Sanjiv Ridge Project

Updated Flora and Vegetation Assessment

ATLAS IRON PTY LTD

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Sanjiv Ridge Iron Ore Project, Updated Flora and Vegetation Assessment

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Cover Photograph: View of cliffs within Stage 2 Development Envelope (Woodman Environmental 2020)

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3	Updated final report with survey data (Stage 2 Development Envelope) and desktop review (2020)	MP	AS	29/1/2021		

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DEFINITIONS

Term	Definition
aff.	Affinitive
Atlas	Atlas Iron Pty Ltd
BAM	Biosecurity and Agriculture Management
CANBR	Centre for Australian National Biodiversity Research
cm	Centimetre
DAF	Department of Agriculture and Food
DBCA	Department of Biodiversity Conservation and Attractions
DoE	Department of the Environment
DPaW	Department of Parks and Wildlife
e.g.	For example
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
ESCAVI	Executive Steering Committee for Australian Vegetation Information
et al.	And others
GDA	Geocentric Datum of Australia
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
IBRA	Interim Biogeographic Regionalisation for Australia
INDVAL	A statistical method for analysing indicator species (indicator value)
JUICE	Software package for editing and analysing phytosociological (plant community) data
km	Kilometre
m	Metre
mm	Millimetre
NVIS	National Vegetation Information System
No.	Number
OptimClass	A method of numerical classification to identify optimal partition from a series of partitions of the same set of sites
PC-ORD	Software package for multivariate statistical analysis of ecological communities
PEC	Priority Ecological Community
Pers. comm.	Personal communication
Pty Ltd	Proprietary Limited
sp.	Species
TEC	Threatened Ecological Community
UCL	Unallocated Crown Land
UPGMA	Unweighted Pair-Group Method using Arithmetic Averages – a hierarchical clustering method
VT	Vegetation Type
WA	Western Australia
WA Herb.	Western Australian Herbarium
WC	Wildlife Conservation
Woodman Environmental	Woodman Environmental Pty Ltd

EXECUTIVE SUMMARY

Atlas Iron Pty Ltd (Atlas Iron) is currently in the process of developing the Sanjiv Ridge Project (formerly known as the Corunna Downs Project), an iron ore project located in the Pilbara region of Western Australia, approximately 33 km south of Marble Bar and 150 km south-east of Port Hedland. This report presents the results of both the desktop and field survey components of the 2014 and 2016 detailed surveys of the Study Area and the targeted search for significant Flora Taxa conducted in 2020.

A total of 413 discrete vascular flora taxa, one known hybrid and one putative hybrid were recorded within the Study Area. Seventeen taxa recorded in the Study Area are considered to be significant flora taxa. This includes 11 DBCA-classified Priority flora taxa, three potentially undescribed taxa, two taxa whose records are significantly disjunct from their known distributions and one taxon considered of taxonomic interest. A targeted search was conducted within the Stage 2 Development Envelope, with targeted survey also conducted in proposed pit areas in 2016. None of the significant taxa are considered to have been comprehensively surveyed for in the remainder of the Study Area, although some opportunistic searching was undertaken for particular taxa. It is considered likely that further locations of the majority of significant flora taxa would be found in the Study Area if targeted survey was undertaken.

A total of 18 introduced flora taxa were recorded by the survey of the Study Area. Records of such taxa were often associated with drainage features that appear to be grazed by cattle in preference to other areas. None of the introduced flora recorded in the Study Area are currently listed as Declared Pests in Western Australia (DPIRD 2020).

The floristic analysis of quadrat data from the Study Area identified 13 VTs that were then manually dissected to identify 15 VTs. Of the 15 VTs mapped within the Study Area, none are considered to represent any TECs as classified by DBCA and endorsed by the Western Australian Minister for Environment, any TECs listed under the EPBC Act, or any PECs as classified by DBCA. Eight VTs are considered to be of local significance, primarily because of their limited extent in the Study Area and also because they form habitat for conservation significant flora. Of these, four VTs are also considered to be potentially regionally significant.

The majority of the vegetation in the Study Area was ranked as being in Excellent condition, with little to no human disturbance and an absence or low levels of introduced flora taxa. However, the majority of larger drainage features, including creeks and flow lines, had lower condition scores as a result of high densities of aggressive introduced species and high grazing and trampling impacts from cattle. There was a general trend towards poorer vegetation in drainage features in the south-western corner of the Study Area and also in closer proximity to Marble Bar in the north, with grazing impacts in drainage features appearing higher than in most other parts of the Study Area.

Based on the presence of the obligate phreatophytes *Melaleuca argentea* and *Eucalyptus camaldulensis*, as well as the facultative phreatophyte *Eucalyptus victrix*, and the potential facultative phreatophytes *Melaleuca glomerata* and *Atalaya hemiglauca*, there is the potential that all areas of vegetation in the Study Area mapped as VT 3, 4, 8, 14 and 15 are

groundwater dependent. As VT 3 typifies deep rocky gorges it is likely to rely upon perched water stores, and is therefore potentially not groundwater dependent. However, two locations of VT3 within the Stage 2 Development Envelope where the obligate phreatophyte *Melaleuca argentea* and *Eucalyptus camaldulensis* subsp. *refulgens* (only in one location) were recorded are considered to be groundwater dependant.

1 INTRODUCTION

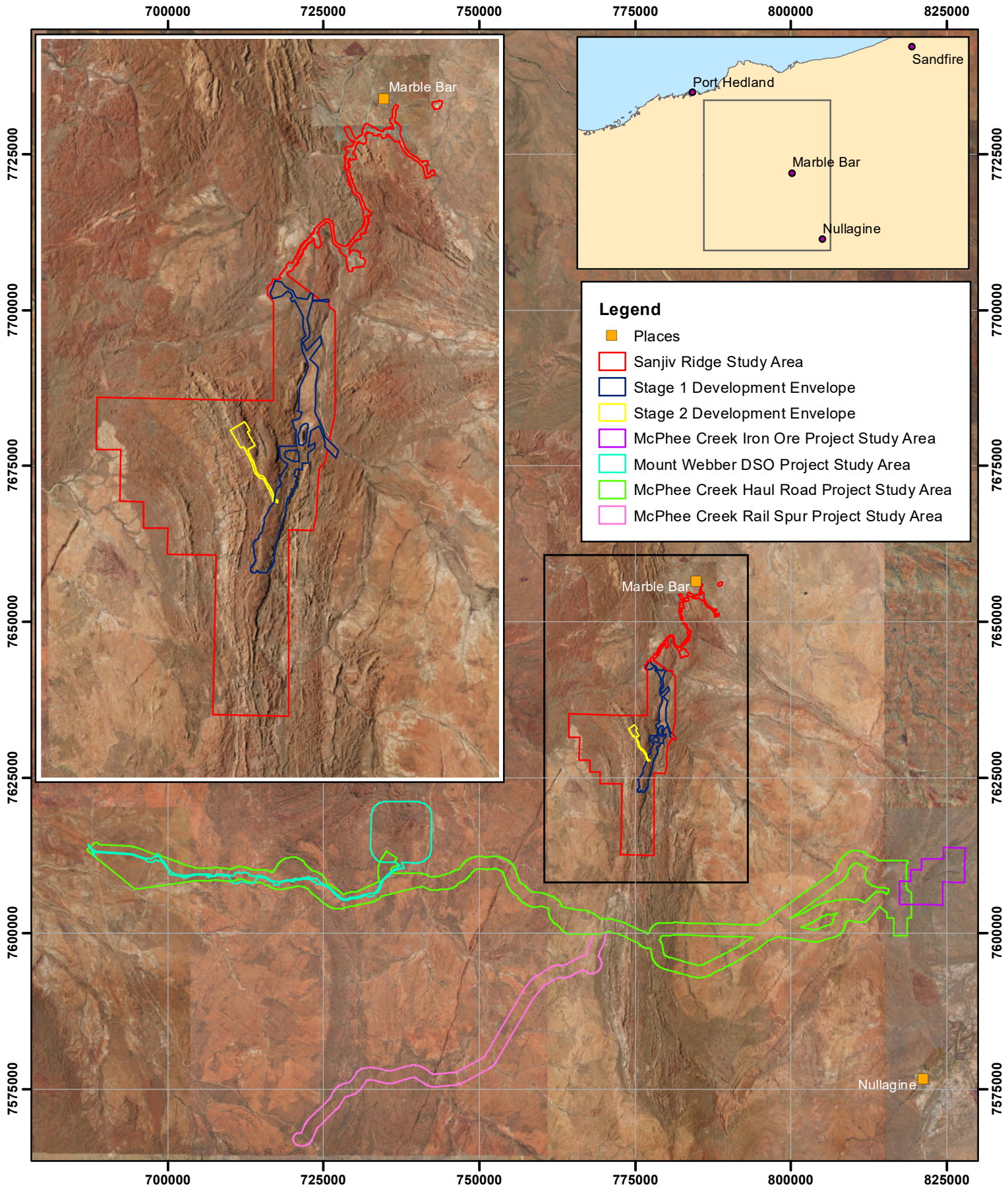
1.1 Project and Study Area Description

Atlas Iron Pty Ltd (Atlas Iron) is currently in the process of developing the Sanjiv Ridge Project (formerly known as the Corunna Downs Project), an iron ore project located in the Pilbara region of Western Australia, approximately 33 km south of Marble Bar. As part of investigations into the development of the Project to mine iron ore, Woodman Environmental Consulting Pty Ltd (Woodman Environmental) conducted a Level 2 flora and vegetation survey of the original Project Study Area ('original Study Area') in 2014. The area mapped in 2014 covered an area of approximately 19,095 ha with the field work conducted during April and May of that year (Woodman Environmental 2014a).

Following revision of the project layout, it was determined that flora and vegetation survey was required over a larger area. In 2016 Atlas commissioned Woodman Environmental to undertake a Level 2 (EPA 2004) flora and vegetation assessment of the extension areas, and any additional work required to inform impact assessment within the original Study Area with respect to flora and vegetation, incorporating the 2014 and 2016 results.

Atlas Iron is now progressing early works to support Stage 2 of the Sanjiv Ridge Project (referred to as the Stage 2 Development Envelope in this report), which includes the above water table mining of an additional ore body (Glen Herring deposit), and additional infrastructure including the development of an additional waste rock dump and connecting haul road. The Stage 2 Development Envelope (Figure 1) is encompassed within the Sanjiv Ridge Project Study Area (Woodman Environmental 2016) and covers approximately 245 ha.

The entire Project Study Area is referred to as the 'Study Area' in this report. The current extent of the Study Area (subject to surveys in 2014 and 2016) and the Stage 2 Development Envelope (subject to survey in 2020) is shown on Figure 1.



Sanjiv Ridge **Study Area Location**	Author: Marco Pratissoli	N
	WEC Ref: Atlas20-14-01	
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	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report Atlas20-14-01.	Revision: A - 22 January 2021	

1.2 Level of Survey

The 2014 and 2016 flora and vegetation assessments were undertaken as per the requirements of Level 2 Detailed survey as defined by the Environmental Protection Authority (EPA) (2004) technical guidance, which was relevant at the time of survey. These surveys were broadly equivalent to a Detailed Survey as defined by EPA's *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016).

A Level 2 Detailed Survey was defined as a background research/desktop study and reconnaissance survey, followed by a detailed field survey. This level of survey was considered appropriate, as a number of surveys had been recently conducted in the vicinity of the Study Area (e.g. Woodman Environmental 2012a, 2012b; 2013a; 2014b, 2014c), which provided regional context when considering the flora and vegetation values of the Study Area.

Based on the above information, the Stage 2 Development Envelope has been assessed adequately for vegetation issues. However, since no Targeted flora survey had been conducted within the Stage 2 Development Envelope (Woodman Environmental 2016), knowledge of the extent of populations of conservation significant flora was deemed lacking, and it is likely that the Stage 2 Development Envelope had not been assessed for the presence of conservation significant flora to a level adequate to address current EPA (2016) requirements. A Targeted Flora Survey as per EPA (2016) was conducted in April 2020 to determine the presence and the extent of conservation significant flora taxa populations within the Stage 2 Development Envelope.

Based on the presence of obligate and facultative phreatophytes, the 2016 survey identified a number of Vegetation Types (VTs) as potential Groundwater Dependant Vegetation (GDVs). Ground truthing of the potential GDVs occurring within the Stage 2 Development Envelope was also conducted during the survey conducted in 2020 to determine the presence of GDV.

This report presents updated results of the desktop investigation of the Study Area, the field survey components of the 2014 and 2016 detailed surveys and the Targeted Flora Search and ground truthing of GDVs conducted within the Stage 2 Development Envelope in 2020.

1.3 Aims

The aim of the flora and vegetation assessment in 2014 was to determine the flora and vegetation values of the Study Area, and to provide baseline information to support impact assessment and management of the environment for future mining activities. The overall objectives of the flora and vegetation assessment were to:

- Compile a list of flora taxa (native and introduced) that occur within the Study Area;
- Identify and record the locations of flora taxa that occur within the Study Area that are one of the following (hereafter referred to as significant flora taxa):
    - Listed Threatened Species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
    - Threatened Flora under the Western Australian *Wildlife Conservation Act 1950* (WC Act); and
    - Priority Flora taxa as classified by the Western Australian (WA) Department of Parks and Wildlife (DPaW);

    - Other significant flora taxa as defined by the EPA (2004).
- Identify and map the location of all Vegetation Types (VTs) that occur within the Study Area;
- Assess the condition of the vegetation within the Study Area;
- Identify and map the location of VTs that occur within the Study Area that are listed as one of the following (herein referred to as significant vegetation):
    - Threatened Ecological Community (TEC) under the EPBC Act;
    - TEC as classified by DPaW and endorsed by the WA Minister for the Environment; and
    - Priority Ecological Community (PEC) as classified by DPaW.

Additional work was required in 2016 to inform an impact assessment. In addition to surveying of the extension area, the 2016 assessment aimed to resolve potentially undescribed taxa identified in 2014 that may be at risk of impact from mining operations. The overall objectives of the resolution of undescribed taxa were to:

- Conduct discussions with the appropriate staff at the WA Herbarium regarding the taxonomic status of the potential new taxa *Abutilon* aff. *hannii*, *Portulaca* sp. and *Schoenus* sp. Marble Bar (D. Coultas & S. Coultas DCSC-Opp 07) (recently described as a new species and named *Schoenus coultasii*) (Western Australia Herbarium 1998-).
- Depending upon the outcome of the resolution of these taxa, undertake surveys in appropriate areas (dependent upon habitat, and location of impact areas on habitat) within the original 2014 survey area, as well as in appropriate areas within the new areas requiring survey (infrastructure extension area and haulage route - 2016 Study Area).

The objectives of the Targeted Flora Survey (as per EPA 2016) conducted in 2020 were:

- Determine the presence and the extent of conservation significant flora taxa populations within the Stage 2 Development Envelope.
- Ground truth potential Groundwater Dependant Vegetation occurring within the Stage 2 Development Envelope.
- Review existing VT mapping for the Stage 2 Development Envelope and amend where necessary.

2 BACKGROUND AND LITERATURE REVIEW

2.1 Study Area

The Study Area (Figure 1) covers approximately 26,021.8 ha. The majority of the Study Area consists of remnant vegetation, with a small number of cleared areas present, including roads, drill lines and tracks. The Study Area is predominantly located on the Panorama and Eginbah Pastoral Leases, with a small portion near the eastern boundary and the northern section of the Stage 1 haulage route located on Unallocated Crown Land (UCL). The Stage 2 Development Envelope is encompassed within the Sanjiv Ridge Study Area (Woodman Environmental 2016) and covers approximately 245 ha (Figure 1). The Desktop Study Area, for interrogation of databases and searches for relevant literature, includes a 40 km buffer of the Study Area.

2.2 Climate

The Study Area is located within the Pilbara region in the Arid Zone of Western Australia, and is classified as desert due to low, erratic rainfall (Beard 1990). The Pilbara region experiences an arid tropical climate with predominantly Summer rainfall (Beard 1990) and is strongly influenced by 'Summer' (December – April) cyclones. The prevalence of such cyclonic events results in the Pilbara receiving slightly higher average annual rainfall (250-300 mm) than the remainder of the Arid Zone. Figure 2 displays average monthly and long-term maximum temperatures, and average long term and monthly rainfall, recorded for Marble Bar, the nearest meteorological station to the Study Area (Bureau of Meteorology 2020).

The highest average daily maximum temperature at Marble Bar occurs in November, December and January (40.8, 42 and 40.7 °C respectively (data from 2000-2020)). The average annual rainfall for this station is 392.7 mm (data from 2000-2020). Average monthly rainfall peaks in Summer, particularly January to March, with rainfall strongly influenced by tropical cyclones which generally form between December and April.

Rainfall received at Marble Bar over the Summer 'wet season' period prior to the 2014 survey being conducted (December 2013 to March 2014) exceeded the average rainfall for this period, with 477 mm received compared to the average of 273.9 mm for the same months. Rainfall at nearby Hillside Station from December 2015 to March 2016 prior to the 2016 survey measured 185 mm, being lower than the average of 243.8 mm for the same months and much lower than the same period in 2014. The Marble Bar meteorological station appears to have not been functioning properly for the first few months of 2016, hence not presenting Summer rainfall for this station. Tropical cyclone Stan passed to the east of Marble Bar on 31st January 2016 however did not produce significant rainfall for Marble Bar (Bureau of Meteorology 2016).

Rainfall received at Marble Bar over the Summer 'wet season' period prior to the 2020 survey (April 2020) exceeded the average rainfall for this period, with 358.4 mm received compared to the average of 299.3 mm for the same months (Bureau of Meteorology 2020). The increased level of rainfall for this period was due to heavy rainfall associated with Tropical Cyclone Blake (Bureau of Meteorology 2021).

