifolia*, *Eulalia aurea* and *Acacia aneura*. A series of sub-types have been identified: • Coolibah and mulga (*Acacia aneura*) woodland over lignum and tussock grasses on clay plains (Coondewanna Flats and Wanna Munna Flats) (P3) • Coolibah woodlands over lignum (*Muehlenbeckia florulenta*) over swamp wandiree (Lake Robinson is the only known occurrence) (P1) • Coolibah woodland over lignum and silky browntop (*Eulalia aurea)* (two occurrences known on Mt Bruce Flats) (P1)	P1 - P3	This is listed due to flora but possess characteristics important for waterbirds.	Major Drainage Line
25	Fortescue Valley Sand Dunes	These red linear sand dune communities lie on the Divide Land System at the junction of the Hamersley Range and Fortescue Valley, between Weeli Wolli Creek and the low hills to the west. A small number are vegetated with *Acacia dictyophleba* scattered tall shrubs over *Crotalaria cunninghamii*, *Trichodesma zeylanicum* var. *grandiflorum* open shrubland. They are regionally rare, small and fragile and highly susceptible to threatening processes.	P3	This is listed due to flora, however may contain desert dwelling vertebrate species as range extensions.	Sand Dune
21	Four Plant Assesmblages of the Wona Landsystem	A system of basalt upland gilgai plains with tussock grasslands occurs throughout the Chichester Range in the Chichester-Millstream National Park, Mungaroona Range Nature Reserve and on adjacent pastoral leases. There are four community types identified within the Wona Land System gilgai plains that are considered susceptible to known threats such as grazing or have constituent rare/restricted species. These are: • Cracking clays of the Chichester and Mungaroona Range. This grassless plain of stony gibber community occurs on the tablelands with very little vegetative cover during the dry season, however during the wet a suite of ephemerals/annuals and short-lived perennials emerge, many of which are poorly known and range-end taxa. • Annual Sorghum grasslands on self mulching clays. This community appears very rare and restricted to the Pannawonica-Robe valley end of Chichester Range. • Mitchell grass plains (*Astrebela* spp.) on gilgai • Mitchell grass and Roebourne Plain grass (*Eragrostis xerophila*) plain on gilgai (typical type, heavily grazed	P1 - P3	This is listed due to flora, however this habitat does contain near endemic fauna.	Gilgai

Table 4.5 Importance of fauna habitats

Fauna habitat	Con. Sig. Species that may breed in the habitat	Con. Sig. Species that may forage in the habitat	Comment
DEGRADED/CLEARED AREAS			
Artificial habitats	• In abandoned mines, quarries and active villages the Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WCA Schedule 1 could be expected; • In abandoned mine shafts, Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* – EPBC Act Vulnerable, WCA Schedule 1 could be expected.	• Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WCA Schedule 1. • In culverts, during night foraging activities, Ghost Bat *Macroderma gigas* - DPaW Priority 4, IUCN Vulnerable could be expected; • In nearby abandoned mine shafts, Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* – EPBC Act Vulnerable, WCA Schedule 1 could be expected	Anthropogenic habitats could provide alternative living and foraging spaces for several conservation significant species, especially the EPBC Act listed Northern Quoll. Several bird species (including migratory species) may use stranded water around human habitats. Culverts play an important role as corridors for animal movement and alternative habitats for other conservation significant species such as the DPaW Priority 4 Ghost Bat.
PLAINS			
Calcrete Area	• Western Pebble-mound Mouse *Pseudomys chapmani* – DPaW Priority 4; • Pilbara Flat-headed Blind Snake *Ramphotyphlops ganei* – DPaW Priority 1;	• Western Pebble-mound Mouse *Pseudomys chapmani* – DPaW Priority 4; • Pilbara Flat-headed Blind Snake *Ramphotyphlops ganei* – DPaW Priority 1; • Ghost Bat *Macroderma gigas* -DPaW Priority 4, IUCN Vulnerable;	No EPBC Act species are restricted to this habitat type, although the DPaW Priority 4 Western Pebble-mound Mouse is known to build mounds in this habitat type.
Gilgai	• Short-tailed Mouse *Leggadina lakedownensis* – DPaW Priority 3	• Short-tailed Mouse *Leggadina lakedownensis* – DPaW Priority 3; • Ghost Bat *Macroderma gigas* -DPaW Priority 4, IUCN Vulnerable; • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern.	The Short-tailed Mouse is considered to be more or less restricted to this habitat type. Other near endemic fauna in this habitat include the Pebble Dragon (*Tympanocryptis cephalus*) and Pilbara Stone Gecko (*Diplodactylus mitchelli*). Gilgai habitat occurs in a number of locations throughout the Pilbara; however, it is generally isolated and spatially small.
Granite dome & boulder piles	• Ghost Bat *Macroderma gigas* - DPaW Priority 4, IUCN Vulnerable; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WC Act Schedule 1; • Long-tailed Dunnart *Sminthopsis longicaudata* – DPaW Priority 1.; • Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WCA Schedule 1; • Pin-striped Finesnout Ctenotus *Ctenotus nigrilineatus* – DPaW Priority 1.	• Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WC Act Schedule 1; • Long-tailed Dunnart *Sminthopsis longicaudata* – DPaW Priority 1; • Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WC Act Schedule 1; • Pin-striped Finesnout Ctenotus *Ctenotus nigrilineatus* – DPaW Priority 1.	Boulder piles provide permanent and temporary refuges to an array of species inhabiting an otherwise fairly open matrix. Granite boulder piles provide either temporary/occasional denning habitat or core denning habitat supporting resident Northern Quoll populations depending on their size and complexity. Granite Domes provide important foraging habitat for the Northern Quoll. The skink *Ctenotus nigrilineatus* is known from this habitat type. The Pilbara Olive Python is also known from this habitat.
Hardpan	• No significant species expected to breed in this habitat	• Eastern Great Egret *Ardea modesta* – EPBC Act Migratory, WCA Schedule 3; • Other EPBC Act listed migratory waders	When these Hardpans are temporarily full of water they may provide habitat for waterbirds.
Mulga	• Pilbara Flat-headed Blind Snake *Ramphotyphlops ganei* – DPaW Priority 1; • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened; • *Ctenotus cf. uber johnstonei* – DPaW Priority 2.	• Pilbara Flat-headed Blind Snake *Ramphotyphlops ganei* – DPaW Priority 1; • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened; • *Ctenotus cf. uber johnstonei* – DPaW Priority 2.	Mulga provides habitat for several species of conservation significance but none are restricted to this habitat type. However, Mulga does support a relatively unique and diverse faunal assemblage, with numerous species restricted to this habitat type.

Fauna habitat	Con. Sig. Species that may breed in the habitat	Con. Sig. Species that may forage in the habitat	Comment
Sand Dune	• Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Greater Bilby *Macrotis lagotis* – EPBC Act Endangered, WCA Schedule 1, IUCN Vulnerable; • Mulgara *Dasycercus* spp. *D. cristicauda* - EPBC Act Vulnerable, WCA Schedule 1, IUCN Least Concern; *D. blythi*: DPaW Priority 4, IUCN Least Concern; • Night Parrot *Pezoporus occidentalis* – EPBC Act Endangered, WCA Schedule 1; • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern.	• Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Greater Bilby *Macrotis lagotis* – EPBC Act Endangered, WCA Schedule 1, IUCN Vulnerable; • Mulgara *Dasycercus* spp. *D. cristicauda* - EPBC Act Vulnerable, WCA Schedule 1, IUCN Least Concern; *D. blythi*: DPaW Priority 4, IUCN Least Concern; • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Night Parrot *Pezoporus occidentalis* – EPBC Act Endangered, WCA Schedule 1;	Dune systems provide potential habitat for Bilby and Mulgara burrows, and foraging habitat. While there is the potential for Mulgara to occur, the area of Sand Dune habitat is not considered extensive enough to support a population of Bilby, however no extensive surveys have been undertaken.
Sand Plain	• Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Greater Bilby *Macrotis lagotis* – EPBC Act Endangered, WCA Schedule 1, IUCN Vulnerable; • Mulgara *Dasycercus* spp. *D. cristicauda* - EPBC ActVulnerable, WCA Schedule 1, IUCN Least Concern; *D. blythi*: DPaW Priority 4, IUCN Least Concern; • Night Parrot *Pezoporus occidentalis* – EPBC Act Endangered, WCA Schedule 1; • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern.	• Australian Bustard Ardeotis australis – DPaW Priority 4, IUCN Least Concern. • Greater Bilby Macrotis lagotis – EPBC Act Endangered, WCA Schedule 1, IUCN Vulnerable; • Mulgara Dasycercus spp. D. cristicauda - EPBC Act Vulnerable, WCA Schedule 1, IUCN Least Concern; D. blythi: DPaW Priority 4, IUCN Least Concern; • Australian Bustard Ardeotis australis – DPaW Priority 4, IUCN Least Concern. • Night Parrot Pezoporus occidentalis – EPBC Act Endangered, WCA Schedule 1;	Sand Plain is considered important breeding habitats for several EPBC Act listed species. They may also support rare or cryptic species such as the Night Parrot.
Sandy/Stony Plain	• Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Greater Bilby *Macrotis lagotis* – EPBC Act Endangered, WCA Schedule 1, IUCN Vulnerable; • Mulgara *Dasycercus* spp. *D. cristicauda* - EPBC Act Vulnerable, WCA Schedule 1, IUCN Least Concern; *D. blythi*: DPaW Priority 4, IUCN Least Concern; • Night Parrot *Pezoporus occidentalis* – EPBC Act Endangered, WCA Schedule 1; • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern.	• Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Greater Bilby *Macrotis lagotis* – EPBC Act Endangered, WCA Schedule 1, IUCN Vulnerable; • Mulgara *Dasycercus* spp. *D. cristicauda* - EPBC Act Vulnerable, WCA Schedule 1, IUCN Least Concern; *D. blythi*: DPaW Priority 4, IUCN Least Concern; • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Night Parrot *Pezoporus occidentalis* – EPBC Act Endangered, WCA Schedule 1;	This habitat type is favoured by many significant species as burrows can be dug in areas of sand deposition.
Stony plains	• Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern; • Spectacled Hare-wallaby *Lagorchestes conspicillatus leichardti* – DPaW Priority 3; • Night Parrot *Pezoporus occidentalis* – EPBC Act Endangered, WCA Schedule 1; • Oriental Plover *Charadrius veredus* – EPBC Act Migratory, WCA Schedule 3.	• Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern; • Greater Bilby *Macrotis lagotis* – EPBC Act Endangered, WCA Schedule 1, IUCN Vulnerable; • Mulgara *Dasycercus* spp. *D. cristicauda* - EPBC Act Vulnerable, WCA Schedule 1, IUCN Least Concern; *D. blythi*: DPaW Priority 4, IUCN Least Concern; • Spectacled Hare-wallaby *Lagorchestes conspicillatus leichardti* – DPaW Priority 3; • Night Parrot *Pezoporus occidentalis* – EPBC Act Endangered, WCA Schedule 1; • Oriental Plover *Charadrius veredus* – EPBC Act Migratory, WCA Schedule 3.	Despite several species utilising this habitat, none are largely restricted to this habitat type. Some significant species are unable to burrow into this substrate therefore are less likely to breed in this habitat.