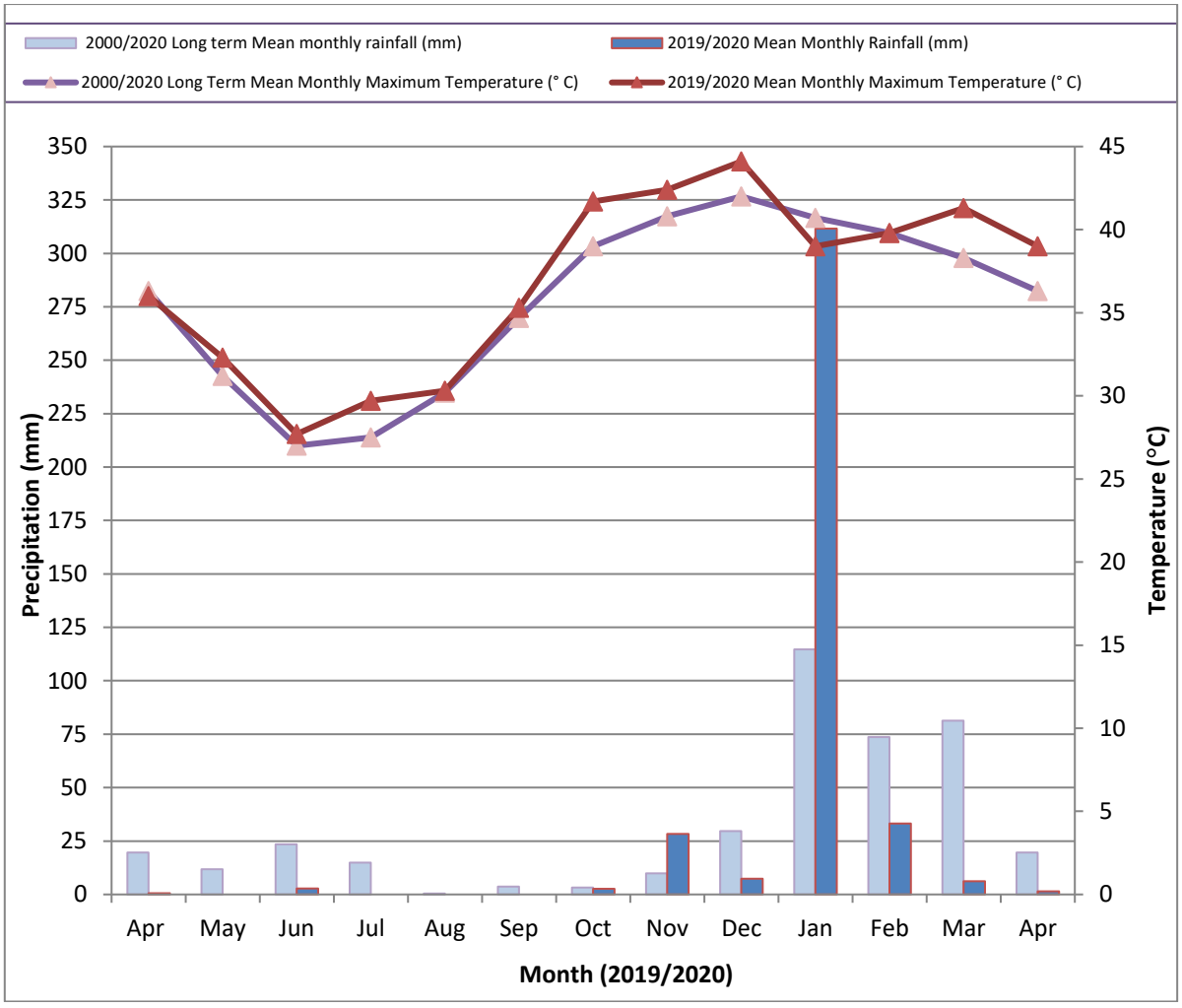


Figure 2: **Mean Monthly and Long Term Maximum Temperatures (° Celsius) and Mean Monthly and Long Term Rainfall (mm) for Marble Bar (Bureau of Meteorology 2020)**

2.3 Geology, Soils and Landforms

The Study Area is located in the Pilbara region (Fortescue Botanical District), which is formed of a basement of Archaean rocks, overlain by massive deposits of Proterozoic sediments and volcanics (Beard 1990). This region is generally mountainous, rising to 1250 m, with hard alkaline red soils on plains and pediments, and shallow and skeletal soils on ranges. The Study Area traverses two physiographic regions as defined by Beard (1975); the Abydos Plain and the Gorge Ranges.

The Abydos Plain is alluvial in origin near the coast, however further inland is of Archaean granite origin. It consists of a variety of features including alluvial plains, pediplains, low stony hills and dissected pediments, low granite outcrops and tors, and basic dykes. It is divided into a number of isolated sections by the Gorge Ranges. The main soils are hard alkaline red soils, some areas with coarse textured A horizons to 45 cm thick, while other areas have shallow stony A horizons. Patches of calcrete also occur. On the eastern part of the plain near the De Grey River, the soils are chiefly neutral and acidic red earths, while on the inland plains behind the Gorge Ranges, chief soils are earthy loams and coarse sands overlying

granite within 90 cm of the soil surface. The alluvial plains along the coast generally consist of red earthy sands with extensive areas of red earths, and hard red soils along creek lines. Deep cracking clays occur in the vicinity of residuals of basic and ultrabasic rocks in the Roebourne area (Beard 1975).

The Gorge Ranges are a rough, steep and abrupt range dissected by a number of rivers through narrow gorges. These ranges consist of Archaean and Lower Proterozoic rocks of sedimentary and volcanic origin, with basic lavas along with dolomites, tuff, banded-iron formations and dolerite dykes, with some narrow valley-plains and high-level gently undulating areas of limited extent (Beard 1975). The soils are generally shallow and stony, with large areas without soil cover. Chief soils are brown loams with significant areas of earthy loams soils, with hard alkaline red soils occurring on lower slopes, and cracking and non-cracking clays on valley floors.

2.4 Regional Vegetation

The Study Area is located in the Pilbara Interim Biogeographic Regionalisation for Australia (IBRA) Region, specifically the PIL1 Chichester subregion (Commonwealth of Australia 2012). The Chichester IBRA subregion comprises the northern section of the Pilbara Craton and consists of undulating Archaean granite and basalt plains and ranges. The plains contain a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on the ranges. Drainage occurs to the north via numerous rivers including De Grey, Oakover and Nullagine. The land is primarily used for native pasture grazing (Kendrick & McKenzie 2001).

Beard mapped the vegetation of the Pilbara Region at a scale of 1:1 000 000 (Beard 1975). As previously mentioned, the Study Area traverses the Abydos Plain and Gorge Ranges physiographic regions within the Pilbara region.

The Abydos Plain is characterised by four broad associations: Shrub steppe, Dwarf-shrub steppe, Grass plains and the Coastal Complex. Of these, shrub steppe is the only association relevant to the Study Area. Shrub steppe is the main community of the granite plain, which is dominated by the *Acacia pyrifolia-Triodia pungens* association, with hummock grasses dotted with widely-spaced shrubs. The plain is broken by stony rises and hills with small ranges, with *Triodia pungens* usually replaced by *T. wiseana*, *T. longiceps* or *T. angusta*, with scattered shrubs. Larger ranges tend to possess little else but Triodia, with only a few scattered shrubs. Major creeks and rivers are wooded with *Eucalyptus camaldulensis* and *Melaleuca leucadendron* (now considered to represent *M. argentea*) (Beard 1975).

The George Ranges are covered with tree steppe on the rockiest parts, often with the trees rather sparse. The dominant tree species is *Eucalyptus brevifolia* (now referred to as *E. leucophloia*), with the hummock grasses a mixture of *Triodia pungens* and *T. brizoides*. This is replaced on the lower slopes and in valleys by shrub steppe of *Acacia bivenosa* and *Triodia pungens*, with *A. pyrifolia* replacing *A. bivenosa* in the valleys (Beard 1975).

Shepherd *et al.* (2002) mapped and described vegetation system associations in the Chichester IBRA subregion related to physiognomy, utilising mapping undertaken by Beard (1975). Vegetation system associations were described at a scale of 1:250,000. Six vegetation

system associations occur in the Study Area, as summarised in Table 1 and shown on Figure 3; one of these (George Ranges_82) occurs over the Stage 2 Development Envelope.

Table 1 presents the current extent of each vegetation system association in relation to its pre-European extent, and the percentage of the current extent of each vegetation system association currently protected for conservation (in DBCA-managed land) (Government of Western Australia 2019). All six vegetation system associations have been subject to very limited clearing, with less than 1 % of each vegetation system association having been cleared since European settlement (Table 1). However, little or none of each vegetation system association is protected for conservation.

Table 1: Extent of Vegetation System Associations within the Study Area (Government of Western Australia 2019)

Vegetation System Association	Description	Current Extent (ha)	Percentage of Pre-European Extent Remaining	Percentage of Current Extent Protected for Conservation
Abydos Plain_93	Hummock grasslands, shrub steppe; kanji over soft spinifex	432,038.31	99.94	0
Abydos Plain-Chichester_93	Hummock grasslands, shrub steppe; kanji over soft spinifex	2,478,504.08	99.86	0.54
George Ranges_82	Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*	316,855.10	99.90	0
George Ranges_171	Hummock grasslands, low tree steppe; snappy gum over soft spinifex & *Triodia brizoides*	269,728.32	99.52	0
George Ranges_587	Mosaic: Hummock grasslands, open low tree-steppe; snappy gum over *Triodia wiseana* / Hummock grasslands, shrub-steppe; kanji over *Triodia pungens*	103,444.39	99.99	0
George Ranges_619	Medium woodland; river gum (*Eucalyptus camaldulensis*)	4,402.59	100	0

In 2004, the Department of Agriculture described land systems within the Pilbara IBRA region, considering general ecological information, vegetation physiognomy and composition, patterns of variation, conservation status, gradational association and land system representation (Van Vreeswyk *et al.* 2004). Eight land systems occur within the Study Area (Table 2), with the Stage 2 Development Envelope occurring on the Capricorn Landsystem. None of these landsystems are considered to be of conservation significance (DBCA 2020a).

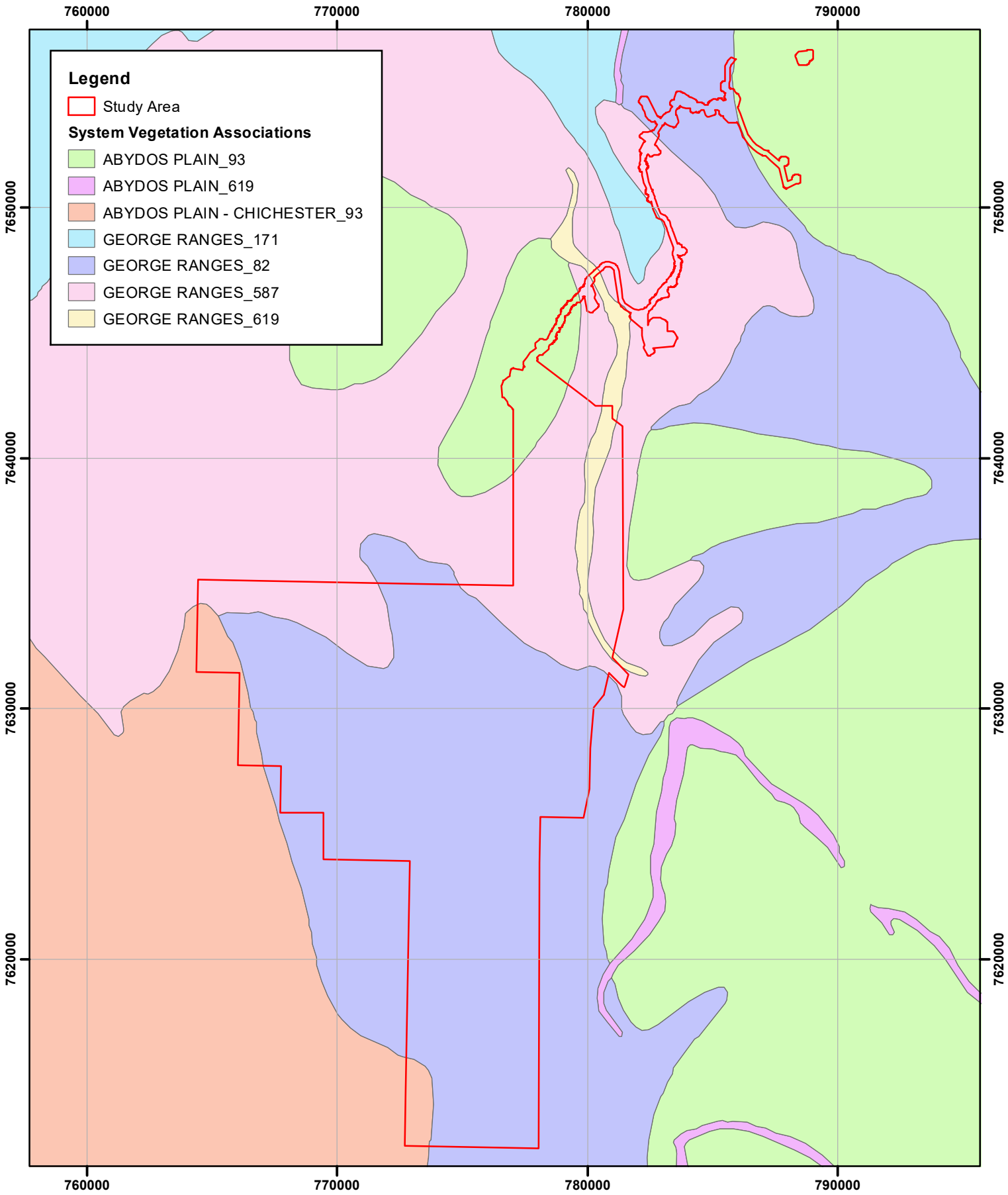
Table 2: Land Systems Located within the Study Area (Van Vreeswyk *et al*. 2004)

Land System	Mapped Extent (ha)	Description of Land System
Boolgeeda	774,800	Stony lower slopes and plains below hill systems supporting hard and soft spinifex grasslands or mulga shrublands
Capricorn	529,600	Hills and ridges of sandstone and dolomite supporting low shrublands or shrubby spinifex grasslands
Granitic	402,000	Rugged granitic hills supporting shrubby hard and soft spinifex grasslands
Macroy	1,309,500	Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands

Land System	Mapped Extent (ha)	Description of Land System
River	408,800	Active flood plains, major rivers and banks supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands
Rocklea	2,299,300	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands
Satirist	37,700	Stony plains and low rises supporting hard spinifex grasslands, and gilgai plains supporting tussock grasslands
Talga	212,400	Hills and ridges of greenstone and chert, and stony plains supporting hard and soft spinifex grasslands

2.4.1 Groundwater Dependant Vegetation

Groundwater Dependant Vegetation assessments have been conducted at Sanjiv Ridge by Woodman Environmental (2018, 2019) to assess groundwater drawdown impact on vegetation within the Study Area. A summary of the results of this assessment is presented in Section 6.4.3.



Sanjiv Ridge **Vegetation System Associations**	Author: Marco Pratissoli	N
	WEC Ref: Atlas20-14-01	
WOODMAN ENVIRONMENTAL	Filename: Atlas20-14-01-f03	**Figure**
	Scale: 1:200,000 (A4)	3
	Projection: GDA 1994 MGA Zone 50	
This map should only be used in conjunction with WEC report Atlas20-14-01.	Revision: A - 22 January 2021	

An updated search of the Department of the Environment and Energy (DoEE) Profile and Threats (SPRAT) database with regard to environmental matters of national significance (MNES) listed under the EPBC Act was performed from a central point within the Study Area with a 50km buffer zone on 11th March 2020 (DoEE 2020a). The results of this search indicate that no TECs listed under the EPBC Act coincide with the Desktop Study Area. The results of this search are presented in Appendix A.

An updated search of DBCA's TEC and PEC database was undertaken to identify the presence of any DBCA-classified TECs and/or DBCA-classified PECs that coincide with the Study Area (DBCA 2020a). The search used the Stage 2 Development Envelope with a 50 km buffer zone. No DBCA-classified TECs or PECs coincide with the Desktop Study Area. Appendix B presents definitions, categories and criteria for TECs and PECs (Department of Environment and Conservation (DBCA 2013)).

2.5 Regional Flora

DBCA's threatened flora databases, including the Western Australian Herbarium (WA Herb.) specimen database, and Threatened and Priority Flora List, were interrogated for updated (2020) information regarding listed significant taxa known from within or in the immediate vicinity of the Study Area (DBCA 2020b). The search was requested for the Study Area with a 40 km buffer zone.

A search of these databases using *NatureMap* (DBCA 2007-) was undertaken for the Study Area with a 40 km buffer zone as part of the Desktop Study to determine recently added records and to confirm the records returned from the DBCA WA Herbarium specimen database and TPFL database search. The *NatureMap* search did not return any additional significant flora taxa.

A total of 23 significant vascular flora taxa have records within the Desktop Study Area; 22 of which are Priority listed taxa (P) and one listed as Threatened (T) (*Quoya zonalis*), as presented in Table 3. The 2020 DBCA database search (DBCA 2020b) returned four taxa that were not returned during similar database searches conducted in 2014 and 2016, as shaded in green in Table 3. Appendix C presents conservation codes for Western Australia flora (DBCA 2020). Of these taxa only *Acacia levata* (P3) is known to occur in the Study Area and none are known to occur within the Stage 2 Development Envelope.

The nearest known location of a significant taxon to the Stage 2 Development Envelope is *Nicotiana umbratica* (P3), known from approximately 3km to the north-east of the Stage 2 Development Envelope (Figure 5) (DBCA 2020b)

Table 3: Threatened and Priority Flora Returned from updated DBCA Database Searches (DBCA 2020b)

Taxon	Status	Source*
Acacia aphanoclada	P1	TPFL; WA Herb.;
Acacia cyperophylla var. *omearana*	P1	WA Herb; NatureMap
Acacia leeuweniana	P1	TPFL; WA Herb.; NatureMap
Acacia levata	P3	TPFL; WA Herb.; NatureMap
Acacia sp. Marble Bar (J.G. & M.H. Simmons 3499)	P1	WA Herb; NatureMap
Bulbostylis burbidgeae	P4	WA Herb; NatureMap

Taxon	Status	Source*
Corchorus sp. Yarrie (J. Bull & D. Roberts CAL 01.05)	P1	WA Herb
Cochlospermum macnamarae	P1	WA Herb; NatureMap
Eragrostis crateriformis	P3	WA Herb; NatureMap
Gomphrena leptophylla	P3	WA Herb; NatureMap
Goodenia nuda	P4	WA Herb
Gymnanthera cunninghamii	P3	WA Herb; NatureMap
Heliotropium murinum	P3	WA Herb; NatureMap
Nicotiana umbratica	P3	WA Herb; NatureMap
Phyllanthus hebecarpus	P3	WA Herb; NatureMap
Ptilotus mollis	P4	WA Herb; NatureMap
Quoya zonalis	T	DBCA
Rhynchosia bungarensis	P4	WA Herb; NatureMap
Rostellularia adscendens var. *latifolia*	P3	WA Herb; NatureMap
Rothia indica subsp. *australis*	P3	WA Herb; NatureMap
Schoenus coultasii	P1	WA Herb; NatureMap
Stylidium weeliwolli	P3	WA Herb; NatureMap
Triodia basitricha	P3	WA Herb

*Sources are:
DBCA – DBCA WA Herbarium and TPFL Databases (2020a);
NatureMap – NatureMap (DBCA 2007-);
DoEE – DoEE (2020)

The interrogation of the Department of the Environment and Energy SPRAT database (DoEE 2020a) with regards to MNES listed under the EPBC Act (Appendix A) returned one flora taxa listed as Threatened Species that is likely to occur in the Desktop Study Area:

- *Quoya zonalis* (Endangered)

The search also identified two significant invasive introduced flora taxa, as likely to occur within the Desktop Study Area as listed below:

- *Cenchrus ciliaris*; and
- *Parkinsonia aculeata*

Cenchrus ciliaris is not listed as a Declared Pest in Western Australia under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) (Department of Primary Industry and Regional Development (DPIRD) 2020), but is considered by the States and Territories to pose a particularly significant threat to biodiversity, as it is known to be invasive under certain conditions (Hussey *et. al.* 2007; DoEE 2020a). *Parkinsonia aculeata* is listed as a Declared Pest in Western Australia (DPIRD 2020) and is a Weed of National Significance (WoNS) (Australian Weeds Committee 2020).

A search for records of introduced taxa within the Study Area and surrounds using the online tool *NatureMap* (DBCA 2007-) returned a total of 10 introduced taxa, these being:

- *Aerva javanica* (Kapok);
- *Aloe vera* var. *officinalis* (Aloe);
- *Argemone ochroleuca* subsp. *ochroleuca* (Mexican Poppy);
- *Bidens bipinnata* (Bipinnate Beggartick);
- *Cenchrus ciliaris* (Buffel Grass);
- *Cenchrus setiger* (Birdwood Grass);

- *Flaveria trinervia* (Speedy Weed);
- *Leucaena leucocephala* (Leucaena);
- *Portulaca pilosa* (Djanggara); and
- *Vachellia farnesiana* (Mimosa Bush).

None of these are listed as Declared Pests in Western Australia under the BAM Act (Department of Agriculture and Food (DAF) 2016) or are Weeds of National Significance (Australian Weeds Committee 2016).

2.6 Local Flora and Vegetation Surveys

A number of flora and vegetation surveys have been conducted in the vicinity of the Study Area, as summarised below in Table 4.

Table 4: Summary of Flora and Vegetation Surveys Previously Conducted in the Vicinity of the Study Area

Project	Location	Study	Parameters of Survey	Number of Taxa	Vegetation	Significant Flora Taxa	Introduced Taxa
Sulphur Spring Project (formerly Panorama Project)	45 km west north-west of Study Area	Mattiske (2007)	-	514 taxa; 161 genera; 58 families	18 vegetation alliances (summarisation of original 52 vegetation alliances mapped over the Panorama Springs project area); No TECs or PECs identified, no vegetation alliances considered to be of conservation significance	5 taxa: *Quoya zonalis* (T); *Euphorbia clementii* (P2); *Acacia glaucocaesia* (P3); *Gymnanthera cunninghamii* (P3); *Ptilotus mollis* (P4)	9 taxa: *Aerva javanica*; *Argemone ochroleuca*; *Cenchrus ciliaris*; *Cynodon dactylon*; *Ricinus communis*; *Setaria verticillata*; *Solanum nigrum*; *Vachellia farnesiana*
Abydos DSO Project	60 km north north-west of Study Area	Woodman Environmental (2012a) – mining project and infrastructure corridor to GNH	133 quadrats established; All vascular plant species recorded	263 taxa (including 2 hybrids); 112 genera; 40 families	10 VTs (one split into two sub-types); No TECs or PECs identified, no VTs considered of regional conservation significance	4 taxa: *Quoya zonalis* (T); *Heliotropium muticum* (P1); *Euphorbia clementii* (P2); *Gymnanthera cunninghamii* (P3); *Abutilon* aff. *hannii* (Potentially undescribed)	4 taxa: *Aerva javanica*; *Cenchrus ciliaris*; *Citrullus colocynthis*; *Malvastrum americanum*
		Woodman Environmental (2012b) – camp and haul road corridor to Marble Bar Road	18 detailed recording sites; dominant species only recorded	62 dominant taxa; 40 genera; 20 families	8 vegetation alliances; No TECs or PECs identified, no vegetation alliances considered to be of conservation significance		
Mt Webber DSO Project	30 km north-west of Study Area	Woodman Environmental (2012c) - mining area and Public Road Upgrade (PRU)	117 quadrats established in mining area (July and August 2010); 87 flora survey quadrats established in PRU (April 2012)	354 taxa; 139 genera; 50 families	16 VTs; No TECs or PECs identified, no VTs considered of regional conservation significance	8 taxa: *Acacia* sp. indet. (potentially undescribed); *Bulbostylis burbidgeae* (P4); *Gomphrena leptophylla* (P3); *Gymnanthera cunninghamii* (P3); *Heliotropium murinum* (P3); *Nicotiana umbratica* (P3); *Ptilotus mollis* (P4);	9 taxa: *Aerva javanica*; *Cenchrus ciliaris*; *Chloris barbata*; *Citrullus lanatus*; *Cynodon dactylon*; *Flaveria trinervia*; *Malvastrum americanum*; *Vachellia farnesiana*

Project	Location	Study	Parameters of Survey	Number of Taxa	Vegetation	Significant Flora Taxa	Introduced Taxa
		Woodman Environmental (2013a) - PRU supplementary survey	21 quadrats established (April 2013)	Additional 12 taxa to Woodman Environmental (2012c) recorded		*Rothia indica* subsp. *australis* (P3); *Abutilon* aff. *hannii* (Potentially undescribed)	
McPhee Creek Iron Ore Project	40 km east of Study Area	Woodman Environmental (2013b) - McPhee Creek Project Study Area	125 quadrats established (May 2012)	309 taxa; 141 genera; 47 families	15 VTs: No TECs or PECs identified, no VTs considered of regional conservation significance	4 taxa: *Acacia aphanoclada* (P1); *Eragrostis crateriformis* (P3); *Rostellularia adscendens* var. *latifolia* (P3); *Ptilotus mollis* (P4)	8 taxa: *Aerva javanica*; *Cenchrus ciliaris*; *Cenchrus setiger*; *Flaveria trinervia*; *Malvastrum americanum*; *Setaria verticillata*; *Vachellia farnesiana*
		Woodman Environmental (2013c) - Targeted significant flora survey	-	-			
		Woodman Environmental (2014b) - Project Discharge Options	39 quadrats established (May 2013)	165 taxa; 105 genera; 38 families			
McPhee Creek Haul Road Project	10 km south of Study Area	Woodman Environmental (2014c) - Eastern Corridor (Yandeyarra to Mt Webber and McPhee Creek)	302 quadrats (June/July 2013)	508 taxa; 7 hybrids; 193 genera; 62 families	22 vegetation types; No TECs or PECs identified, no VTs considered of regional conservation significance	14 taxa: *Acacia cyperophylla* var. *omearana* (P1); *Acacia* sp. Nullagine (B.R. Maslin 4955) (P1); *Cochlospermum macnamarae* (P1); *Rothia indica* subsp. *australis* (P3); *Acacia levata* (P3); *Eragrostis crateriformis* (P3); *Gymnanthera cunninghamii* (P3); *Heliotropium murinum* (P3); *Nicotiana umbratica* (P3); *Phyllanthus hebecarpus* (P3); *Bulbostylis burbidgeae* (P4); *Goodenia nuda* (P4); *Ptilotus mollis* (P4); *Acacia* sp. indet. (potentially undescribed)	19 taxa: *Argemone ochroleuca*; *Bidens bipinnata*; *Cenchrus ciliaris*; *Cenchrus setiger*; *Chloris barbata*; *Chloris virgata*; *Citrullus lanatus*; *Cynodon dactylon*; *Digitaria ciliaris*; *Echinochloa colona*; *Flaveria trinervia*; *Malvastrum americanum*; *Solanum nigrum*; *Sonchus oleraceus*; *Trianthema portulacastrum*; *Tribulus terrestris*; *Vachellia farnesiana*

Project	Location	Study	Parameters of Survey	Number of Taxa	Vegetation	Significant Flora Taxa	Introduced Taxa
McPhee Creek Rail Project	13 km southwest of Study Area	Woodman Environmental (2014d) – Rail spur linking Eastern Corridor to a third party rail line	188 quadrats (May/June 2014)	364 taxa; 6 hybrids; 159 genera; 54 families	18 vegetation types; No TECs or PECs identified, three VTs considered of potential regional conservation significance (VT7, 8, 23)	*Cochlospermum macnamarae* (P1); *Rothia indica* subsp. *australis* (P3); *Eragrostis crateriformis* (P3); *Gymnanthera cunninghamii* (P3); *Heliotropium murinum* (P3); *Nicotiana umbratica* (P3); *Rostellularia adscendens* var. *latifolia* (P3); *Bulbostylis burbidgeae* (P4); *Rhynchosia bungarensis* (P4); *Abutilon* aff. *hannii* (Potentially undescribed)	*Aerva javanica*; *Argemone ochroleuca*; *Bidens bipinnata*; *Cenchrus ciliaris*; *Citrullus lanatus*; *Cynodon dactylon*; *Flaveria trinervia*; *Malvastrum americanum*; *Parkinsonia aculeata*; *Sonchus oleraceus*; *Vachellia farnesiana*
Miralga Creek Iron Ore Project	40 km north-west of Study Area	Woodman Environmental (2019b) - Sandtrax; Miralga West/Miralga Creek and two Stockyard locations	107 quadrats (May 2019)	380 taxa; 1 hybrid; 157 genera; 54 families	12 vegetation types; No TECs or PECs identified, four VTs considered of potential regional conservation significance (VT 2, 6, 9, 11)	18 taxa: *Corchorus* sp. Yarrie (J. Bull & D. Roberts CAL 01.05) (P1); *Euphorbia inappendiculata* var. *inappendiculata* (P2); *Eragrostis crateriformis* (P3); *Euphorbia clementii* (P3); *Dolichocarpa* sp. Hamersley Station (A.A. Mitchell PRP 1479) (P3); *Triodia basitricha* (P3); *Triodia chichesterensis* (P3); *Goodenia nuda* (P4); *Abutilon aff. hannii* (Potentially undescribed); *Polymeria* sp (Potentially undescribed)	20 taxa: *Aerva javanica*; *Argemone ochroleuca*; *Calotropis procera*; *Cenchrus ciliaris*; *Cenchrus setiger*; ?*Chenopodium* sp.; *Chloris virgata*; *Citrullus colocynthis*; *Cynodon dactylon*; *Cyperus rotundus*; *Echinochloa colona*; *Flaveria trinervia*; *Malvastrum americanum*; *Passiflora foetida* var. *hispida*; *Portulaca pilosa*; *Setaria verticillata*; *Solanum nigrum*; *Stylosanthes hamata*; *Tribulus terrestris*; *Vachellia farnesiana.*

2.7 Overview of Significant and Introduced Flora Taxa

2.7.1 Significant Flora

A list of significant flora taxa that are known from within or in the vicinity of the Study Area is presented in Table 5, along with their current DBCA-classified Priority Flora rankings (where applicable) and habitat (Western Australian Herbarium 1998-). This list has been compiled from the results of updated searches of DBCA's databases (Table 3; DBCA 2020b), and from historical local flora surveys undertaken in the vicinity of the Study Area (Table 4).

A total of 30 significant taxa are known from within or in the vicinity of the Study Area, including DBCA-classified Priority Flora taxa and potentially undescribed taxa. Of these, only *Acacia levata* (P3) has previously been recorded within the Study Area with 10 locations returned from the database search (DBCA 2020b).

Table 5: Significant Flora Taxa known from within or in the Vicinity of the Study Area

Taxon	Status	Description	Source
Abutilon aff. *hannii*	Potentially Undescribed	Shrub. Rocky drainage lines	Other
Acacia aphanoclada	P1	Slender, wispy shrub, 1.7–5 m high. Skeletal stony soils. Rocky hills, ridges & rises	TPFL; WA Herb.; NatureMap Other
Acacia cyperophylla var. *omearana*	P1	Tree, 4–10 m high, 'minni-ritchi' bark. Stony & gritty alluvium. Along drainage lines	WA Herb Other
Acacia fecunda	P3	Erect, obconic shrub, to 3 m, Quartzite gibbers over grey-red skeletal soil. Along shallow creeks and drainage lines, hills, road verges	TP List
Acacia glaucocaesia	P3	Dense, glabrous shrub or tree, 1.8-6 m high. Red loam, sandy loam, clay. Floodplains	TPFL; WA Herb.; Other
Acacia leeuweniana	P1	Narrow, obconic tree, to 14 m high, bark 'minni-ritchi'. Inflorescence in spikes. Gritty, skeletal red-grey sandy loam, light orange-brown gravelly sand, granite. In rock fissures in outcrops, among boulders	TPFL; WA Herb.; NatureMap
Acacia levata	P3	Spreading shrub to 3 m high. Granite outcrops and hill slopes	TPFL; WA Herb.; NatureMap Other
Acacia sp. indet.	Potentially Undescribed	Spreading to erect shrub to 0.5 m high. Flats	Other
Acacia sp. Marble Bar (J.G. & M.H. Simmons 3499)	P1	Shrub, inflorescence in spikes, to 30mm long	WA Herb; NatureMap
Acacia sp. Nullagine (B.R. Maslin 4955)	P1	Erect, spindly shrub, to 3 m high, bark 'minni-ritchi', grey above, red underneath. Rocky clay. Low-lying areas between rocky hills	WA Herb.; Other
Bulbostylis burbidgeae	P4	Tufted, erect to spreading annual, grass-like or herb (sedge), 0.03-0.25 m high. Granitic soils. Granite outcrops, cliff bases	WA Herb.; NatureMap Other
Cochlospermum macnamarae	P1	Spreading, multi-stemmed shrub to 2 m high. Granite outcrops	WA Herb.; NatureMap Other

Taxon	Status	Description	Source
Corchorus sp. Yarrie (J. Bull & D. Roberts CAL 01.05)	P1	Shrub to 0.7 m. Drainage lines on or near mesas	WA Herb
Eragrostis crateriformis	P3	Annual grass to 0.4 m high. Seasonally wet areas, flats	WA Herb.; NatureMap Other
Euphorbia clementii	P2	Erect herb to 0.6 m high. Stony undulating plains	Other
Gomphrena leptophylla	P3	Prostrate to erect, spreading annual herb to 0.15 m. Variety of habitats	WA Herb; NatureMap Other
Goodenia nuda	P4	Erect, perennial herb to 0.5 m high. Seasonally moist sites	WA Herb.; Other
Gymnanthera cunninghamii	P3	Erect shrub to 2 m high. Sandy soils in river and creek channels	WA Herb.; NatureMap Other
Heliotropium murinum	P3	Short-lived perennial, herb to 0.4 m high. Red sand. Plains, stony granitic plains	WA Herb; NatureMap Other
Heliotropium muticum	P1	Ascending to spreading perennial herb to 0.3 m high. Plains with sand and often granite	WA Herb .; Other
Nicotiana umbratica	P3	Erect annual or short-lived perennial herb to 0.7 m high. Granite outcrops and cliffs	WA Herb; NatureMap Other
Phyllanthus hebecarpus	P3	Erect, often dense shrub to 1.5 m high. Granite outcrops	WA Herb.; NatureMap Other
Quoya zonalis	T	Erect, woolly shrub to 1.2 m. Steep south-facing sandstone or ironstone slopes	TPFL; WA Herb.; DoEE, Other
Ptilotus mollis	P4	Compact, perennial shrub, to 0.5 m high, soft grey foliage. Stony hills and screes	WA Herb; NatureMap Other
Rhynchosia bungarensis	P4	Compact, prostrate shrub or climber to 0.5 m, resinous foliage. Outcrops, boulders	WA Herb; NatureMap Other
Rostellularia adscendens var. *latifolia*	P3	Herb or shrub to 0.3 m high. Creeks, rocky hills	WA Herb; NatureMap Other
Rothia indica subsp. *australis*	P3	Prostrate or spreading annual herb to 0.3 m high. Seasonally inundated sandy areas, flats	WA Herb.; NatureMap Other
Schoenus coultasii	P1	Tufted grass-like (sedge), 0.15 m high. Granite seepage area. Brown sandy loam.	WA Herb.; NatureMap
Stylidium weeliwolli	P3	Annual, herb, 0.1-0.25 m high. Gritty sand soil, sandy clay. Edge of watercourses.	WA Herb.; NatureMap
Triodia basitricha	P3	Hummock grass to 0.5 m high. Hills, floodplains and lower slope with red brown loam or brown clay loam with ironstone.	WA Herb.

*Note: Sources of records are:

- TPFL – DBCA Threatened and Priority Flora Database
- WA Herb. – WA Herbarium specimen database
- NatureMap – NatureMap Search (DBCA 2007-);
- Other – Historical local surveys listed in Table 4

2.7.2 Introduced Flora

An updated list of introduced flora taxa known from within or in the vicinity of the Study Area is displayed in Table 6, and has been compiled from WA Herbarium specimen data (DBCA 2007-), from the search of the DoE database (DoEE 2020a), and from historical local flora surveys (Table 4).

A total of 27 introduced taxa are known to occur within or in the vicinity of the Study Area. One Taxa (*Parkinsonia aculeata*) is Declared Pests under s22 (2) of the BAM Act and is also a Weed of National Significance (Australian Weeds Committee 2020). Eleven taxa are considered to be of high ecological impact by the Pilbara Region Weed Prioritisation Process (DBCA 2014). Appendix D provides descriptions of each rating from DBCA (2014).

Table 6: Introduced Flora Taxa Known to Occur Within or in the Vicinity of the Study Area

Taxon	Common Name	Comments
Aerva javanica	Kapok Bush	Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Aloe vera var. *officinalis*	Aloe	Not assessed (DBCA 2014)
Argemone ochroleuca subsp. *ochroleuca*	Mexican Poppy	Environmental impact rated as 'Unknown' in Western Australia (DBCA 2014)
Bidens bipinnata	Bipinnate Beggartick	Environmental impact rated as 'Unknown' in Western Australia (DBCA 2014)
Bidens subalternans var. simulans		Not assessed (DBCA 2014)
Cenchrus ciliaris	Buffel Grass	Federally recognized as being highly invasive and pose a significant threat to biodiversity Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Cenchrus setiger	Birdwood Grass	Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Chloris barbata	Purpletop Chloris	Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Chloris virgata	Feathertop Rhodes Grass	Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Citrullus colocynthis	Colocynth	Environmental impact rated as 'Unknown' in Western Australia (DBCA 2014)
Citrullus lanatus	Pie Melon	Environmental impact rated as 'Unknown' in Western Australia (DBCA 2014)
Cynodon dactylon	Couch	Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Digitaria ciliaris	Summer Grass	Environmental impact rated as 'Unknown' in Western Australia (DBCA 2014)
Echinochloa colona	Awnless Barnyard Grass	Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Flaveria trinervia	Speedy Weed	Not assessed (DBCA 2014)
Leucaena leucocephala	Leucaena	Not assessed (DBCA 2014)
Malvastrum americanum	Spiked Malvastrum	Environmental impact rated as 'High' in Western Australia (DBCA 2014)

Taxon	Common Name	Comments
Parkinsonia aculeata	Parkinsonia	Weed of National Significance (Australian Weeds Committee 2020); Declared Pest in Western Australia (Department of Agriculture and Food 2020); Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Physalis angulata	Wild Gooseberry	Environmental impact rated as 'Unknown' in Western Australia (DBCA 2014)
Portulaca pilosa	Djanggara	Not assessed (DBCA 2014) – changed status from native to weed in 2015
Ricinus communis	Castor Oil Plant	Not assessed (DBCA 2014)
Setaria verticillata	Whorled Pigeon Grass	Environmental impact rated as 'High' in Western Australia (DBCA 2014)
Solanum nigrum	Black Berry Nightshade	Environmental impact rated as 'Low' in Western Australia (DBCA 2014)
Sonchus oleraceus	Common Sowthistle	Environmental impact rated as 'Low' in Western Australia (DBCA 2014)
Trianthema portulacastrum	Giant Pigweed	Not assessed (DBCA 2014)
Tribulus terrestris	Caltrop	Environmental impact rated as 'Unknown' in Western Australia (DBCA 2014)
Vachellia farnesiana	Mimosa Bush	Environmental impact rated as 'High' in Western Australia (DBCA 2014)

3 METHODS

3.1 Personnel and Licensing

Table 7 lists the personnel involved in both fieldwork and plant identifications for the survey of the Study Area. Field team leaders of all surveys have had previous field experience in areas similar to the Study Area, including the nearby Atlas McPhee Creek Haul Road and McPhee Creek Rail Spur Projects, with personnel involved in plant identifications having several years of taxonomic experience with the flora of the Pilbara region.