Fauna habitat	Con. Sig. Species that may breed in the habitat	Con. Sig. Species that may forage in the habitat	Comment
RANGES			
Crest/Slope	• Pilbara Flat-headed Blind Snake *Ramphotyphlops ganei* – DPaW Priority 1; • Western Pebble-mound Mouse *Pseudomys chapmani* – DPaW Priority 4.	• Pilbara Flat-headed Blind Snake *Ramphotyphlops ganei* – DPaW Priority 1; • Western Pebble-mound Mouse *Pseudomys chapmani* – DPaW Priority 4; • Ghost Bat *Macroderma gigas* -DPaW Priority 4, IUCN Vulnerable; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WC Act Schedule 1; • Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* – EPBC Act Vulnerable, WCA Schedule 1.	No EPBC species are restricted to this habitat type, although the DPaW Priority 4 Western Pebble-mound Mouse is largely restricted to this habitat type within the Study Area. This habitat is very common in the region.
Gorge/Gully	• Ghost Bat *Macroderma gigas* - DPaW Priority 4, IUCN Vulnerable; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WC Act Schedule 1; • Long-tailed Dunnart *Sminthopsis longicaudata* – DPaW Priority 1.; • Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WCA Schedule 1; • Pin-striped Finesnout Ctenotus *Ctenotus nigrilineatus* – DPaW Priority 1.	• Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WC Act Schedule 1; • Long-tailed Dunnart *Sminthopsis longicaudata* – DPaW Priority 1; • Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WC Act Schedule 1; • Pin-striped Finesnout Ctenotus *Ctenotus nigrilineatus* – DPaW Priority 1.	Gorge/Gully habitat provides potential breeding, shelter and foraging sites for Pilbara Olive Python and Ghost Bat and possibly Pilbara Leaf-nosed Bat. They could also provide temporary roosts and transitional habitats for other bats. Gorge/Gully areas provide habitat for the blindsnake, *Ramphotyphlops ganei* and Rainbow Bee-eater, although neither of these species is restricted to this habitat type. Gorges and gullies are day time retreats for other larger mammals and reptiles.
Minor Drainage Line	• Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WC Act Schedule 1; • Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3.	• Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WCA Schedule 1; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WCA Schedule 1; • Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* – EPBC Act Vulnerable, WCA Schedule 1; • Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3; • Cattle Egret *Bubulcus ibis* – EPBC Act Migratory, WCA Schedule 3; • Eastern Great Egret *Ardea modesta* – EPBC Act Migratory, WCA Schedule 3. • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern. • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened.	Minor Drainage Lines have the potential to provide habitat for a number of conservation significant fauna, but these species are not restricted to this habitat type. Due to the general lack of tall, hollow-bearing trees, most Minor Drainage Lines are not commonly used for nesting. Some species may utilise this habitat transiently, as corridors during dispersal.
RIPARIAN			
Drainage Area	• Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3; • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened; • Australian Bustard *Ardeotis australis* – DPaW Priority 4, IUCN Least Concern;	• Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WCA Schedule 1; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WCA Schedule 1; • Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* – EPBC Act Vulnerable, WCA Schedule 1; • Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3; • Cattle Egret *Bubulcus ibis* – EPBC Act Migratory, WCA Schedule 3; • Eastern Great Egret *Ardea modesta* – EPBC Migratory, WCA Schedule 3; • Grey Falcon *Falco hypoleucos* – DPaW Priority 4; • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened; • Peregrine Falcon *Falco peregrines* – WC Act Schedule 4.	A fairly diverse floristic assemblage provides habitat for a number of significant species. These species are not restricted to this habitat type.

Fauna habitat	Con. Sig. Species that may breed in the habitat	Con. Sig. Species that may forage in the habitat	Comment
Drainage Line	• Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3; • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened;	• Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WCA Schedule 1; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WCA Schedule 1; • Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* – EPBC Act Vulnerable, WCA Schedule 1; • Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3; • Cattle Egret *Bubulcus ibis* – EPBC Migratory, WCA Schedule 3; • Eastern Great Egret *Ardea modesta* – EPBC Act Migratory, WCA Schedule 3; • Grey Falcon *Falco hypoleucos* – DPaW Priority 4; • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened; • Peregrine Falcon *Falco peregrines* – WC Act Schedule 4.	Provides habitat for a number of significant species and aids in dispersal by providing a protected habitat. These species are not restricted to this habitat type.
Fortescue Marsh Samphire	• After inundation this habitat provides for many EPBC listed Waders.	• After inundation this habitat provides for many EPBC listed Waders.	Many migratory bird species may occur in this habitat type after heavy rains. *Ctenotus cf. uber johnstonei* may also occur. The Night Parrot has been recorded north of Fortescue Marsh near to similar samphire habitat.
Major Drainage Line	• Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WCA Schedule 1; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WCA Schedule 1; • Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3; • Grey Falcon *Falco hypoleucos* – DPaW Priority 4; • Peregrine Falcon *Falco peregrines* – WCA Schedule 4 • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened.	• Pilbara Olive Python *Liasis olivaceus barroni* – EPBC Act Vulnerable, WCA Schedule 1; • Northern Quoll *Dasyurus hallucatus* – EPBC Act Endangered, WCA Schedule 1; • Pilbara Leaf-nosed Bat *Rhinonicteris aurantia* – EPBCAct Vulnerable, WCA Schedule 1; • Rainbow Bee-eater *Merops ornatus* – EPBC Act Migratory, WCA Schedule 3; • Cattle Egret *Bubulcus ibis* – EPBC Act Migratory, WCA Schedule 3; • Eastern Great Egret *Ardea modesta* – EPBC Act Migratory, WCA Schedule 3; • Grey Falcon *Falco hypoleucos* – DPaW Priority 4; • Bush Stone-curlew *Burhinus grallarius* – DPaW Priority 4, IUCN Near Threatened; • Peregrine Falcon *Falco peregrines* – WC Act Schedule 4.	Major Drainage Lines represent an area of high local abundance and diversity for birds, and may provide breeding (the taller trees and the tree hollows favour nesting habitats) and foraging habitat for several EPBC Act listed conservation significant species. Many species use them as corridors during dispersal. River pools within Major Drainage Lines may also attract EPBC Act -listed Migratory birds