All plant material was collected under the scientific licences pursuant to the *Wildlife Conservation Act 1950* Section 23C and Section 23F (2014-2016 surveys) and Regulation 62 of *Biodiversity Conservation Regulations 2018* (2020 targeted survey) as listed in Table 7.

Table 7: Personnel and Licensing Information

Personnel	Role	Qualifications	Flora Collecting Permit (WC Act)
David Coultas	Project manager 2014; Fieldwork (team leader) 2014/2016 surveys; Plant identifications	BSc (Environmental Biology) (Hons)	2014: SL010958 (Section 23C) 106-1314 (Section 23F) 2016: SL011774 (Section 23C) 121-1516 (Section 23F)
Bethea Loudon	Project manager 2016; Fieldwork (team leader) 2014/2016 surveys; Plant identifications; Reporting	BSc (Biology)	2014: SL010956 (Section 23C) 108-1314 (Section 23F) 2016: SL011773 (Section 23C) 123-1516 (Section 23F)
John Grantham	Fieldwork 2014 survey	BSc (Environmental Restoration/Conservation Biology)	2014: SL010961 (Section 23C) 109-1314 (Section 23F)
Samuel Coultas	Fieldwork 2014/2016 surveys	BSc (Environmental Biology)	2014: SL010963 (Section 23C) 111-1314 (Section 23F) 2016: SL011775 (Section 23C) 124-1516 (Section 23F)
Emalyn Loudon	Fieldwork 2016 survey	BAgrib (Agriculture) (Hons)	-
Marco Pratissoli	Project manager 2020; Fieldwork (team leader) 2020	BSc (Plants Biotechnology); Post Grad Dip (Environmental Biology)	2020: FB62000057 143-1920
Jaroslav Hruban	Fieldwork 2020 survey	MSc (Ecological and Evolutionary Biology)	2020: FB62000251

3.2 Aerial Photography Interpretation

Prior to surveys conducted in 2014 and 2016, initial interpretation of ortho-rectified aerial photography at a scale of 1:10,000 was conducted to determine preliminary vegetation patterns present within the Study Area, with quadrats allocated based on these patterns. A minimum of three quadrats were allocated to each discernible vegetation pattern where possible; such replication is required for meaningful results to be produced following floristic analysis of quadrat data, and to provide local context for VT distribution.

3.3 Field Survey Methods – 2014 and 2016

The field survey was conducted over two visits in Autumn 2014, from the 31st March – 9th April, and from the 30th April – 9th May; and over one visit in Autumn 2016 from 2nd – 13th May. These visits were conducted 6-8 weeks after significant Summer rainfall in 2014 and reasonable rainfall in 2016. This is considered to be the most appropriate time to survey in the Pilbara Bioregion, as the majority of taxa in the Pilbara are likely to flower following significant rainfall. However, March of both survey years recorded significantly less rain than the long term average indicating that flowering periods had the potential to be shortened without rain events in April.

Access to the Study Area was achieved on foot and by vehicle using existing vehicle and exploration tracks. However, large parts of the Study Area were not accessible by vehicle, necessitating access by foot only.

A total of 357 non-permanent flora survey quadrats were established during the surveys. All quadrats covered an area of 2500 m^2, and generally measured 50 m by 50 m, however in narrow vegetation patterns such as those associated with drainage lines, quadrats measured 100 m by 25 m. This quadrat size corresponds to that used during the DPaW (now listed as Department of Biodiversity, Conservation and Attractions) Pilbara Biodiversity Survey (McKenzie *et al.* 2009), and is the standard size used in Pilbara flora and vegetation surveys. At least 3 quadrats were surveyed within each vegetation pattern initially identified from aerial photography interpretation. The quadrats were orientated north-south/east-west where possible, with the bearings of each side recorded for any quadrats that could not be established in this fashion.

All vascular flora taxa that were visually identifiable within each quadrat were recorded. At least one reference specimen of most taxa (excluding common, distinctive taxa) encountered was collected for verification and identification purposes.

The following information was recorded at each quadrat:

- Personnel;
- Unique quadrat number;
- Date of survey;
- GPS (Global Positioning System) coordinates (GDA (Geocentric Datum of Australia) 94);
- Site photograph;
- Topography (including landform type and aspect);
- Soil colour and type (including the presence of any rock outcropping and surface stones);
- Vegetation condition (adapted from Keighery (1994) for the Pilbara Biological Survey (McKenzie *et al.* (2009), presented in Appendix E);
- Approximate time since fire;
- Presence of disturbance (if any);
- Percentage foliage cover (for each taxon); and
- Height (m) (for each taxon, excluding climbers/aerial shrubs).

Additional flora taxa were also recorded opportunistically in the Study Area via a search in the general vicinity of each quadrat, and during traverses on foot between quadrats.

Mapping notes of vegetation pattern boundaries and distribution were also taken while traversing on foot and by vehicle. This was to aid in mapping polygons of vegetation patterns that were not allocated quadrats. Not all vegetation pattern polygons received quadrats because of time constraints, however many polygons could be confidently allocated to a final VT using a combination of mapping notes and aerial photograph interpretation.

Specific, targeted searching for significant flora taxa in the Study Area was not undertaken as part of the 2014 survey, however searching while traversing to and between quadrats was undertaken. In 2016, targeted searching via transects with personnel spread approximately 20-50 m apart, was conducted in footprint areas where significant (Priority listed) were recorded to determine population extent and plant numbers for future impact assessment. Where populations of known significant flora taxa were identified, a representative collection of material was made, and the abundance and spatial distribution (using hand held Garmin GPS coordinates) of individuals within each population was recorded where possible. All areas traversed in the Study Area are presented as track logs on Figure 4.

Any locations of introduced flora taxa identified in the Study Area while traversing to and between quadrats were treated using the same methods as used for locations of significant flora taxa.

3.4 Field Survey Methods - 2020

Targeted searching for significant flora taxa within the Stage 2 Development Envelope was conducted in 2020 to determine the presence and the extent of conservation significant flora taxa populations within the Stage 2 Development Envelope. Flora taxa that were targeted for survey were based on the updated desktop assessment presented in Section 2.7.1, as well as review of the known locations of significant flora within the Stage 2 Development Envelope, or where VTs providing preferred habitat for significant flora taxa were present in the Stage 2 Development Envelope.

The whole of the Stage 2 Development Envelope was searched with transects spaced approximately 100 m apart. Numbers of individuals and location were recorded for each significant flora taxa encountered. Track logs of the search conducted within the Stage 2 Development Envelope are presented on Figure 4.

Ground truthing of the vegetation types included within the Stage 2 Development Envelope was also conducted whilst searching to confirm the results of the 2014 and 2016 surveys. Where discrepancies were found in the determination of the VT boundaries field observation were recorded and used to modify the original mapping. Particular attention was given to potential Groundwater Dependant Vegetation (GDV) with all gullies, creeks and gorges walked and searched for GDV indicator taxa.

775000 780000 785000 790000

7665000 7660000 7655000 7650000 7645000 7640000

CE-187 CE-188 CE-002 CE-003 CE-004 CE-005 CE-011 CE-190 CE-323 CE-322 CE-189 CE-006 CE-008 CE-324 CE-317 CE-320 CE-319 CE-321 CE-015 CE-017 CE-018 CE-019 CE-316 CE-024 CE-315 CE-186 CE-029 CE-026 CE-027 CE-030 CE-198 CE-028 CE-025 CE-193 CE-313 CE-314 CE-023 CE-197 CE-194 CE-196 CE-195 CE-021 CE-020 CE-192 CE-185 CE-034 CE-035 CE-191 CE-184 CE-033 CE-032 CE-312 CE-311 CE-310 CE-036 CE-044 CE-038 CE-039 CE-037 CE-043 CE-047 CE-042 CE-045 CE-309 CE-040 CE-041 CE-182 CE-307 CE-183 CE-178 CE-308 306b CE-051 CE-049 CE-048 CE-050 CE-063 CE-068 054 CE-053 CE-052

Legend

- Study Area
- Quadrats (WEC 2014, 2016)
- Track Logs (2016)

775000 780000 785000 790000

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report Atlas20-14-01.

N

Sanjiv Ridge
Survey Quadrats and Track Logs

Revision: A - 22 January 2021 Scale: 1:75,000 (A3)

Author: Marco Pratissoli

WEC Ref: Atlas20-14-01

Filename: Atlas20-14-01-f04

Projection: GDA 1994 MGA Zone 50

Figure

4.1

765000 770000 775000 780000

7635000 7630000 7625000 7620000 7615000

CE-064 CE-065 CE-066 CE-055 CE-057 CE-069 CE-059 CE-179 CE-058 CE-071 CE-180 CE-060 CE-073 CE-075 CE-072 CE-074 CE-100 CE-076 CE-079 CE-304 CE-090 CE-077 CE-078 CE-062 CE-305 CE-303 CE-080 CE-081 CE-094 CE-096 CE-082 CE-177 CE-099 CE-098 CE-174 CE-175 CE-084 CE-170 CE-172 CE-173 CE-171 CE-165 CE-110 CE-087 CE-302 CE-108 CE-109 CE-104 CE-107 CE-105 CE-125 CE-127 CE-128 CE-126 CE-118 CE-119 CE-120 CE-130 CE-132 CE-121 CE-129 CE-131 CE-133 CE-122 CE-134 CE-123 CE-136 CE-135 CE-137 CE-152 CE-151 CE-138 CE-164 CE-153 CE-139 CE-154 CE-141 CE-156 CE-155 CE-144 CE-158 CE-157 CE-146 CE-147 CE-160 CE-148 CE-149 CE-163

CD007 CD008 CD010 CD011 CD009 CD013 CD017 CD022 CD020 CD021 CD025 CD016 CD012 CD015 CD027 CD006 CD018 CD307 CD019 CD002 CD024 CD035 CD014 CD311 CD306 CD023 CD039 CD301 CD028 CD040 CD004 CD201 CD042 CD312 CD001 CD041 CD032 CD059 CD073 CD074 Cd038 CD053 CD061 CD054 CD036 CD046 CD060 CD062 CD045 CD183 CD079 CD080 CD083 CD082 CD063 CD050 CD087 CD052 CD068 CD047 CD048 CD049 CD200 CD251 CD055 CD084 CD065 CD057 CD058 CD077 CD051 CD056 CD076 CD075 CD069 CD070 CD086 CD090 CD102 CD108 CD091 CD088 CD085 CD089 CD092 CD204 CD118 CD098 CD109 CD104 CD112 CD111 CD115 CD305 CD107 CD117 CD116 CD099 CD129 CD119 CD131 CD130 CD126 CD134 CD120 CD132 CD303 CD137 CD133 CD123 CD138 CD135 CD121 CD304 CD136 CD142 CD253 CD140 CD139 CD302 CD143 CD122 CD152 CD147 CD150 CD149 CD148 CD162 CD156 CD165 CD254 CD159 CD164 CD158 CD180 CD166 CD160 CD203 CD252 CD161 CD167 CD168 CD163 CD157 CD177 CD172 CD174 CD173 CD169 CD176 CD171 CD202 CD182 CD407 CD308 CD310 CD309 CD181

Legend

- Study Area
- Stage 2 Development Envelope
- Quadrats (WEC 2014, 2016)
- Track Logs (2014)
- Track Logs (2016)

WOODMAN ENVIRONMENTAL

N

This map should only be used in conjunction with WEC report Atlas20-14-01.

Sanjiv Ridge
Survey Quadrats and Track Logs

Revision: A - 22 January 2021 Scale: 1:75,000 (A3)

Author: Marco Pratissoli

WEC Ref: Atlas20-14-01

Filename: Atlas20-14-01-f04

Projection: GDA 1994 MGA Zone 50

Figure

4.2

774000 776000 778000

7632000

7630000

7628000

CD027
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CD074
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CD061
CD060
CD062
CD083
CD082
CD068
CD065

Legend

- Study Area
- Stage 1 Development Envelope
- Stage 2 Development Envelope
- Quadrats (WEC 2014, 2016)
- Track Logs (2020)
- Track Logs (2014)

WOODMAN ENVIRONMENTAL

N

This map should only be used in conjunction with WEC report Atlas20-14-01.

Sanjiv Ridge
Survey Quadrats and Track Logs

Revision: A - 22 January 2021 Scale: 1:17,000 (A3)

Author: Marco Pratissoli

WEC Ref: Atlas20-14-01

Filename: Atlas20-14-01-f04-3

Projection: GDA 1994 MGA Zone 50

Figure

4.3

3.5 Plant Collection and Identification

Specimens of any unknown taxa that were collected were pressed for later identification at the WA Herbarium. Identifications were undertaken by experienced botanists Bethea Loudon and David Coultas. External experts of particular families or genera were consulted for any specimens considered to be difficult to identify or of taxonomic interest.

Taxon nomenclature generally follows *FloraBase* (Western Australian Herbarium 1998 -) with all names checked against the current DBCA Max database to ensure their validity. However, in cases where names of plant taxa have been published recently in scientific literature but have not been adopted on *FloraBase* (Western Australian Herbarium 1998 -), nomenclature in the published literature is followed. The conservation status of each taxon was checked against *FloraBase*, which provides the most up-to-date information regarding the conservation status of flora taxa in Western Australia.

Specimens of interest, including significant flora taxa, range extensions of taxa and potential new taxa, will be sent to the WA Herbarium for consideration for vouchering as soon as practicable. However, this process is via donation, and the WA Herbarium may not voucher all specimens, in accordance with its own requirements. The specimen vouchering will be supported by completed Threatened and Priority Flora Report Forms submitted to DBCA (Species and Communities Branch) in the case of listed significant flora (e.g. Threatened and Priority flora taxa).

3.6 Floristic Analysis

Classification analysis of quadrat floristic data to define VTs was conducted using quadrats from the Study Area incorporating data collection in 2014 and 2016. The resultant VTs were compared to those presented in Woodman Environmental 2014a for consistency and to clarify regional significance of mapped VTs.

Classification analysis of quadrat floristic data to determine the regional significance of VTs was conducted using quadrats from both the Study Area and several other Atlas studies conducted in the vicinity of the Study Area. This approach produced a single VT dataset across these studies, and provides a level of regional context when assessing the distribution and conservation significance of VTs. The classification analysis was conducted on a taxon and quadrat data matrix compiled from quadrat data, utilising a total of 1119 quadrats and 640 perennial vascular taxa from the following studies:

- 108 quadrats from the Mount Webber Direct Shipping Ore Project (Woodman Environmental 2012c, 2013a);
- 164 quadrats from the McPhee Creek Iron Ore Project (Woodman Environmental 2013b, 2014b);
- 302 quadrats from the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c);
- 188 quadrats from the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d); and
- 357 quadrats established in the Study Area as part of this study.

The locations of these studies are shown on Figure 1.

Taxa belonging to several categories were removed prior to analysis, as listed below:

- Ephemeral taxa – the presence of ephemeral taxa is strongly influenced by seasonal conditions, with fewer taxa and individuals usually present following below-average rainfall. As the taxon data matrix was compiled from quadrats surveyed over several years with differing seasonal conditions, ephemeral taxa were excluded to remove variation associated with this factor;
- Introduced taxa – introduced taxa were excluded as their distributions are generally defined by the presence of disturbance (e.g. clearing, animal movement) rather than particular habitat types;
- Singletons (taxa recorded only once in the quadrat dataset) – singletons were removed as they provide little information in datasets;
- Known and putative hybrids – hybrids were removed as they are generally present as isolated individuals and at scattered locations only, and as they are generally of unknown or presumed origin;
- Taxa where identification was unclear – such taxa were removed from the analysis where identification was unclear due to poor available material in the field;
- Taxa present in recently burnt areas only – a number of quadrats across most of the studies utilised for the floristic analysis had been recently burnt, including many in the Study Area that were noted as being burnt within the last year. Fire in the Pilbara region results in prolific germination of many taxa, with a large proportion of these being ephemeral taxa (Woodman Environmental field observations). There are also a number of short-lived perennial taxa that also germinate prolifically following fire in the Pilbara region that were recorded in recently burnt quadrats, but were completely absent (or almost so) from unburnt quadrats. To attempt to mitigate variation in taxon composition as a result of fire history, such taxa were also removed from the analysis. These include taxa such as *Heliotropium skeleton, Crotalaria novae-hollandiae*, *Trichodesma zeylanicum* and several *Cullen* species; and
- Taxa with ephemeral above-ground parts only – a number of perennial taxa that produce ephemeral above-ground parts which senesce when conditions are unfavourable were also removed from the analysis. Such taxa, while easily identifiable at some sites when conditions were favourable, could not be confidently identified at all sites because such material was absent or in poor condition. Taxa in this category included rhizomatous taxa such as *Cheilanthes* and *Fimbristylis* species, and taxa with woody rootstocks such as *Ptilotus nobilis* subsp. *nobilis* and *Zornia albiflora*.

Some perennial taxa and infra-taxa were also amalgamated where taxonomy was unclear or could not be determined in all cases, such as *Grevillea wickhamii* variants. All taxa omitted and amalgamated from the floristic analysis (other than ephemerals, hybrids or singletons) are presented in Appendix F.

Initially, an OptimClass analysis was undertaken to determine the most suitable approach to classification based on the available data. OptimClass (Tichý *et al.* 2010) evaluates the quality of a set of different partitions of the same dataset, based on the number of taxa that are faithful to clusters of that partition. Faithful taxa are identified using the Fisher's exact test for the right-tailed hypothesis, which is a suitable measure of statistical fidelity of taxa to clusters of quadrats (Sokal & Rohlf 1995; Chytrý et al. 2002).

For the OptimClass analysis a selection of the most widely-used techniques in community ecology were tested, including Unweighted Pair-Group Method using Arithmetic Averages (UPGMA), Beta Flexible Clustering and Ward's Method in combination with a Bray-Curtis Index, Similarity Ratio, Chord Distance and none or logarithmic and/or power transformations of species percentage foliage cover. The full list of combinations tested is shown in Appendix G. The cluster analyses used to calculate OptimClass values were performed using the software packages JUICE 7.0.123 (Tichý 2002) and PC-ORD 6.08 (McCune & Mefford 2011).

The OptimClass analysis influenced the selection of a classification analysis using a one-layer data matrix (presence/absence data only) with no transformation, with Beta Flexible Clustering ($\beta = 0.25$) as the clustering tool, and Bray-Curtis as the similarity ratio.

Classification analysis was conducted using the PATN (V3.12) package (Belbin & Collins 2009), with the results of the classification produced as a dendrogram. A taxon and quadrat matrix was produced, with the matrix sorted into taxon groups generated from the classification. Indicator taxon analysis (INDVAL) was conducted using PC-ORD (McCune & Mefford 2011) using the method of Dufrene & Legendre (1997). The INDVAL measures were used to determine the indicator taxa for each VT and a Monte Carlo permutation test was used to test for the significance of the indicator taxa. The Bray-Curtis coefficient was used to generate an association matrix for the classification analysis. This association matrix consisted of pairwise coefficients of similarities between quadrats based on floristic data. Agglomerative, hierarchical clustering, using flexible UPGMA (ß=-0.25), was used to generate a quadrat classification dendrogram (Sneath & Sokal 1973).

3.7 Vegetation Type Mapping and Description

OptimClass analysis of Study Area quadrat data identified approximately 13 quadrat clusters as the optimal number when applying the classification parameters outlined in Section 3.5. The classification dendrogram and taxon group matrix were initially examined at the 13-cluster level, to determine the plausibility of clusters.

Quadrats within each group were manually compared to determine the level in the dendrogram at which to delineate VTs. The manual comparison was also utilised to identify any quadrats that had been misclassified by the analysis. Such misclassification of quadrats has occurred in previous floristic analyses conducted by Woodman Environmental, with higher numbers of quadrats deemed misclassified in previous floristic analyses of Pilbara region quadrat datasets (e.g. Woodman Environmental 2014c) compared to floristic analyses of quadrat datasets from areas outside the Pilbara region, including the Coolgardie and Geraldton Sandplains regions (e.g. Woodman Environmental 2013d, 2014e). A number of factors potentially contribute to quadrat misclassification, including disturbance history (fire or grazing – both particularly common factors in the Pilbara bioregion), situation of quadrats in ecotones (the transition zone between VTs), misidentification of taxa during survey (most often because of poor available material), naturally low taxon richness, and the relatively homogenous species composition of vegetation in the Pilbara region across widely differing soil, substrate and topographical types (Woodman Environmental field observations). This process determined a final number of clusters that were considered to represent VTs.

Manual comparison of quadrats in the floristic analysis identified a number of apparently misclassified quadrats within the dendrogram following the investigation of their soil, topography and taxon composition. This appeared to be most often related to the situation of quadrats in ecotones or where species richness was very low reducing the ability of the analysis to place them properly. These misclassified quadrats were investigated to determine their relationships to other groups in the dendrogram, based primarily on dominant taxon composition, and to a lesser extent soil, substrate and topographical type, and were then reassigned to the most appropriate group. This process is subjective, relying on knowledge of the Study Area and its species composition, landforms and disturbance history, and also a general knowledge of vegetation patterns in the Pilbara region. A list of all quadrats manually reassigned, and the reasoning for the reassignment, is presented in Appendix H.

VT descriptions have been adapted from the National Vegetation Information System (NVIS) Australian Vegetation Attribute Manual Version 6.0 (Executive Steering Committee for Australian Vegetation Information (ESCAVI) 2003). This model follows nationally-agreed guidelines to describe and represent VTs, so that comparable and consistent data is produced nation-wide. It must be noted that the NVIS system utilises vegetation descriptions derived from structural characteristics of the individual community units, while the VTs presented in this report have been derived from analysis of site floristics, excluding any structural component. VTs therefore may include multiple structural types. Considering the effect of disturbance factors such as fire on vegetation structure, this approach is designed to provide a map of VTs that reflect taxon composition and the influences of the physical and chemical environment rather than disturbance history.

For the purposes of this report, it is considered that a VT is equivalent to a NVIS sub-association as described in ESCAVI (2003). Common taxa within each stratum were generally defined as taxa that occurred in greater than one-third of quadrats established within a particular VT (however this varied slightly depending on the number of quadrats); these may include taxa not in the VT description, as the VT description is based on dominance within each stratum, as well as the frequency that a taxon was recorded within each VT.

The locations of quadrats within each VT were used in conjunction with aerial photography interpretation and field notes taken during survey to develop VT mapping polygon boundaries. These VT mapping polygon boundaries were then digitised using Geographic Information System (GIS) software.

The VT polygons have been modified and updated where necessary in the Stage 2 Development Envelope after review of the mapping undertaken in the field in 2020. No further quadrat data however was collected during the 2020 surveys.

3.8 Vegetation Condition Mapping

Vegetation condition was recorded at all quadrats, and also opportunistically within the Study Area where areas of disturbance to vegetation were noted (e.g. weed infestations, areas of heavy grazing, mineral exploration). Vegetation condition was described using a vegetation condition scale adapted from Keighery (1994) that was utilised by DPaW during the Pilbara Biodiversity Survey (McKenzie *et al.* 2009), and is presented in Appendix E.

Vegetation condition polygon boundaries for the Study Area were developed using this information in conjunction with aerial photography interpretation, and were digitised as for VT polygon boundaries.

3.9 Significant Flora and Vegetation

EPA Technical Guidance (EPA 2016) considers that any taxon listed as Threatened under relevant legislation (BC Act, EPBC Act), or classified by DBCA as Priority flora, is considered to be significant. Such taxa are therefore addressed in this report. Technical Guidance (EPA 2016) also notes that a flora taxon may also be considered as significant if it meets one of the following criteria:

- locally endemic or association with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems)
- new species or anomalous features that indicate a potential new species
- representative of the range of a species (particularly, at the extremes of range recently discovered range extensions, or isolated outliers of the main range)
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

It is considered that the criterion of level of reservation (i.e. presence in conservation reserves such as national parks or nature reserves) is difficult to apply in the context of this report, as the Pilbara region is both relatively poorly-surveyed and poorly-reserved, and it is therefore not possible to accurately determine the reservation status of a particular taxon. However, level of reservation may be relevant in the context of addressing the significance of a taxon that meets one of the other criteria listed above, particularly listed Threatened or Priority flora taxa, as taxa meeting these criteria may be of higher significance if they are not or are poorly reserved.

Significant taxa are discussed in Section 5.2.

No classification of the potential local significance of locations of significant flora taxa has been undertaken as part of this study, as has previously been undertaken by Woodman Environmental for other studies conducted for Atlas (e.g. Woodman Environmental 2014c). It is considered that such a classification is best undertaken as part of any overall impact assessment that may need to be undertaken for the Project, as significant flora data may change prior to such an impact assessment being conducted.

EPA Technical Guidance (EPA 2016) considers that vegetation listed as a TEC under the EPBC Act, or classified as a TEC or PEC by DBCA, is considered to be significant. Such vegetation is therefore addressed in this report. Technical Guidance (EPA 2016) also notes that vegetation may also be considered as significant if it meets one of the following criteria:

- restricted distribution
- degree of historical impact from threatening processes
- a role as a refuge
- providing an important function required to maintain ecological integrity of a significant ecosystem.

These criteria are generally applicable to VTs mapped in the Study Area and are therefore used to determine whether a VT is locally significant (with 'local' referring to the Study Area). It is more difficult to apply these criteria in a regional context, as there is no publicly-available Pilbara-wide dataset of VTs. However, the floristic analysis of quadrats from the Study Area and a number of other studies in the vicinity of the Study Area (see Section3.6) has produced a relatively geographically-widespread VT dataset that provides a reasonable level of context when considering the significance of VTs. These criteria are therefore applied to the VTs mapped in the Study Area in the context of this VT dataset, to determine potentially regionally significant VTs. Assessment of the significance of the VTs of the Study Area was undertaken in 2016; review of such assessment in 2020 was limited to the vegetation of the Stage 2 Development Envelope only. Significant vegetation is discussed in Section 6.4.

4 ADEQUACY AND LIMITATIONS OF SURVEY

4.1 Adequacy of Survey

The Study Area covers approximately 26,021.8 ha, with 357 quadrats established within it. Quadrats were established in all preliminary vegetation patterns discernable by initial aerial photograph interpretation (see Section 3.2 and 3.3), both to adequately sample variation in vegetation throughout the Study Area, and to ensure adequacy of sampling for vascular plant taxa. Historic discussion held with Dr. Stephen van Leeuwen of DPaW (now DBCA) indicated that a sampling intensity of one 50 m x 50 m quadrat per square kilometre provides an acceptable level of sampling to characterise vegetation assemblages in the Pilbara. This sampling intensity has also been adopted by other mining companies (for example, BHP Billiton) as their standard for flora and vegetation surveys for Environmental Impact Assessment in the Pilbara. Given the size of the Study Area, 260 quadrats are required to meet this ratio. The number of quadrats established in the Study Area exceeds this amount, and is therefore considered to be an acceptable number.

To provide an indication of the adequacy of this survey, a species accumulation curve was produced using PC-ORD (V6.08) (McCune and Mefford 2011). Species accumulation curves represent a theoretical model of the relationship between sampling intensity and species accumulation; when sampling intensity is increased, species accumulation is reduced, and a species accumulation curve becomes asymptotic.

The species accumulation curve for quadrat data from the Study Area was generated using all native taxa (both annual and perennial) recorded within each quadrat. Species accumulation calculations for the Study Area were then undertaken via PC-ORD, utilising the Chao-2

estimator for species richness (Chao 1987), and compared to the actual number of species recorded in the Study Area. This gives some indication as to whether sufficient quadrats have been surveyed to adequately sample the species richness in the Study Area. As the generation of species accumulation curves includes quadrat data only, and not opportunistically-recorded taxa, the indication of adequacy of survey provided is considered to be conservative.

Figure 5 presents the species accumulation curve generated from quadrat data from the Study Area. Using the Chao-2 estimator, the recorded number of taxa within quadrats is equivalent to 89.5 % of the estimated taxon richness in the Study Area. Sampling was therefore considered to be adequate using this estimation measure.

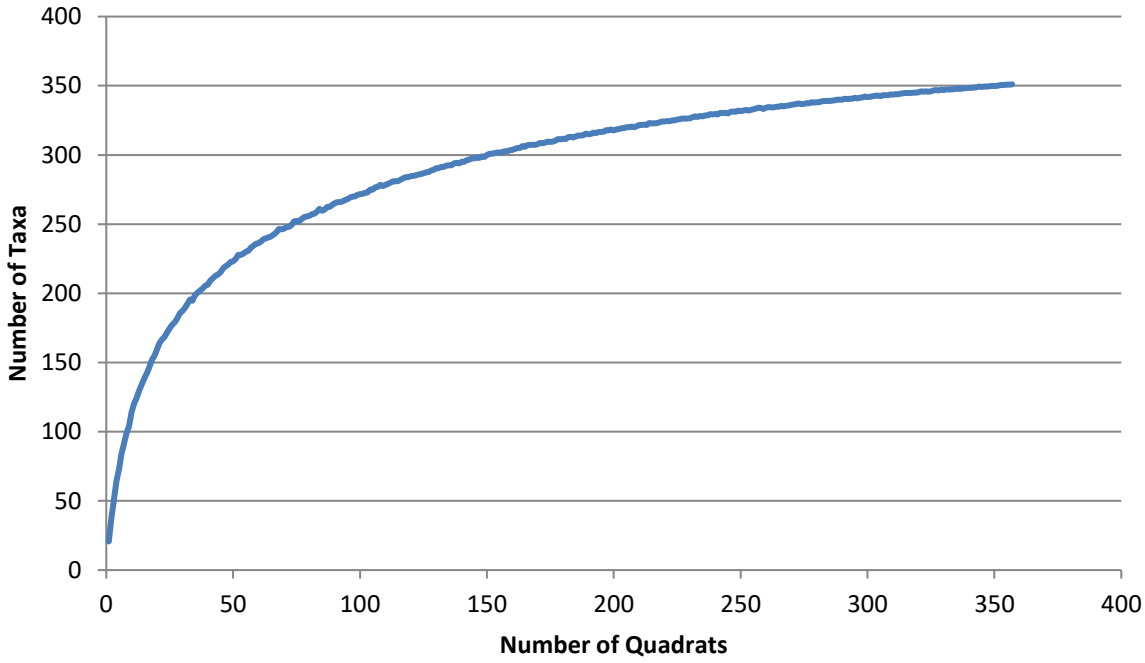

Figure 5: Study Area Species Accumulation Curve

It is of interest that the estimated number of taxa in the Study Area from quadrats only using Chao-2 was 392; when opportunistic records of taxa are included, 413 taxa were recorded in the Study Area (see Section 5.1), indicating that the Study Area was well-sampled.

Another adequacy of survey measure is that developed by Mueller-Dombois and Ellenberg (1974), who suggest that a cut-off point might be when a 10% increase in quadrats surveyed results in a 5% (or less) increase in taxa recorded. This measure was also calculated using all native taxa recorded within each quadrat. The number of quadrats established in the Study Area satisfies this adequacy measure suggested by Mueller-Dombois and Ellenberg (1974), with the final taxon increase value of 1.52 % recorded following a 10 % increase in quadrats.

4.2 Limitations of Survey

Table 8 presents the limitations of the flora and vegetation survey of the Study Area in accordance with EPA Technical Guidance (EPA 2016).

Table 8: Limitations of the Flora and Vegetation Survey of the Study Area

Limitation	Limitation of Survey	Comment
Level of survey	No	Level 2 Detailed Survey: The detailed field survey conducted in March and May 2014 and in May 2016, within the usual peak flowering season in the Pilbara region. Replicated quadrats were established in each vegetation pattern identified in the Study Area. EPA (2016) indicates that survey should also be undertaken in other seasons, and it is noted that some perennial taxa expected to occur in the Study Area flower in other seasons (e.g. Winter). However, it is considered that survey in the peak flowering season only is adequate in this case, as it considered likely that most taxa that flower outside the peak flowering season could be identified during the survey period. Although the surveys undertaken in 2014 and 2016 were undertaken as per the guidance presented in EPA (2004), the parameters of survey and statistical floristic assessment conform to those presented in EPA (2016). Targeted survey: Targeted flora survey conforming to the requirements of EPA (2016) was undertaken in the Stage 2 Development Envelope during 2020. During the targeted search conducted in 2020 all potentially suitable habitats were systematically searched for significant flora.
Competency/experience of the consultant(s) carrying out the survey	No	Senior personnel undertaking the survey have had experience in conducting similar assessments, including assessments in nearby areas in the Pilbara region such as the McPhee Creek Haul Road Project (Woodman Environmental 2014c). Senior personnel provided guidance to less experienced botanists throughout all surveys where necessary.
Scope (floral groups that were sampled; some sampling methods not able to be employed because of constraints?)	No	All vascular groups that were present during the detailed survey were sampled. No constraints prevented appropriate sampling techniques (quadrat establishment, foot transects) being employed during the 2014-2016 surveys. All significant flora taxa as per the updated desktop assessment were surveyed for in the Stage 2 Development Envelope (2020 surveys).
Proportion of flora identified, recorded and/or collected	Potential minor	A high proportion of perennial vascular taxa were recorded based on the intensity and method of survey (2014 and 2016 surveys). A high proportion of ephemeral vascular taxa were recorded based on the intensity and method of survey, and above-average rainfall prior to the 2014 survey. Although rainfall prior to the 2016 survey was lower than average, numerous ephemeral taxa were present and identifiable however the entire suite of taxa that may potentially have been present may not have been recorded in 2016 (see timing/weather/season/cycle below). Unknown vascular taxa were collected, with specimens identified at the WA Herbarium. Adequacy of survey measures indicate a high percentage (89.5%) of taxa expected to occur in the Study Area was recorded (Chao-2 estimator), and the number of quadrats established in the Study Area satisfies the criterion suggested by Mueller-Dombois and Ellenberg (1974), with an increase of 1.52 % in species recorded per increase of 10 % of quadrats.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data	No	Sources of information used included government databases (DBCA, DoEE) and several reports and unpublished data from the vicinity of the Study Area. Good contextual information for the Study Area was available prior to all surveys. DBCA database information was updated for the 2020 targeted flora survey.

Limitation	Limitation of Survey	Comment
The proportion of the task achieved and further work which might be needed	Potential minor	The detailed surveys completed in 2014 and 2016, with the surveys including some searching for significant flora taxa. However, searching for significant flora was not conducted within the Stage 2 Development Envelope. Targeted searching within the entire Stage 2 Development Envelope was completed in 2020.
Timing/weather/season/ cycle	Potential minor	The field survey was conducted in Autumn following significant Summer rainfall in 2014, corresponding with the optimum flowering period for the Pilbara region. The 2014 flowering period was considered by Woodman Environmental to be good, with above-average rainfall (477 mm compared to the average of 273.9 mm) (Bureau of Meteorology 2016) over the Summer 'wet season' (December 2013 – March 2014). The 2016 field survey was conducted in Autumn following lower than average rainfall (185 mm compared to the average of 243.8 mm) (Bureau of Meteorology 2016) over the Summer 'wet season' (December 2015 – March 2016) with no rainfall immediately prior to the survey in April. The 2016 flowering period was considered to be average by Woodman Environmental however the majority of taxa recorded were able to be identified in the absence of flowering or fruiting material. The 2020 targeted search was conducted in Autumn following significant Summer rainfall, corresponding with the optimum flowering period for the Pilbara region. The 2020 flowering period was considered by Woodman Environmental to be good, with above-average rainfall (358.4 mm compared to the average of 299.3 mm) (Bureau of Meteorology 2020)
Disturbances (e.g. fire, flood, accidental human intervention etc.), which affected results of survey	Potential minor	A significant proportion of the Study Area was burnt by an intense fire in October 2013 (Outback Ecology 2013). It is considered that the fire did not greatly affect the ability to identify vascular taxa in the Study Area, as above-average rainfall over the Summer 'wet season' in 2014 subsequent to the fire promoted significant growth of re-sprouting perennial taxa and germination and growth of non-sprouting taxa. It is likely that the final number of taxa recorded may be higher than if the Study Area was unburnt, as many taxa in the Pilbara appear to only germinate prolifically following fire (Woodman Environmental field observations). However, the fire has had a significant impact on the composition of vegetation in the Study Area, with post-fire coloniser taxa dominating burnt areas, but often absent from unburnt areas. This resulted in the approach to analysis of floristic data being altered, with taxa considered to be present only in recently burnt areas excluded from the analysis. The fire also affected mapping of VTs in some parts of the Study Area, with boundaries of VTs being difficult to determine both in the field and on aerial photography in some instances. Portions of the 2016 extension area had been very recently burnt by a very hot fire and experienced limited germination as a result of low rainfall post-fire. Proposed quadrats in these areas were not undertaken, instead field notes on soil, geology and taxa present were recorded in order to match the landform to a VT based on previous experience of the area (2014 survey). The remainder of the 2016 extension area and the entire Stage 2 Development Envelope had not been significantly affected by fire in recent years.
Intensity of survey	No	The survey intensity was considered adequate to identify floristic groupings of terrestrial flora as required by a detailed survey, with replication of quadrats in VTs and foot searching undertaken throughout the Study Area. The targeted flora search intensity was considered adequate to determine the extent of significant flora and vegetation throughout the Stage 2 Development Envelope.