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Appendix A Number of individual species records at different habitats

Sp name	Artificial Habitat	Boulders	Calcrete Area	Cleared	Crest/Slope	Drainage Area	Drainage Line	Gilgai	Gorge/Gully	Granite Domes	Hardpan	Major Drainage Line	Minor Drainage Line	Mulga	Sand Plain	Stony Plain	Total	No of habitats recorded
Acanthophis wellsi				2	3										2	2	**9**	**4**
Amphibolurus longirostris				1	35	23	1	5	11			97	31	9	29	55	**298**	**12**
Antaresia perthensis			1	8	10	1			2				1	1	3	2	**29**	**9**
Antaresia stimsoni			1	4	8	1			2			1	1	1	2		**21**	**9**
Aspidites melanocephalus					2	1							1				**4**	**3**
Brachyurophis approximans					8	8	1	1	5			9	5	3	2	1	**43**	**10**
Caimanops amphiboluroides					1	1		3			2			1	2	2	**12**	**7**
Carlia munda				3	34	18	1	5	3		2	25	10	12	7	50	**170**	**12**
Carlia triacantha					2								2	2	18	2	**26**	**5**
Chelodina steindachneri									1			2		2			**6**	**4**
Crenadactylus ocellatus					3	1					1						**5**	**3**
Cryptoblepharus buchananii					2				2			1		2		1	**8**	**5**
Cryptoblepharus carnabyi					1				2								**3**	**2**
Cryptoblepharus plagiocephalus					2												**2**	**1**
Cryptoblepharus ustulatus					27				8				4			1	**40**	**4**
Ctenophorus caudicinctus			3	3	151	23	1	12	2		3	9	49	5	17	25	**303**	**13**
Ctenophorus isolepis				4	21	91			8		1	8	5	36	279	20	**473**	**10**
Ctenophorus nuchalis				2	3	3				1			2	1	35	6	**53**	**8**
Ctenophorus reticulatus				1	4	1		1			7		1	8	2	14	**40**	**10**
Ctenotus aff. helenae												2					**2**	**1**
Ctenotus ariadnae					4							3		1	51		**59**	**4**
Ctenotus duricola					33	31	1	2	7			4	7	2	39	6	**132**	**10**
Ctenotus grandis				2	8	24	1		5			1	6		119		**166**	**8**
Ctenotus hanloni						2			2				1	1	2		**8**	**5**
Ctenotus helenae			1	5	66	146		9	37		19	109	16	48	90	104	**650**	**12**
Ctenotus leonhardii												1					**1**	**1**
Ctenotus nigrilineatus										1							**1**	**1**
Ctenotus pantherinus				4	111	42	1	18	4		21	30	15	12	135	120	**513**	**12**
Ctenotus piankai									1								**1**	**1**
Ctenotus quattuordecimlineatus					2												**2**	**1**
Ctenotus rubicundus				1	15				1							2	**19**	**4**
Ctenotus rutilans					10	1							1		1		**13**	**4**
Ctenotus saxatilis		1	1	3	185	42	2	2	89	3		35	44	13	135	15	**570**	**14**
Ctenotus schomburgkii					3	2		2			4		2	1		2	**16**	**7**

Sp name	Artificial Habitat	Boulders	Calcrete Area	Cleared	Crest/Slope	Drainage Area	Drainage Line	Gilgai	Gorge/Gully	Granite Domes	Hardpan	Major Drainage Line	Minor Drainage Line	Mulga	Sand Plain	Stony Plain	Total	No of habitats recorded
Ctenotus serventyi														7	4	2	**13**	**3**
Ctenotus uber					4	43		1						30	18	22	**118**	**6**
Cyclodomorphus melanops			1		13	6			2		2	2	2		11	15	**54**	**9**
Cyclorana australis															1		**1**	**1**
Cyclorana maini				3	33	3			4	1		12	5	4	6	2	**76**	**11**
Cyclorana platycephala												1					**1**	**1**
Dasycercus blythi				5	7	1								1	135	2	**151**	**6**
Dasykaluta rosamondae				3	17	29	1		3			1	1	1	142	26	**224**	**10**
Dasyurus hallucatus	23	6		13	3		3		3	6			1	1	15		**74**	**10**
Delma butleri					2									1	4	1	**8**	**4**
Delma elegans					3				1						1		**5**	**3**
Delma haroldi						2						3			2		**7**	**3**
Delma nasuta					12	8			1			6	5			12	**44**	**6**
Delma pax				1	9	11			4			8	3	3	10	5	**54**	**9**
Delma tincta				1	13	4						1	6	2	7	10	**44**	**8**
Demansia psammophis				2	12	3			2	1	1	9	4	6	24	14	**78**	**11**
Demansia rufescens				2	10	1			2			4	2		1	3	**25**	**8**
Diplodactylus conspicillatus				12	8	90			1			24	2	22	123	40	**322**	**9**
Diplodactylus pulcher					4			2			2			2		9	**19**	**5**
Diplodactylus savagei					27	6			1			8	6	1	2	2	**53**	**8**
Diplodactylus stenodactylus					5	1							1				**7**	**3**
Diplodactylus wombeyi					5	1											**6**	**2**
Diporiphora valens			2		3	3					2	1		1	1	22	**35**	**8**
Diporiphora winneckei															2		**2**	**1**
Egernia cygnitos					1												**1**	**1**
Egernia depressa		2			9					1			3	1	2	1	**19**	**7**
Egernia formosa					12	4			6			3	10	1	1		**37**	**7**
Eremiascincus fasciolatus					3	1			1				1		1	2	**9**	**6**
Eremiascincus richardsonii						3					1	2		2	1	2	**11**	**6**
Furina ornata					7			1							2	1	**11**	**4**
Gehyra pilbara					3												**3**	**1**
Gehyra punctata					38	3			7			11	18	1	9	2	**89**	**8**
Gehyra variegata			1	3	30	20	1	1	8		4	36	3	26	52	33	**222**	**14**
Heteronotia binoei			1	4	36	10	1	1	14		3	52	10	2	27	23	**184**	**13**
Heteronotia spelea					16				5				1	1	1	2	**26**	**6**
Leggadina lakedownensis					3			4									**7**	**2**