Limitation	Limitation of Survey	Comment
Completeness and mapping reliability	Potential minor	The survey of the Study Area was considered complete in terms of mapping of VTs. Mapping reliability was considered good as high resolution aerial photography was used, with 357 quadrats established in the Study Area. Foot and vehicle transects were employed, however recent fire affected mapping reliability in some instances. Searching for significant flora taxa was undertaken in 2016, however this did not include targeted survey of all potential habitat for conservation significant flora and was restricted to potential mining areas. Targeted Survey of all potential habitat for conservation significant flora in the Stage 2 Development Envelope was conducted in 2020 with foot transects spaced approximately 100 m apart.
Resources and experience of personnel	No	Adequate resources including experienced field personnel and taxonomists with appropriate expertise in Pilbara region flora were utilised.
Remoteness and/or access problems	No	Access to the Study Area was considered adequate. Some parts were difficult to access on foot because of the distances from traversable vehicle tracks and the steep, hilly terrain, and therefore were surveyed less intensely than areas close to traversable vehicle tracks. However, remoteness or access issues are not considered to have affected the results of the survey. All of the Stage 2 Development Envelope was able to be accessed for survey in 2020.

5 RESULTS – FLORA OF THE STUDY AREA

5.1 Vascular Flora Census

A total of 413 discrete vascular flora taxa including one known hybrid (listed on *FloraBase* (Western Australian Herbarium 2020)) and one putative hybrid were recorded within the Study Area during surveys in 2014 - 2016. These taxa represent 63 families and 177 genera. The most well-represented families were Fabaceae (80 taxa, plus one known and one putative hybrid), Poaceae (62 taxa), Malvaceae (38 taxa), Cyperaceae (21 taxa), Amaranthaceae (20 taxa) and Asteraceae (17 taxa).

Average taxon richness per quadrat was 22.5 (± 12.8), with the greatest number of taxa recorded in a single quadrat being 75, and the lowest number being three. A full list of taxa recorded in the Study Area (including both quadrat data and opportunistic collections) is presented in Appendix I. Raw quadrat data, including species lists for each quadrat, is presented in Appendix R.

5.2 Significant Flora Taxa

A total of 16 significant flora taxa were recorded within the Study Area during the 2014 and 2016 surveys. Table 9 presents the list of significant flora taxa recorded in the Study Area, together with location information. Records displayed are from the surveys of the Study Area and the targeted search within the Stage 2 Development Envelope (labelled as 'WEC') as well as from DBCA's threatened flora databases (labelled as 'DBCA'). Locations of significant flora taxa from these surveys of the Study Area are presented in Appendix J, and also presented on an overview figure of the Study Area (Figure 6). Locations of significant flora taxa known from within and in the vicinity of the Study Area are also displayed in greater detail in Appendix K (Figures 6.0 – 6.44).

No conservation significant flora taxa were found to occur within the Stage 2 Development Envelope during the search conducted in 2020. One taxon of taxonomic interest (*Triumfetta* aff. *appendiculata*) was recorded at 22 different locations, for a total of 143 individuals within the Stage 2 Development Envelope during the 2020 targeted search.

5.2.1 Listed Significant Flora Taxa

No Threatened Flora taxa listed under the *Biodiversity Conservation Act 2016*, or Threatened Species listed under the EPBC Act, were recorded within the Study Area; 11 DBCA-classified Priority Flora taxa were recorded within the Study Area during 2014 - 2016, being:

- *Cochlospermum macnamarae* (P1);
- *Schoenus coultasii* (P1);
- *Acacia levata* (P3);
- *Eragrostis crateriformis* (P3);
- *Heliotropium murinum* (P3);
- *Nicotiana umbratica* (P3);
- *Rostellularia adscendens* var. *latifolia* (P3);
- *Rothia indica* subsp. *australis* (P3);
- *Stylidium weeliwolli* (P3);

- *Swainsona thompsoniana* (P3); and
- *Ptilotus mollis* (P4).

These taxa are discussed further below.

Table 9: Summary of Significant Flora Taxa Known from within the Study Area

Taxon	Conservation Code	Total Number of Locations Recorded in Study Area (WEC 2014-2016)	Total Number of Locations Recorded in Stage 2 Development Envelope (WEC 2020)	Total Number of Individuals Recorded in Study Area (WEC 2014-2016)	Total Number of Individuals Recorded in Stage 2 Development Envelope (WEC 2020)	Vegetation Types	Record Source
Cochlospermum macnamarae	P1	8	0	154	0	2	WEC
Schoenus coultasii	P1	1	0	50	0	1	WEC
Acacia levata	P3	16*	0	245*	0	1, 10, 11, C	WEC; DBCA
Eragrostis crateriformis	P3	14	0	272	0	2, 5, 7	WEC
Heliotropium murinum	P3	3	0	3	0	4	WEC
Nicotiana umbratica	P3	2	0	115	0	3, 9	WEC
Rostellularia adscendens var. *latifolia*	P3	2	0	101	0	10, 15	WEC
Rothia indica subsp. *australis*	P3	13	0	255	0	2	WEC
Stylidium weeliwolli	P3	1	0	2	0	1	WEC
Swainsona thompsoniana	P3	3	0	3	0	6	WEC
Ptilotus mollis	P4	36	0	779	0	10, 11, 13, 14	WEC
Abutilon aff. *hannii*	Potentially undescribed	3	0	Not counted	0	14	WEC
Oldenlandia sp.	Potentially undescribed	1	0	1	0	15	WEC
Portulaca sp.	Potentially undescribed	1	0	Not counted	0	14	WEC
Acrostichum speciosum	Significantly Disjunct Record	1	0	3	0	3	WEC
Eriocaulon pusillum	Significantly Disjunct Record	1	0	10	0	1	WEC

*Note: number of locations includes six records of *A. levata* (P3) returned from DBCA database searches (DBCA 2020b); no counts of individuals are available, therefore assumed each location to represent '1' individual

765000 770000 775000 780000 785000 790000 795000

7655000 7650000 7645000 7640000 7635000 7630000 7625000 7620000 7615000

Legend

Study Area

Vegetation Types

1
2
3
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12
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14
15
C
NS

Significant Flora

Aah *Abutilon* aff. *hannii*
Acsp *Acrostichum* speciosum
Alev *Acacia levata* (P3)
Alev *Acacia levata* (P3) - DBCA Records
Cmac *Cochlospermum macnamarae* (P1)
Ecr *Eragrostis crateriformis* (P3)
Epus *Eriocaulon pusillum*
Hmur *Heliotropium murinum* (P3)
Num *Nicotiana umbratica* (P3)
Osp *Oldenlandia sp.*
Pmo *Ptilotus mollis* (P4)
Psp *Portulaca* sp.
Radl *Rostellularia adscendens* var. *latifolia* (P3)
Rin *Rothia indica* subsp. *australis* (P3)
SspM *Schoenus coultasii* (P1)
Swe *Stylidium weeliwolli* (P3)
Swt *Swainsona thompsoniana* (P3)
Taa *Triumfetta* aff. *appendiculata*

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report Atlas20-14-01.

N

Sanjiv Ridge
Vegetation Types and Significant Flora

Revision: A - 22 January 2021 Scale: 1:125,000 (A3)

Author: Marco Pratissoli
WEC Ref: Atlas20-14-01
Filename: Atlas20-14-01-f06-Overview
Projection: GDA 1994 MGA Zone 50

Figure
6

***Cochlospermum macnamarae* (P1)**

Cochlospermum macnamarae (P1) is a spreading, multi-stemmed seasonally deciduous shrub to 2 m high (Plate 1), occurring on granite outcrops, and until recently was only known from the type locality (Hislop *et al.* 2013). This taxon is endemic to Western Australia, occurring over a range of approximately 105 km, from southeast of the Study Area in the east to south of the intersection of the Great Northern Highway and Hillside-Woodstock Road in the west (Western Australian Herbarium 1998-). There are nine DBCA records of this taxon in Western Australia, representing four broad localities (groups of point records in close proximity). None of these localities occur in conservation reserves (Western Australian Herbarium 1998-). This taxon was previously recorded in the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c) and the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d).

Cochlospermum macnamarae (P1) was recorded at eight point locations during the surveys of the Study Area, with 154 individuals recorded (Table 9). All locations occur on granite outcrops in the south-west corner of the Study Area (Appendix K, Figure 6.40). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 1: *Cochlospermum macnamarae* (P1) (Photos: Woodman Environmental)

***Schoenus coultasii* (P1)**

Schoenus coultasii (P1) is an annual tufted grass-like sedge growing to 0.15 m high. This species was found to occur on a granite seepage area with brown sandy loam (Western Australian Herbarium 1998-).

A specimen collected within the Study Area in 2014 was identified by a specialist taxonomist at the WA Herbarium as being a new undescribed taxon; it has since been named *Schoenus coultasii*. As this record is the only known collection, this taxon is presently of conservation significance and has been listed as P1 (Western Australian Herbarium 1998-). It was recorded at a single point location during this survey of the Study Area, where approximately 50 individuals were noted (Table 9). The location is in a seepage area on the edge of granite outcropping (Appendix K, Figure 6.18). The area is in the central west section of the Study Area, the same location where *Stylidium weeliwolli* (P3) and *Eriocaulon pusillum* were

recorded. This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

***Acacia levata* (P3)**

Acacia levata (P3) is a spreading, multi-stemmed shrub to 3 m high (Plate 2), which occurs in sandy loam over granite on hill slopes and plains (Western Australian Herbarium 1998-, Woodman Environmental 2014d). This taxon is endemic to Western Australia, occurring over a range of approximately 135 km, from south of the southern boundary of Kangan Station in the west, to the north-west corner of Bonney Downs Station in the east (DBCA 2007-). There are 22 DPaW records of this taxon located in Western Australia which occur at nine broad localities across its range. None of these localities occur in conservation reserves (DBCA 2007-). This taxon was also recorded in the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c).

This taxon was recorded at 10 locations during the surveys within the Study Area, consisting of approximately 239 individuals (Table 9). An additional six locations are known from the Study Area (DBCA 2020b) (Appendix K; Sheet 6.18), bringing the total known locations in the Study Area to 16, consisting of a total of approximately 245 individuals. Three additional locations to the west of the Study Area were also recorded by Woodman Environmental while traversing to the Study Area, and a further single DBCA location is also known from the vicinity of the Study Area (Appendix K; Sheet 6.25)). All locations occur on undulating hills underlain by granite (or rarely metamorphosed granite) generally in the north-west corner of the Study Area (Appendix K, Figures 6.18 and 6.25). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

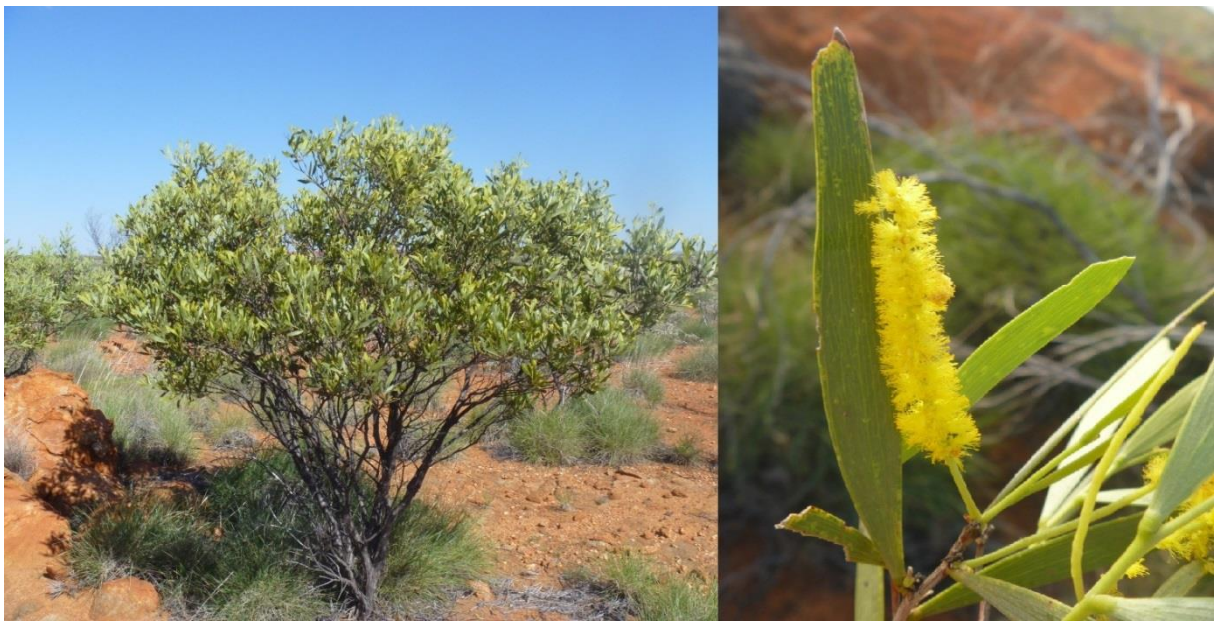

Plate 2: *Acacia levata* (P3) (Photos: Woodman Environmental)

***Eragrostis crateriformis* (P3)**

Eragrostis crateriformis (P3) is a delicate, ephemeral grass to 0.4 m high (Plate 3), which occurs on clay creek banks and in clay depressions (Western Australian Herbarium 1998-; Woodman Environmental 2014c). This taxon occurs over a range of approximately 1,370 km in Western Australia, from near Onslow in the west, to near Balgo Hills in the Tanami Desert

in the east (DBCA 2007-). It also occurs in the Northern Territory (Council of Heads of Australasian Herbaria 2016; DBCA 2007-). There are 49 DBCA records of this taxon (Western Australian Herbarium 1998-) in Western Australia. These records occur at 17 broad localities across its range in Western Australia. Two of these localities occur in Millstream-Chichester National Park and one locality occurs in the DBCA-managed ex-Meentheena Station (LR3129/890) (DBCA 2007-). This taxon was recorded in the McPhee Creek Iron Ore Project (Woodman Environmental 2013b, c), McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c) and the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d).

Eragrostis crateriformis (P3) was recorded at 13 point locations during the surveys of the Study Area, with approximately 260 individuals recorded (Table 9). The locations occur in clay depressions and minor drainage lines in the central section of the Study Area (Appendix K, Figures 6.16 and 6.23). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 3: *Eragrostis crateriformis* (P3) (Photos: Woodman Environmental)

***Heliotropium murinum* (P3)**

Heliotropium murinum (P3) is a perennial, herb to 0.4 m high (Plate 4), which generally occurs on red sand plains, sometimes with granite (Western Australian Herbarium 1998-; Woodman Environmental 2014c). This taxon is endemic to Western Australia, occurring over a range of approximately 150 km, from Woodstock Reserve in the west, to ex-Meentheena Station in the east (DBCA 2007-). There are 15 DBCA records of this taxon (DBCA 2020c) in Western Australia consisting of seven broad localities. One locality occurs in the DPaW-managed ex-Meentheena Station (LR3129/890). This taxon was also recorded in the Mt Webber DSO Project Area (Woodman Environmental 2012c), the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c) and the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d).

Heliotropium murinum was recorded at 3 point locations consisting of 3 plants (Table 9). The locations occur on plains in the central section of the Study Area (Appendix K, Figures 6.16). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 4: *Heliotropium murinum* (P3) (Photos: Woodman Environmental)

***Nicotiana umbratica* (P3)**

Nicotiana umbratica (P3) is an erect, aromatic, short-lived perennial or ephemeral herb to 0.7 m high (Plate 5), which occurs in shaded sites such as under boulders or cliffs on granite outcrops and in gorges (Western Australian Herbarium 1998-, Woodman Environmental 2014c). This taxon is endemic to Western Australia, occurring over a range of approximately 178 km, from near Shay Gap in the north-east, to south of Hillside Station in the south-west (DBCA 2007-). There are 18 DBCA records of this taxon occurring at 17 broad localities across its range. This taxon was recorded in the Mt Webber DSO Project (Woodman Environmental 2012c), the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c) and the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d).

Nicotiana umbratica (P3) was recorded at two point locations during the surveys of the Study Area, with 115 individuals recorded (Table 9). Both locations occur in gorges under boulders in the north-eastern and south-eastern parts of the Study Area (Appendix K, Figures 6.22 and 6.37). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 5: *Nicotiana umbratica* (P3) (Photo: Woodman Environmental)

***Rostellularia adscendens* var. *latifolia* (P3)**

Rostellularia adscendens var. *latifolia* (P3) is an erect, perennial herb to 0.3 m high (Plate 6), which occurs near creeks or on rocky hills (Western Australian Herbarium 1998-). This taxon occurs over a range of approximately 420 km in Western Australia, from Warrawagine Station in the north-east, to near Hamersley Station in the south-west (DBCA 2007-). It also occurs in the Northern Territory, South Australia, Queensland and New South Wales (Council of Heads of Australasian Herbaria 2016). There are 39 DBCA records of this taxon in Western Australia (Western Australian Herbarium 1998-). This taxon was also recorded in the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d). These records occur at 28 broad localities across its range, with six of these localities occurring in Karijini National Park (DBCA 2007-).

This taxon was recorded at two point locations during the surveys of the Study Area consisting of over 100 individuals (Table 9). One location was in a rocky creekline on a hill slope in the central western part of the Study Area, and the other was in a drainage line in the northern section of the Study Area (Appendix K, Figures 6.32 and 6.4 respectively). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 6: *Rostellularia adscendens* var. *latifolia* (P3) (Photos: Woodman Environmental)

***Rothia indica* subsp. *australis* (P3)**

Rothia indica subsp. *australis* (P3) is a prostrate, hairy ephemeral herb to 0.3 m high (Plate 7), occurring on sand hills and sandy flats, often near drainage lines (Western Australian Herbarium 1998-; Woodman Environmental 2014c). This taxon occurs over a range of approximately 980 km in Western Australia, from De Grey Station in the west to near Kiwirrkurra in the Gibson Desert in the east (Western Australian Herbarium 1998-). It also occurs in the Northern Territory and Queensland (Council of Heads of Australasian Herbaria 2016). There are 22 DBCA records of this taxon in Western Australia, (Western Australian Herbarium 1998-). These records occur at nine localities across its range in Western Australia. None of these localities occur in conservation reserves (Western Australian Herbarium 1998-). This taxon was recorded in the Mt Webber DSO Project (Woodman Environmental 2012c), the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c) and the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d).