Sp name	Artificial Habitat	Boulders	Calcrete Area	Cleared	Crest/Slope	Drainage Area	Drainage Line	Gilgai	Gorge/Gully	Granite Domes	Hardpan	Major Drainage Line	Minor Drainage Line	Mulga	Sand Plain	Stony Plain	Total	No of habitats recorded
Lerista bipes					7	4			2				10		18		**41**	**5**
Lerista labialis						2			34			66	10	9	183	8	**312**	**7**
Lerista macropisthopus														1			**1**	**1**
Lerista muelleri				1	16	4	1	2	1			17	6	2	6	11	**67**	**11**
Lerista neander					1	5							1	2	1		**10**	**5**
Lerista sp.															2		**2**	**1**
Lerista timida					1	8						8			3	14	**34**	**5**
Lerista zietzi					14	2			6				9	2	2	1	**36**	**7**
Lialis burtonis			1		15	1			2			3	2		11	1	**36**	**8**
Liasis olivaceus barroni				4	17	2			19			5	1				**48**	**6**
Litoria rubella			1	1	15	3			11		1	12	5	2		1	**53**	**11**
Lucasium stenodactylum				3	31	27		1	6		1	10	7	11	57	37	**191**	**11**
Lucasium wombeyi					22	3			1				3	1		1	**31**	**6**
Macrotis lagotis				2						1		1			34		**38**	**4**
Menetia greyii			1		19	7		1	4		3	18	5	27	15	14	**115**	**12**
Menetia surda					3												**3**	**1**
Morethia ruficauda					71	5			9	1		7	17	1	5	4	**120**	**9**
Neobatrachus kunapalari												1					**1**	**1**
Neobatrachus sutor					2												**2**	**1**
Nephrurus wheeleri				5	13	6	1	1				12	4	3	16	2	**63**	**10**
Ningaui timealeyi			2	2	24	4			5			3	3	1	14	23	**81**	**10**
Notaden nichollsi															1		**1**	**1**
Notomys alexis				2	6	10	1					3	2	3	44		**71**	**8**
Notoscincus ornatus						6									4		**10**	**2**
Oedura marmorata					29	3			16			1	13		1		**63**	**6**
Parasuta monachus			1		3	3					1	4		1		3	**16**	**7**
Planigale ingrami					7			1				1	5	1		4	**19**	**6**
Planigale maculata					18	2		2				3		1	5	2	**33**	**7**
Pogona minor			2	1	19	9		3	2		3	3	2	2	15	6	**67**	**12**
Proablepharus reginae				1	2	1		1							1	2	**8**	**6**
Pseudantechinus roryi		1			1												**2**	**2**
Pseudantechinus woolleyae					4				3								**7**	**2**
Pseudomys chapmani			40	255	2910	146	12		2			34	53	25	67	91	**3635**	**11**
Pseudomys delicatulus															1		**1**	**1**
Pseudomys desertor				5	26	2	1	1				1		1	24	2	**63**	**9**
Pseudomys hermannsburgensis			1	2	41	18	1	5	8			3	4	8	48	17	**156**	**12**

Sp name	Artificial Habitat	Boulders	Calcrete Area	Cleared	Crest/Slope	Drainage Area	Drainage Line	Gilgai	Gorge/Gully	Granite Domes	Hardpan	Major Drainage Line	Minor Drainage Line	Mulga	Sand Plain	Stony Plain	Total	No of habitats recorded
Pseudomys nanus															1		**1**	**1**
Pseudonaja mengdeni				4	4	3			2	1		2			22	6	**45**	**9**
Pseudonaja modesta				1	1	6		1						3	10	2	**24**	**7**
Pseudonaja nuchalis				1	2	2						1	1	1	3	1	**12**	**8**
Pseudophryne douglasi									2			1	2				**5**	**3**
Pygopus nigriceps					1	1						7		2		1	**12**	**5**
Pygopus nigriceps nigriceps				1											1		**2**	**2**
Ramphotyphlops ammodytes				2	10	2						1	3		6	1	**25**	**7**
Ramphotyphlops ganei					4				7			3	4			3	**21**	**5**
Ramphotyphlops grypus			1	1	6		1		3			2	3	3	5	2	**27**	**10**
Ramphotyphlops hamatus					7	3						3	3	2	2		**20**	**6**
Ramphotyphlops pilbarensis																1	**1**	**1**
Rhinonicteris aurantia					3				1				1				**5**	**3**
Rhynchoedura ornata				4	27	32	1	2			2	11	2	7	28	19	**135**	**11**
Saccolaimus flaviventris					2							1		1			**4**	**3**
Scotorepens greyii					4	2						3		1			**10**	**4**
Sminthopsis crassicaudata						1											**1**	**1**
Sminthopsis longicaudata				2													**2**	**1**
Sminthopsis macroura				1	18	2		14			1	9		3	2	22	**72**	**9**
Sminthopsis ooldea						1											**1**	**1**
Sminthopsis youngsoni					1	9			6			9		3	39	1	**68**	**7**
Strophurus ciliaris					1												**1**	**1**
Strophurus elderi					4	6			2						3	3	**18**	**5**
Strophurus jeanae				3	7	2			8						61		**81**	**5**
Strophurus wellingtonae				3	10	5	1		2		1	3		1	15	3	**44**	**10**
Suta fasciata					3			1					1	2	1		**8**	**5**
Suta punctata				2		2										4	**8**	**3**
Tachyglossus aculeatus					11	2			1	1					1	1	**17**	**6**
Tiliqua multifasciata				6	16	6	1	1	2				4	1	27	10	**74**	**10**
Tympanocryptis cephalus								4								11	**15**	**2**
Underwoodisaurus seorsus					15								3				**18**	**2**
Uperoleia glandulosa												1					**1**	**1**
Uperoleia russelli													1		1		**2**	**2**
Uperoleia saxatalis					5							3	6				**14**	**3**
Varanus acanthurus				4	57	18	2		2			13	4	1	9	6	**116**	**10**
Varanus brevicauda					5	9								3	18	5	**40**	**5**