This taxon was recorded at 13 point locations during these surveys within of the Study Area, with approximately 255 individuals recorded (Table 9). These point locations all occur at one locality within close proximity (within a few hundred meters) of each other in sandy soil adjacent to sheet flow and small drainage lines in the lower eastern section of the Study Area (Appendix K, Figure 6.23). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 7: *Rothia indica* subsp. *australis* (P3) (Photos: Woodman Environmental)

***Stylidium weeliwolli* (P3)**

Stylidium weeliwolli (P3) is an ephemeral herb to 0.25 m high (Plate 8), which occurs on the edges of pools and watercourses, and in seepage areas (DBCA 2007-). This taxon is endemic to Western Australia, occurring over a range of approximately 360 km, from Mount Augustus in the south-west, to near the western edge of Hillside Station in the north-east (DBCA 2020c). There are 39 DBCA records of this taxon (DBCA 2007-). These records represent 10 broad localities across its range. One locality each occurs in Mount Augustus National Park and Barlee Range Nature Reserve (DBCA 2007-).

The collection in the Study Area is an extension of the known range of this taxon. It was recorded at a single point location during the survey, in the central west section of the Study Area, where two flowering individuals were noted (Table 9). It is likely that further individuals that had finished flowering were present, but not discernible. The location is in a seepage area on the edge of granite outcropping (Appendix K, Figure 6.18). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 8: *Stylidium weeliwolli* (P3) (Photo: Woodman Environmental)

***Swainsona thompsoniana* (P3)**

Swainsona thompsoniana (P3) is a prostrate herb to 0.2 m high (Western Australian Herbarium 1998-). It occurs across a range of approximately 320 km from near Nullagine in the east to east of Pannawonica in the west. There are a total of 23 DBCA records of this taxon consisting of 14 broad localities. Two of these localities occur in Millstream-Chichester National Park and one occur in Karijini National Park (DBCA 2007-).

This taxon was recorded at three point locations during the surveys of the Study Area, with three individuals noted (Table 9). These locations were all within VT 5 in the northern part of the Study Area (Appendix K, Figures 6.4 and 6.6). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

***Ptilotus mollis* (P4)**

Ptilotus mollis (P4) is a low, compact shrub with soft grey foliage to 0.5 m high (Plate 9), which occurs on stony hill tops and scree slopes (Western Australian Herbarium 1998-). This taxon occurs over a range of approximately 640 km in Western Australia, from near the north-western edge of Karlamilyi (formerly Rudall River) National Park in the east, to the north-eastern corner of Cane River Conservation Park in the west (DBCA 2007-). There are 36 DBCA records of this taxon in Western Australia (DBCA 2007-) occurring across at 15 broad localities across its range. There is one locality of *Ptilotus mollis* within Karijini National Park and one within Cane River Conservation Park (Western Australian Herbarium 1998-). This taxon also recorded in the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c).

Ptilotus mollis was recorded at 36 point locations during the surveys of the Study Area, consisting of approximately 779 individuals (Table 9). All locations occur on cliffs and scree slopes of ranges of eroded dolerite origin in the southern part of the Study Area (Appendix K, Figures 6.34, 6.35, 6.37, 6.39, 6.40, 6.41). It was also recorded at an additional five locations

to the south of the Study Area while traversing to the Study Area, with 90 individuals recorded. This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Plate 9: *Ptilotus mollis* (P4) (Photo: Woodman Environmental)

5.2.2 Non-listed Significant Flora Taxa

Abutilon* aff. *hannii

A collection identified by a specialist taxonomist at the WA Herbarium as *Abutilon* aff. *hannii* was collected within the Study Area. This specimen matches a small number of other collections from the Pilbara bioregion (one of which is currently lodged as *Abutilon hannii*). However, these collections differ significantly in indumentum characters from all other *Abutilon hannii* collections in Western Australia (which are all from the Kimberley region). Although there has been speculation as to whether these collections may represent introgression between *Abutilon macrum* and *Abutilon hannii*, this was considered to be very unlikely given that, typical *Abutilon hannii* does not occur anywhere near the Pilbara. Therefore, these collections may represent an undescribed taxon. However, *Abutilon* is currently under active revision, and it may fall within the concept of a described taxon upon publication of this revision (M. Hislop *pers. comm.* 2014, 2016).

Abutilon aff. *hannii* was recorded at three locations in the Study Area however no counts of individuals were made (Table 9; Appendix K, Figures 6.36, 6.39, 6.41). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

It was also recorded at three locations in the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d), and one location in the Abydos DSO Project area (Woodman Environmental 2012a). It appears to be restricted to rocky drainage lines, and was not commonly encountered during this or the aforementioned surveys. As this taxon appears to be fairly uncommon in the Pilbara region, and is not currently known from any conservation reserves, it is considered that it should be treated as being of significance, pending taxonomic resolution.

***Portulaca* sp.**

A specimen identified by a specialist taxonomist at the WA Herbarium as *Portulaca* sp. was collected within the Study Area in 2014. *Portulaca* is currently under revision, with almost all recognised names currently being applied tentatively at best. However, this collection does not match other taxa commonly collected in the Pilbara, and appears to be similar to *Portulaca digyna* (M. Hislop *pers. comm.* 2014), a species currently known only from the Kimberley region (Western Australian Herbarium 1998-). It therefore may represent an undescribed taxon. As the collection from the Study Area is the only known collection of this potentially undescribed taxon, this taxon is considered to be of significance. It was recorded at a single point location during the surveys of the Study Area however no counts of individuals were made (Table 9). The location is in a minor, slightly rocky drainage line (Appendix K, Figure 6.27). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Acrostichum speciosum

A collection of a fern species, *Acrostichum speciosum,* was made from a single location within the Study Area, in a gorge with permanent or semi-permanent flowing water (Figure 6). Although this species is widely distributed in the Kimberley region of WA, and is also widely distributed in the Northern Territory, Queensland and northern New South Wales (Council of Heads of Australasian Herbaria 2014), there is currently only one other record from the Pilbara bioregion (Council of Heads of Australasian Herbaria 2014). The collection of this species in the Study Area represents a highly disjunct location of a species that occupies a relatively specific habitat type (permanently or semi-permanently wet, shaded areas) that is uncommon and likely to be restricted in the general region. Therefore, it is considered that the location of this species in the Study Area should be treated as being of significance. Three clumps of stems were noted at the single location in the Study Area (Table 9; Appendix K, Figure 6.34). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Eriocaulon pusillum

A collection of *Eriocaulon pusillum* was made from a single location within the Study Area, in a seepage area on the edge of granite outcropping, the same location where *Stylidium weeliwolli* (P3) and *Schoenus coultasii* (P1) (Section 5.2.1) were recorded (Appendix K, Figure 6.1). This specimen was identified by a specialist taxonomist at the WA Herbarium, who noted that this species is not known to occur in the Pilbara region, being restricted to the Kimberley region. The two collections of *Eriocaulon cinereum* lodged at the WA Herbarium (the only species of *Eriocaulon* known to occur in the Pilbara) need to be re-examined to confirm their identity, and it is possible they may represent *Eriocaulon pusillum* also (M. Hislop *pers. comm.* 2014). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

Although *Eriocaulon pusillum* is widely distributed in the Kimberley region of WA, and is also widely distributed in the Northern Territory and Queensland (Council of Heads of Australasian Herbaria 2020), the collection of this species in the Study Area represents a highly disjunct location of a species that occupies a relatively specific habitat type (permanent or semi-permanently wet, shaded areas) that is uncommon and likely restricted in the general region. Therefore, it is considered that the location of this species in the Study Area be treated as being of significance. Approximately 10 individuals were noted at the single location (Table 9) in the central west section of the Study Area (Appendix K, Figure 6.18).

***Oldenlandia* sp.**

A collection of *Oldenlandia* sp. was made from a single location within the Study Area, in a drainage line (Appendix K, Figure 6.9). A specialised taxonomist described this collection as either atypical material of *Oldenlandia crouchiana* (not conservation significant), or otherwise potentially an unrecognised taxon. However, the collection of additional material is required to clarify taxonomic status of *Oldenlandia* sp. (M. Hislop *pers. comm.* 2016). This taxon was not recorded in the Stage 2 Development Envelope during surveys in 2020.

5.3 Other Taxa of Interest

***Abutilon* sp.**

A collection identified by a specialist taxonomist at the WAHerb as *Abutilon* sp. was collected within the Study Area. This collection could not be assigned to any taxa known to occur in the Pilbara region. It may represent an undescribed taxon, however *Abutilon* is currently under active revision, and it may fall within the concept of a described taxon upon publication of this revision (M. Hislop *pers. comm.* 2014).

It was recorded in nine quadrats in the Study Area, and was also recorded at 25 locations in the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c), and 11 in the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d), usually on dolerite hills. It was noted as being common at many of these locations. Although it is considered to be of taxonomic interest, it is not considered to be of significance, given that it is known to be fairly widespread and common, and is expected to occur elsewhere in the region based on the landforms and soils it is known to occur on.

Bonamia* aff. *pilbarensis

A collection identified by a specialist taxonomist at the WAHerb as *Bonamia* aff. *pilbarensis* was collected within the Study Area. This collection is of interest; it has close affinities to *Bonamia pilbarensis*, sharing the same winged seed character, however its indumentum of dense hairs, which gives it an overall grey colour, is very much at variance with the sparse indumentum and overall green colour of *Bonamia pilbarensis*. *Bonamia* is currently under active revision, and this entity may fall within the concept of a described taxon upon publication of this revision (M. Hislop *pers. comm.* 2013).

It was recorded in 17 quadrats in the Study Area, generally on calcrete areas. *Bonamia* aff. *pilbarensis* was also recorded at numerous locations in the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c), and the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d). It was relatively common at most locations. Although it is considered to be of taxonomic interest, it is not considered to be of significance,

given that it is known to be fairly widespread and common, and is expected to occur elsewhere in the region based on the landforms and soils it is known to occur on.

Corchorus* aff. *walcottii

A collection identified as *Corchorus* aff. *walcottii* was collected within the Study Area. This collection is similar to *Corchorus walcottii* in indumentum characters. However, the collection appears to have persistent sepals in fruit, at variance to *Corchorus walcottii* and similar to *Corchorus laniflorus.* The fruit collected was relatively immature, and therefore collection of more mature fruit is desirable to facilitate a taxonomic resolution. This collection may therefore represent an undescribed taxon. In a revision of *Corchorus*, it was noted that a number of collections examined from the Pilbara region required further study (Halford 2004); judging by this, as well as numerous collections lodged at the WAHerb that have not been determined to species level (Western Australian Herbarium 1998-), further study of *Corchorus* as a whole in the Pilbara region is required.

This entity was recorded in three quadrats in the Study Area, on granitic soils and in drainage lines. It was also recorded at two locations in the McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014d). Recent re-examination of collections identified as *Corchorus laniflorus* from the McPhee Creek Haul Road Project Study Area has resulted in these collections also being determined as this entity, with this entity recorded in 20 quadrats within the McPhee Creek Haul Road Project Study Area (Woodman Environmental 2014c). This entity is not considered to be of conservation significance, given that it is known to be fairly widespread and common, and is expected to occur elsewhere in the region based on the landforms and soils it is known to occur on.

Goodenia* aff. *microptera

A collection identified by a specialist taxonomist as *Goodenia* aff. *microptera* was collected within the Study Area. This collection is of interest; it has some affinity to *Goodenia microptera,* however differs in a number of respects, including stem indumentum and robustness, and in having a wing above the auricle on the upper corolla lobes that is equal in size to the opposite one. In the latter respect, the collection is similar to *Goodenia nuda*, however this species differs from the collection in leaf and stem indumentum. Similar collections have been seen from a number of other locations elsewhere in the Pilbara (L. Sage *pers. comm.* 2014).

Goodenia aff. *microptera* was recorded in six quadrats in the Study Area, usually associated with granite or occasionally dolerite hills, and was relatively common at most locations. Although it is considered to be of taxonomic interest, it is not considered to be of significance, given that it is known to occur elsewhere in the Pilbara, and is expected to be relatively common.

Triumfetta* aff. *appendiculata

A collection identified by a specialist taxonomist at the WAHerb as *Triumfetta* aff. *appendiculata* was collected within the Study Area in 2014 and 2016. This collection is of interest; it has affinity to *Triumfetta appendiculata,* however differs most noticeably in having much longer sepal appendages than the known range for this species. Several collections noted in the most recent revision of *Triumfetta* (Halford 1997) as *Triumfetta* aff. *appendiculata* do not match the collection from the Study Area, as they have sepal

appendages within the normal range for *Triumfetta appendiculata* (M. Hislop *pers. comm.* 2014).
Further study is required to confirm its taxonomic status, with the collection potentially representing an extreme form of *Triumfetta appendiculata*, or potentially an undescribed taxon. Although it is considered to be of taxonomic interest, it is not considered to be of significance, given that it is common over a relatively wide area of the Study Area, and is likely to occur elsewhere in the region based on the landforms it occurs on.

This entity was recorded in 32 quadrats in the Study Area in 2016, often on rocky dolerite or metamorphosed granite hills, and was relatively common at most locations. A total of 143 individuals at 22 locations were recorded within the Stage 2 Development Envelope in 2020.

Hybrids

The hybrid taxon *Senna glutinosa* subsp. *x luerssenii* was collected in the Study Area. This is a known hybrid that is listed on the Census of Western Australian Plants (Western Australian Herbarium 1998-). *Acacia ancistrocarpa* x *tumida* var. *pilbarensis* was also collected in the Study Area. *Acacia ancistrocarpa* x *tumida* var. *pilbarensis* is a putative hybrid and is not listed on the Census of Western Australian Plants (Western Australian Herbarium 1998-). Neither of these entities are considered to be of significance.

5.4 Distribution Extensions and Distribution Gaps

Table 10 presents taxa where the collections from the Study Area represent extensions to the known distribution of such taxa, or otherwise fill gaps within the known distribution of such taxa, according to NatureMap (DBCA 2007-).

Table 10: Taxa Where Collections Represent Range Extensions to the Known Ranges of these Taxa, or Fill Distribution Gaps (DBCA 2007-)

Taxon	Description
Abutilon malvifolium	Fills gap in known distribution
Acacia arrecta	Extension of known distribution to the north
Acrostichum speciosum	Fills gap in known distribution
Austrobryonia pilbarensis	Fills gap in known distribution
Bergia ammannioides	Fills gap in known distribution
Bergia pedicellaris	Fills gap in known distribution
Blumea tenella	Fills gap in known distribution
Buchnera linearis	Fills gap in known distribution
Calotropis procera	Extension of known distribution to the south
Clerodendrum tomentosum var. *lanceolatum*	Fills gap in known distribution
Cochlospermum macnamarae (P1)	Extension of known distribution to the north
Crotalaria dissitiflora subsp. *benthamiana*	Extension of known distribution to the east
Cullen graveolens	Fills gap in known distribution
Eleocharis geniculata	Fills gap in known distribution
Eragrostis desertorum	Fills gap in known distribution
Eriachne flaccida	Fills gap in known distribution
Eriocaulon pusillum	Extension of known distribution to the south
Euphorbia coghlanii	Fills gap in known distribution
Ficus platypoda	Fills gap in known distribution
Fimbristylis elegans	Fills gap in known distribution
Gastrolobium grandiflorum	Fills gap in known distribution
**Passiflora foetida* var. *hispida*	Fills gap in known distribution

Taxon	Description
Peplidium sp. E Evol. Fl. Fauna Arid Aust. (A.S. Weston 12768)	Fills gap in known distribution
Peripleura virgata	Fills gap in known distribution
Podolepis capillaris	Extension of known distribution to the north
Rostellularia adscendens var. *latifolia*	Fills gap in known distribution
Schoenus falcatus	Fills gap in known distribution
Sida macropoda sens lat.	Extension of known distribution to the south
Sida spinosa	Fills gap in known distribution
Sida sp. excedentifolia (J.L. Egan 1925)	Fills gap in known distribution
Sonchus oleraceus	Fills gap in known distribution
Stylidium weeliwolli (P2)	Extension of known distribution to the north
Swainsona thompsoniana (P3)	Extension of known distribution to the east
Tephrosia clementii	Fills gap in known distribution
Tephrosia stipuligera	Fills gap in known distribution

5.5 Introduced Taxa

A total of 18 introduced flora taxa were recorded during the surveys of the Study Area. Table 11 presents a list of the introduced flora taxa recorded in the Study Area, together with location information, and ratings for each introduced taxon under the Environmental Weed Strategy for Western Australia (DBCA 2014). There were no Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) (WA) recorded within the Study Area (DPIRD 2020). Locations of each of these flora taxa are presented in Appendix J, and an overview of locations throughout the Study Area displayed on Figure 7. Appendix L (Figures 7.0 – 7.44) presents further detail with regards to the location of these taxa.

Table 11: Summary of Introduced Taxa Recorded from within the Study Area

Taxon	Number of Locations Recorded in the Study Area	Vegetation Types	Environmental Weeds Rating (DBCA 2014)
Aerva javanica	71	4, 5, 10, 12, 14, 15	High
?*Amaranthus viridis*	2	14, 15	Low
Argemone ochroleuca subsp. *ochroleuca*	2	14	Mild
Calotropis procera	14	14, 15	High
Cenchrus ciliaris	133	2, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15	High
Cenchrus setiger	1	15	High
Chloris barbata	3	8, 15	Low
Cynodon dactylon	8	14, 15	Moderate
Echinochloa colona	4	15	Mild
Flaveria trinervia	4	14, 15	Not assessed
Malvastrum americanum	3	10, 14	Moderate
Passiflora foetida var. *hispida*	2	3	High
Portulaca pilosa	1	1	Not assessed
Setaria verticillata	1	15	Low
Solanum nigrum	1	15	Moderate
Sonchus oleraceus	2	15	Moderate
Tribulus terrestris	1	15	Not assessed
Vachellia farnesiana	1	15	High

760000 765000 770000 775000 780000 785000 790000

7655000 7650000 7645000 7640000 7635000 7630000 7625000 7620000 7615000

Legend

- Study Area

Vegetation Condition

E	Excellent
VG/E	Very Good - Excellent
VG	Very Good
G/VG	Good - Very Good
G	Good
P/G	Poor - Good
P	Poor
VP/P	Very Poor - Poor
VP	Very Poor
C	Cleared Land

Introduced Flora

?Avi	*?*Amaranthus viridis*
Aej	**Aerva javanica*
Aroo	**Argemone ochroleuca* subsp. *ochroleuca*
Cap	**Calotropis procera*
Cec	**Cenchrus ciliaris*
Chb	**Chloris barbata*
Cse	**Cenchrus setiger*
Cyd	**Cynodon dactylon*
Ecc	**Echinochloa colona*
Flt	**Flaveria trinervia*
Maa	**Malvastrum americanum*
Pfh	**Passiflora foetida* var. *hispida*
Ppi	**Portulaca pilosa*
Sev	**Setaria verticillata*
Sol	**Sonchus oleraceus*
Son	**Solanum nigrum*
Trt	**Tribulus terrestris*
Vaf	**Vachellia farnesiana*

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC report Atlas20-14-01.