Sp name	Artificial Habitat	Boulders	Calcrete Area	Cleared	Crest/Slope	Drainage Area	Drainage Line	Gilgai	Gorge/Gully	Granite Domes	Hardpan	Major Drainage Line	Minor Drainage Line	Mulga	Sand Plain	Stony Plain	Total	No of habitats recorded
Varanus bushi					6	9					3		1	7	6	5	**37**	**7**
Varanus caudolineatus					8	14					1	1	1	14	2	2	**43**	**8**
Varanus eremius					2	10			2				6		23	1	**44**	**6**
Varanus gilleni						2											**2**	**1**
Varanus gouldii					3	5						3	3	1	22		**37**	**6**
Varanus panoptes													1			1	**2**	**2**
Varanus pilbarensis		2			7				8				4			1	**22**	**5**
Varanus tristis				5	13		1	1	2			7	5			4	**38**	**8**
Vermicella snelli					1	1											**2**	**2**
Zyzomys argurus		1			41	2			96	1		4	6	1		2	**154**	**9**

Appendix B Percentage of individual species records at different habitats

Sp name	Artificial Habitat	Boulders	Calcrete Area	Cleared	Crest/Slope	Drainage Area	Drainage Line	Gilgai	Gorge/Gully	Granite Domes	Hardpan	Major Drainage Line	Minor Drainage Line	Mulga	Sand Plain	Stony Plain
Acanthophis wellsi	0	0	0	22	33	0	0	0	0	0	0	0	0	0	22	22
Amphibolurus longirostris	0	0	0	0	12	8	0	2	4	0	0	33	10	3	10	18
Antaresia perthensis	0	0	3	28	34	3	0	0	7	0	0	0	3	3	10	7
Antaresia stimsoni	0	0	5	19	38	5	0	0	10	0	0	5	5	5	10	0
Aspidites melanocephalus	0	0	0	0	50	25	0	0	0	0	0	0	25	0	0	0
Brachyurophis approximans	0	0	0	0	19	19	2	2	12	0	0	21	12	7	5	2
Caimanops amphiboluroides	0	0	0	0	8	8	0	25	0	0	17	0	0	8	17	17
Carlia munda	0	0	0	2	20	11	1	3	2	0	1	15	6	7	4	29
Carlia triacantha	0	0	0	0	8	0	0	0	0	0	0	0	8	8	69	8
Chelodina steindachneri	0	0	0	0	0	0	0	0	17	0	0	33	0	33	0	0
Crenadactylus ocellatus	0	0	0	0	60	20	0	0	0	0	20	0	0	0	0	0
Cryptoblepharus buchananii	0	0	0	0	25	0	0	0	25	0	0	13	0	25	0	13
Cryptoblepharus carnabyi	0	0	0	0	33	0	0	0	67	0	0	0	0	0	0	0
Cryptoblepharus plagiocephalus	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Cryptoblepharus ustulatus	0	0	0	0	68	0	0	0	20	0	0	0	10	0	0	3
Ctenophorus caudicinctus	0	0	1	1	50	8	0	4	1	0	1	3	16	2	6	8
Ctenophorus isolepis	0	0	0	1	4	19	0	0	2	0	0	2	1	8	59	4
Ctenophorus nuchalis	0	0	0	4	6	6	0	0	0	2	0	0	4	2	66	11
Ctenophorus reticulatus	0	0	0	3	10	3	0	3	0	0	18	0	3	20	5	35
Ctenotus aff. helenae	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0
Ctenotus ariadnae	0	0	0	0	7	0	0	0	0	0	0	5	0	2	86	0
Ctenotus duricola	0	0	0	0	25	23	1	2	5	0	0	3	5	2	30	5
Ctenotus grandis	0	0	0	1	5	14	1	0	3	0	0	1	4	0	72	0
Ctenotus hanloni	0	0	0	0	0	25	0	0	25	0	0	0	13	13	25	0
Ctenotus helenae	0	0	0	1	10	22	0	1	6	0	3	17	2	7	14	16
Ctenotus leonhardii	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0
Ctenotus nigrilineatus	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0
Ctenotus pantherinus	0	0	0	1	22	8	0	4	1	0	4	6	3	2	26	23
Ctenotus piankai	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Ctenotus quattuordecimlineatus	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Ctenotus rubicundus	0	0	0	5	79	0	0	0	5	0	0	0	0	0	0	11
Ctenotus rutilans	0	0	0	0	77	8	0	0	0	0	0	0	8	0	8	0
Ctenotus saxatilis	0	0	0	1	32	7	0	0	16	1	0	6	8	2	24	3
Ctenotus schomburgkii	0	0	0	0	19	13	0	13	0	0	25	0	13	6	0	13
Ctenotus serventyi	0	0	0	0	0	0	0	0	0	0	0	0	0	54	31	15
Ctenotus uber	0	0	0	0	3	36	0	1	0	0	0	0	0	25	15	19

Sp name	Artificial Habitat	Boulders	Calcrete Area	Cleared	Crest/Slope	Drainage Area	Drainage Line	Gilgai	Gorge/Gully	Granite Domes	Hardpan	Major Drainage Line	Minor Drainage Line	Mulga	Sand Plain	Stony Plain
Cyclodomorphus melanops	0	0	2	0	24	11	0	0	4	0	4	4	4	0	20	28
Cyclorana australis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Cyclorana maini	0	0	0	4	43	4	0	0	5	1	0	16	7	5	8	3
Cyclorana platycephala	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0
Dasycercus blythi	0	0	0	3	5	1	0	0	0	0	0	0	0	1	89	1
Dasykaluta rosamondae	0	0	0	1	8	13	0	0	1	0	0	0	0	0	63	12
Dasyurus hallucatus	31	8	0	18	4	0	4	0	4	8	0	0	1	1	20	0
Delma butleri	0	0	0	0	25	0	0	0	0	0	0	0	0	13	50	13
Delma elegans	0	0	0	0	60	0	0	0	20	0	0	0	0	0	20	0
Delma haroldi	0	0	0	0	0	29	0	0	0	0	0	43	0	0	29	0
Delma nasuta	0	0	0	0	27	18	0	0	2	0	0	14	11	0	0	27
Delma pax	0	0	0	2	17	20	0	0	7	0	0	15	6	6	19	9
Delma tincta	0	0	0	2	30	9	0	0	0	0	0	2	14	5	16	23
Demansia psammophis	0	0	0	3	15	4	0	0	3	1	1	12	5	8	31	18
Demansia rufescens	0	0	0	8	40	4	0	0	8	0	0	16	8	0	4	12
Diplodactylus conspicillatus	0	0	0	4	2	28	0	0	0	0	0	7	1	7	38	12
Diplodactylus pulcher	0	0	0	0	21	0	0	11	0	0	11	0	0	11	0	47
Diplodactylus savagei	0	0	0	0	51	11	0	0	2	0	0	15	11	2	4	4
Diplodactylus stenodactylus	0	0	0	0	71	14	0	0	0	0	0	0	14	0	0	0
Diplodactylus wombeyi	0	0	0	0	83	17	0	0	0	0	0	0	0	0	0	0
Diporiphora valens	0	0	6	0	9	9	0	0	0	0	6	3	0	3	3	63
Diporiphora winneckei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Egernia cygnitos	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Egernia depressa	0	11	0	0	47	0	0	0	0	5	0	0	16	5	11	5
Egernia formosa	0	0	0	0	32	11	0	0	16	0	0	8	27	3	3	0
Eremiascincus fasciolatus	0	0	0	0	33	11	0	0	11	0	0	0	11	0	11	22
Eremiascincus richardsonii	0	0	0	0	0	27	0	0	0	0	9	18	0	18	9	18
Furina ornata	0	0	0	0	64	0	0	9	0	0	0	0	0	0	18	9
Gehyra pilbara	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Gehyra punctata	0	0	0	0	43	3	0	0	8	0	0	12	20	1	10	2
Gehyra variegata	0	0	0	1	14	9	0	0	4	0	2	16	1	12	23	15
Heteronotia binoei	0	0	1	2	20	5	1	1	8	0	2	28	5	1	15	13
Heteronotia spelea	0	0	0	0	62	0	0	0	19	0	0	0	4	4	4	8
Leggadina lakedownensis	0	0	0	0	43	0	0	57	0	0	0	0	0	0	0	0
Lerista bipes	0	0	0	0	17	10	0	0	5	0	0	0	24	0	44	0
Lerista labialis	0	0	0	0	0	1	0	0	11	0	0	21	3	3	59	3
Lerista macropisthopus	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0

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Lerista muelleri	0	0	0	1	24	6	1	3	1	0	0	25	9	3	9	16
Lerista neander	0	0	0	0	10	50	0	0	0	0	0	0	10	20	10	0
Lerista sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Lerista timida	0	0	0	0	3	24	0	0	0	0	0	24	0	0	9	41
Lerista zietzi	0	0	0	0	39	6	0	0	17	0	0	0	25	6	6	3
Lialis burtonis	0	0	3	0	42	3	0	0	6	0	0	8	6	0	31	3
Liasis olivaceus barroni	0	0	0	8	35	4	0	0	40	0	0	10	2	0	0	0
Litoria rubella	0	0	2	2	28	6	0	0	21	0	2	23	9	4	0	2
Lucasium stenodactylum	0	0	0	2	16	14	0	1	3	0	1	5	4	6	30	19
Lucasium wombeyi	0	0	0	0	71	10	0	0	3	0	0	0	10	3	0	3
Macrotis lagotis	0	0	0	5	0	0	0	0	0	3	0	3	0	0	89	0
Menetia greyii	0	0	1	0	17	6	0	1	3	0	3	16	4	23	13	12
Menetia surda	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Morethia ruficauda	0	0	0	0	59	4	0	0	8	1	0	6	14	1	4	3
Neobatrachus kunapalari	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0
Neobatrachus sutor	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Nephrurus wheeleri	0	0	0	8	21	10	2	2	0	0	0	19	6	5	25	3
Ningaui timealeyi	0	0	2	2	30	5	0	0	6	0	0	4	4	1	17	28
Notaden nichollsi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Notomys alexis	0	0	0	3	8	14	1	0	0	0	0	4	3	4	62	0
Notoscincus ornatus	0	0	0	0	0	60	0	0	0	0	0	0	0	0	40	0
Oedura marmorata	0	0	0	0	46	5	0	0	25	0	0	2	21	0	2	0
Parasuta monachus	0	0	6	0	19	19	0	0	0	0	6	25	0	6	0	19
Planigale ingrami	0	0	0	0	37	0	0	5	0	0	0	5	26	5	0	21
Planigale maculata	0	0	0	0	55	6	0	6	0	0	0	9	0	3	15	6
Pogona minor	0	0	3	1	28	13	0	4	3	0	4	4	3	3	22	9
Proablepharus reginae	0	0	0	13	25	13	0	13	0	0	0	0	0	0	13	25
Pseudantechinus roryi	0	50	0	0	50	0	0	0	0	0	0	0	0	0	0	0
Pseudantechinus woolleyae	0	0	0	0	57	0	0	0	43	0	0	0	0	0	0	0
Pseudomys chapmani	0	0	1	7	80	4	0	0	0	0	0	1	1	1	2	3
Pseudomys delicatulus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Pseudomys desertor	0	0	0	8	41	3	2	2	0	0	0	2	0	2	38	3
Pseudomys hermannsburgensis	0	0	1	1	26	12	1	3	5	0	0	2	3	5	31	11
Pseudomys nanus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Pseudonaja mengdeni	0	0	0	9	9	7	0	0	4	2	0	4	0	0	49	13
Pseudonaja modesta	0	0	0	4	4	25	0	4	0	0	0	0	0	13	42	8
Pseudonaja nuchalis	0	0	0	8	17	17	0	0	0	0	0	8	8	8	25	8

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Pseudophryne douglasi	0	0	0	0	0	0	0	0	40	0	0	20	40	0	0	0
Pygopus nigriceps	0	0	0	0	8	8	0	0	0	0	0	58	0	17	0	8
Pygopus nigriceps nigriceps	0	0	0	50	0	0	0	0	0	0	0	0	0	0	50	0
Ramphotyphlops ammodytes	0	0	0	8	40	8	0	0	0	0	0	4	12	0	24	4
Ramphotyphlops ganei	0	0	0	0	19	0	0	0	33	0	0	14	19	0	0	14
Ramphotyphlops grypus	0	0	4	4	22	0	4	0	11	0	0	7	11	11	19	7
Ramphotyphlops hamatus	0	0	0	0	35	15	0	0	0	0	0	15	15	10	10	0
Ramphotyphlops pilbarensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100
Rhinonicteris aurantia	0	0	0	0	60	0	0	0	20	0	0	0	20	0	0	0
Rhynchoedura ornata	0	0	0	3	20	24	1	1	0	0	1	8	1	5	21	14
Saccolaimus flaviventris	0	0	0	0	50	0	0	0	0	0	0	25	0	25	0	0
Scotorepens greyii	0	0	0	0	40	20	0	0	0	0	0	30	0	10	0	0
Sminthopsis crassicaudata	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
Sminthopsis longicaudata	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0
Sminthopsis macroura	0	0	0	1	25	3	0	19	0	0	1	13	0	4	3	31
Sminthopsis ooldea	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
Sminthopsis youngsoni	0	0	0	0	1	13	0	0	9	0	0	13	0	4	57	1
Strophurus ciliaris	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0
Strophurus elderi	0	0	0	0	22	33	0	0	11	0	0	0	0	0	17	17
Strophurus jeanae	0	0	0	4	9	2	0	0	10	0	0	0	0	0	75	0
Strophurus wellingtonae	0	0	0	7	23	11	2	0	5	0	2	7	0	2	34	7
Suta fasciata	0	0	0	0	38	0	0	13	0	0	0	0	13	25	13	0
Suta punctata	0	0	0	25	0	25	0	0	0	0	0	0	0	0	0	50
Tachyglossus aculeatus	0	0	0	0	65	12	0	0	6	6	0	0	0	0	6	6
Tiliqua multifasciata	0	0	0	8	22	8	1	1	3	0	0	0	5	1	36	14
Tympanocryptis cephalus	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	73
Underwoodisaurus seorsus	0	0	0	0	83	0	0	0	0	0	0	0	17	0	0	0
Uperoleia glandulosa	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0
Uperoleia russelli	0	0	0	0	0	0	0	0	0	0	0	0	50	0	50	0
Uperoleia saxatalis	0	0	0	0	36	0	0	0	0	0	0	21	43	0	0	0
Varanus acanthurus	0	0	0	3	49	16	2	0	2	0	0	11	3	1	8	5
Varanus brevicauda	0	0	0	0	13	23	0	0	0	0	0	0	0	8	45	13
Varanus bushi	0	0	0	0	16	24	0	0	0	0	8	0	3	19	16	14
Varanus caudolineatus	0	0	0	0	19	33	0	0	0	0	2	2	2	33	5	5
Varanus eremius	0	0	0	0	5	23	0	0	5	0	0	0	14	0	52	2
Varanus gilleni	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
Varanus gouldii	0	0	0	0	8	14	0	0	0	0	0	8	8	3	59	0

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Varanus panoptes	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	50
Varanus pilbarensis	0	9	0	0	32	0	0	0	36	0	0	0	18	0	0	5
Varanus tristis	0	0	0	13	34	0	3	3	5	0	0	18	13	0	0	11
Vermicella snelli	0	0	0	0	50	50	0	0	0	0	0	0	0	0	0	0
Zyzomys argurus	0	1	0	0	27	1	0	0	62	1	0	3	4	1	0	1