N

Sanjiv Ridge
Introduced Flora and Vegetation Condition

Revision: A - 22 January 2021 Scale: 1:130,000 (A3)

Author: Marco Pratissoli

WEC Ref: Atlas20-14-01

Filename: Atlas20-14-01-f07-Overview

Projection: GDA 1994 MGA Zone 50

Figure

7

Aerva javanica (Kapok Bush) (Plate 10) is a short-lived soft-wooded herb to 1.6 m in height (Hussey *et al.* 2007; DBCA 2007-). It is a widespread weed of the Pilbara bioregion, and is also common throughout the Kimberley. It is often found on sandy soils, along drainage lines or in disturbed areas. This taxon was rated as High under the Environmental Weed Strategy for Western Australia, due to its high level of invasiveness, wide current or potential distribution and high level of environmental impact to structure, composition and function of ecosystems (DBCA 2014). This taxon was recorded at 71 locations throughout the Study Area in a variety of habitats, including rocky slopes and drainage lines (Appendix L, Figures 7.2 – 7.42). It was relatively common at most locations.

Plate 10: *Aerva javanica* (Kapok) (Photo: Woodman Environmental)

Amaranthus viridis (Green Amaranth) could not be confirmed from a collection made in the Study Area due to inadequate material however the collection is suspected to be this taxon. It is an erect annual herb to 1 m high (Plate 11), with upright green flower spikes during the dry season in the tropics of Australia, and during summer in the south-west of W.A. (Hussey *et al.* 2007; Western Australian Herbarium 1998-). It generally occurs in disturbed and settled areas. *Amaranthus viridis* was ranked as Low under the Environmental Weed Strategy for Western Australia (DBCA 2014) as it has a low ecological impact, a low current and potential distribution and a slow dispersal rate. *Amaranthus viridis* was recorded at two locations within the Study Area, in disturbed drainage lines (Appendix L, Figure 7.33). It was uncommon at both locations.

Plate 11: *Amaranthus viridis* (Green Amaranth) (Photo: R.G. and F.J Richardson (Centre for Australian National Biodiversity Research (CANBR)) 2016)

Argemone ochroleuca subsp. *ochroleuca* (Mexican Poppy) (Plate 12) is a robust annual herb growing to 1 m high with yellow milky sap and deeply divided and very prickly leaves (Hussey *et al.* 2007; Western Australian Herbarium 1998-). Originally introduced as a garden plant, it is now widespread across the Pilbara, Gascoyne and Carnarvon bioregions, occurring along the coarse sand banks and gravel beds of the major river systems in these areas. It also occurs in the Avon valley and south-west (Hussey *et al.* 2007; Western Australian Herbarium 1998-). This taxon was rated Mild under the Environmental Weed Strategy for Western Australia; despite its rapid dispersal and wide distribution, it is considered to have a low level of ecological impact where it occurs (DBCA 2014). *Argemone ochroleuca* subsp. *ochroleuca* was recorded at two locations within the Study Area, both of which were located within drainage lines (Appendix L, Figures 7.7 and 7.39).

Plate 12: *Argemone ochroleuca* subsp. *ochroleuca* (Mexican Poppy) (Photo: C.G. Wilson (CANBR 2016))

Calotropis procera (Rubber Tree) (Plate 13) is a garden escape that has become a serious weed in the Kimberley region. It is a shrub to small tree, 1-4 m tall, with purple and white flowers January to December. The milky sap of this taxon can cause a rash or irritation upon contact (Hussey *et al.* 2007; Western Australian Herbarium 1998-). *Calotropis procera* was rated as High under the Environmental Weed Strategy for Western Australia, due to its high level of invasiveness, wide current or potential distribution and moderate ecological impact where it occurs (DBCA 2014). *Calotropis procera* was recorded at 14 locations within the Study Area (Appendix L, Figures 7.9, 7.11, 7.16, 7.21, 7.23, 7.36 and 7.39). The majority of these locations were associated with drainage lines that were disturbed by cattle grazing.

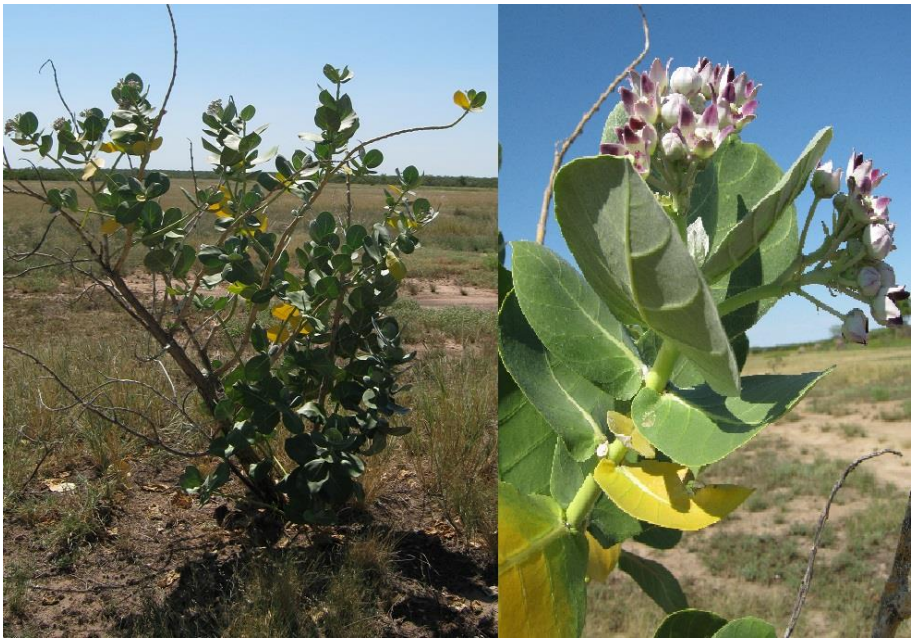

Plate 13: *Calotropis procera* (Rubber Tree) (Photo: Woodman Environmental)

Cenchrus ciliaris (Buffel Grass) (Plate 14) is a perennial tussock grass to 1.5 m high (Western Australian Herbarium 1998-). It is distributed widely, occurring from Geraldton to the Pilbara and Kimberley regions, and the adjacent desert areas. It is most often found on roadsides, in creek lines and on river edges. It was originally introduced into pastoral regions as a pasture grass and alters the fire characteristics by generating a high level of flammable fuel (Hussey *et al.* 2007). This taxon was rated as High under the Environmental Weed Strategy for Western Australia, due to its high level of invasiveness, wide current or potential distribution and high level of environmental impact to structure, composition and function of ecosystems (DBCA 2014). *Cenchrus ciliaris* was recorded at 133 locations throughout the Study Area (Appendix L, Figures 7.2 – 7.44), most often in drainage lines, but occasionally on rocky slopes. It was relatively common at most locations, sometimes dominating the lower stratum.

Plate 14: *Cenchrus ciliaris* (Buffel Grass) (Photo: M. Fagg (CANBR 2016))

Cenchrus setiger (Birdwood Grass) (Plate 15) is an erect, tussock grass to 0.5 m high (Western Australian Herbarium 1998-). It is a widespread, serious weed of watercourses from the Kimberley to Geraldton, occurring on sand dunes, plains, rangelands, stony hillsides and floodplains (Hussey *et al.* 2007, Western Australian Herbarium 1998-). This taxon was rated as High under the Environmental Weed Strategy for Western Australia, due to its high level of invasiveness, wide current or potential distribution and high level of environmental impact to structure, composition and function of ecosystems (DBCA 2014). This taxon was recorded at one location in the Study Area in a drainage line (Appendix L, Figure 7.23).

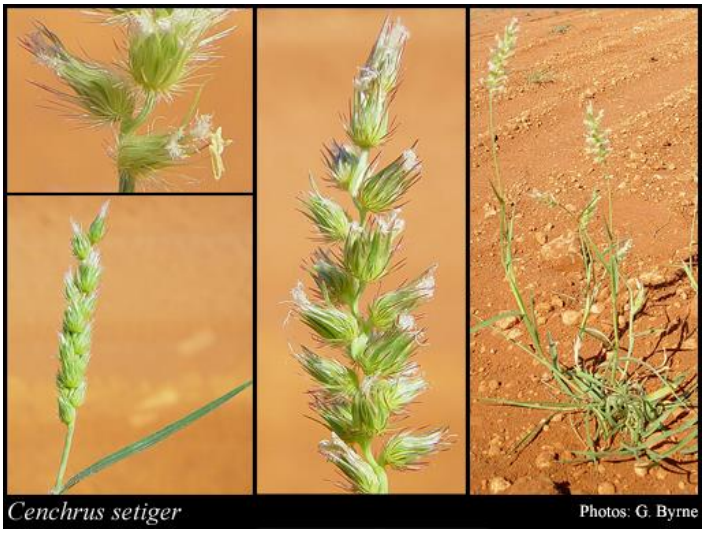

Plate 15: *Cenchrus setiger* (Birdwood Grass) (Photo G. Byrne (Western Australian Herbarium 1998-))

Chloris barbata (Purpletop Chloris) (Plate 16) is an annual or short-lived perennial grass growing to 0.9 m high. This species occurs throughout the Kimberley and Pilbara regions on levee banks, on road verges, in disturbed areas and along creek lines (Hussey *et al.* 2007, Western Australian Herbarium 1998-). *Chloris barbata* was ranked as Low under the Environmental Weed Strategy for Western Australia (DBCA 2014), as despite having a high ecological impact and rapid dispersal rate, it has only a moderate current and potential distribution. It was recorded at three locations in the Study Area, all within drainage lines (Appendix L, Figures 7.9, 7.21 and 7.44).

Plate 16: *Chloris barbata* (Purpletop Chloris) (Photo: R. Randall (Western Australian Herbarium 1998-))

Cynodon dactylon (Couch) (Plate 17) is prostrate, perennial grass to 0.3 m high (Western Australian Herbarium 1998-). It is widespread across W.A, invading wetlands and river edges (Hussey *et al.* 2007; Western Australian Herbarium 1998-). *Cynodon dactylon* was rated as Moderate under the Environmental Weed Strategy for Western Australia, as it is both invasive and has a wide current and potential distribution (DBCA 2014). *Cynodon dactylon* was recorded at eight locations in the Study Area (Appendix L, Figures 7.4, 7.7, 7.9, 7.16, 7.19, 7.23 and 7.36), generally found in drainage lines disturbed by cattle grazing.

Plate 17: *Cynodon dactylon* (Couch) (Photo: M. Fagg ((CANBR 2016))

Echinochloa colona (Awnless Barnyard Grass) is a tufted annual grass growing to 0.9 m high (Plate 18) (Western Australian Herbarium 1998-). It is a widespread weed of creeks, swamps

and irrigated crops in the Kimberley and Pilbara (Hussey *et al.* 2007). This taxon was rated as Mild under the Environmental Weed Strategy for Western Australia (DBCA 2014). *Echinochloa colona* was recorded at four locations in the Study Area, all within drainage lines (Appendix L, Figures 7.4, 7.16 and 7.23).

Plate 18: *Echinochloa colona* (Awnless Barnyard Grass) (Photo: S. M. Armstrong and J. English (Western Australian Herbarium 1998-))

Flaveria trinervia (Speedy Weed) (Plate 19) is an erect herb or shrub to 1 m in height (Western Australian Herbarium 1998-). Until recently this taxon was known in Australia as *Flaveria australasica* subsp. *australasica*, and was considered a native taxon. It was therefore not assessed under the Environmental Weed Strategy for Western Australia (DBCA 2014). This taxon is widespread through the Pilbara region, and also occurs in the Kimberley region, generally occurring in drainage features and disturbed areas (Western Australian Herbarium 1998-). *Flaveria trinervia* was recorded at four locations within the Study Area, all within drainage lines (Appendix L, Figures 7.21, 7.23 and 7.33).

Plate 19: *Flaveria trinervia* (Speedy Weed) (Photo: F. Humphreys (CANBR 2016))

Malvastrum americanum (Spiked Malvastrum) (Plate 20) is a shrub to 1.3 m high (Western Australian Herbarium 1998-). It occurs on river and creek margins, wastelands and many arid

zone habitats from the Kimberly to the Pilbara and Gascoyne bioregions (Hussey *et al.* 2007). It was rated as Moderate under the Environmental Weed Strategy for Western Australia, as it is invasive and has a wide current and potential distribution, but is not considered to cause a high level of environmental impact where it occurs (DBCA 2014). *Malvastrum americanum* was recorded at three locations within the Study Area; two of which were in drainage lines, with one on a rocky ridge (Appendix L, Figures 7.36 and 7.41). It was uncommon at all locations.

Plate 20: *Malvastrum americanum* (Spiked Malvastrum) (Photo: M. Fagg (CANBR 2016))

Passiflora foetida var. *hispida* (Stinking Passion Flower) (Plate 21) is a garden escape that has become common in disturbed areas of creek and river banks from the Kimberley region to Carnarvon. It is a hairy perennial vine with an unpleasant smell (Hussey *et al.* 2007; Western Australian Herbarium 1998-). It was rated as High under the Environmental Weed Strategy for Western Australia, due to its rapid dispersal, potential for wide distribution and its high ecological impact and abundance in the areas where it occurs (DBCA 2014). *Passiflora foetida* var. *hispida* was recorded at two locations within the Study Area, growing in rocky gorges (Appendix L, Figure 7.29). It was common at both locations, and was covering much of the native vegetation present at one location.

Plate 21: *Passiflora foetida* var. *hispida* (Stinking Passion Flower) (Photo: G. Byrne (Western Australian Herbarium 1998-))

Portulaca pilosa (Djanggara) is a succulent, erect or prostrate annual herb growing to 0.2 m high (Western Australian Herbarium 1998-). This taxon occurs in disturbed areas in the Kimberley and Pilbara on sandy, loamy and clayey soils (Hussey *et al.* 2007, Western Australian Herbarium 1998-). *Portulaca pilosa* was recorded at one location in the Study Area (Appendix L, Figure 7.18).

Plate 22: *Portulaca pilosa* (Djanggara) (Photo: G. Byrne and C. P. Campbell (Western Australian Herbarium 1998-))

Setaria verticillata (Whorled Pigeon Grass) (Plate 22) occurs across the Kimberley and Pilbara regions, where it is widespread in disturbed areas, along riverbanks and in shrubland areas. It is a loosely tufted annual grass to 1.3 m high (Hussey *et al.* 2007, Western Australian Herbarium 1998-). *Setaria verticillata* was ranked as Low under the Environmental Weed Strategy for Western Australia (DBCA 2014), as despite having a high ecological impact and rapid dispersal where it occurs, it has only a moderate current distribution and low potential distribution. *Setaria verticillata* was recorded at one location within the Study Area (Appendix L, Figure 7.21), in a drainage line disturbed by cattle grazing.

Plate 23: *Setaria verticillata* (Whorled Pigeon Grass) (Photo: M. Fagg (CANBR 2016))

Solanum nigrum (Black Berry Nightshade) is an erect perennial herb or short-lived shrub growing to 1 m high (Plate 24) (Western Australian Herbarium 1998-). It is a common agricultural and bushland weed with toxic black berries (Hussey *et al.* 2007, Western Australian Herbarium 1998-). This taxon was rated as Moderate under the Environmental Weed Strategy for Western Australia, as it is both invasive and has a wide current and potential distribution (DBCA 2014). *Solanum nigrum* was recorded at one location in the Study Area in a drainage line (Appendix L, Figure 7.23).

Plate 24: *Solanum nigrum* (Black Berry Nightshade) (Photo: S. M. Armstrong, K. C. Richardson and J. F. Smith (Western Australian Herbarium 1998-))

Sonchus oleraceus (Common Sowthistle) (Plate 25) is an erect annual herb growing to 1.5 m high with yellow flowers (Western Australian Herbarium 1998-). This species is widespread

on roadsides, gardens and wasteland throughout Western Australia, but is most common in the south-west (Hussey *et al.* 2007). *Sonchus oleraceus* is rated as Moderate under the Environmental Weed Strategy for Western Australia as it is considered to be an invasive species, and has a wide current distribution (DBCA 2014). *Sonchus oleraceus* was recorded at two locations within the Study Area (Appendix L, Figures 7.4 and 7.21), in a drainages line disturbed by cattle grazing. It was uncommon at both locations.

Plate 25: *Sonchus oleraceus* (Common Sowthistle) (Photo: M. Fagg (CANBR 2016))

Tribulus terrestris (Caltrop) is a prostrate, annual herb occurring on sandy soils (Western Australian Herbarium 1998-). It is a widespread weed in the Kimberley and Arid Zone of Western Australia (Hussey *et al.* 2007). This taxon was recorded at one location within the Study Area within a drainage line (Appendix L, Figure 7.16).

Plate 26: *Tribulus terrestris* (Caltrop) (Photo: S. M. Armstrong, J. Dodd and R. Knox (Western Australian Herbarium 1998-))

Vachellia farnesiana (Mimosa Bush) is an erect, spreading, thicket-forming, thorny tree or shrub, to 4 m high (Plate 27) (Western Australian Herbarium 1998-). It is a widespread weed of roadsides, creeks, rivers and disturbed floodplains throughout pastoral regions from the Kimberly to Carnarvon and Wiluna (Hussey *et al.* 2007). This taxon rated as High under the Environmental Weed Strategy for Western Australia, due to its rapid dispersal, potential for wide distribution and its high ecological impact and abundance in the areas where it occurs (DBCA 2014). *Vachellia farnesiana* was recorded at one location in the Study Area within a drainage line (Appendix L, Figure 7.23).

Plate 27: *Vachellia farnesiana* (Mimosa Bush) (Photo: J. English, S. D. Hopper and E. Wajon (Western Australian Herbarium 1998-))

6 RESULTS - VEGETATION OF THE STUDY AREA

6.1 Vegetation Type Mapping – Native Vegetation

The floristic analysis (see Section 3.5) arranged the quadrats into two very broad groups in the dendrogram with Group 1 being further split into two groups, with the groups distributed sequentially from top to bottom in the dendrogram:

- Group 1 (VTs 1 – 9) corresponds to vegetation generally occurring on granitic plains and low granite outcrops (dominating the Abydos Plain physiographic region (as defined by Beard (1975), which comprises a relatively small proportion of the Study Area); flats and other water-retaining areas (such as clay pans and depressions), and vegetation associated with shaded rocky outcropping (including gorges) (VTs 1 – 9);
- Group 2 (VTs 10 – 13) corresponds to vegetation generally occurring on hills of volcanic origin (such as dolerite, ironstone or metamorphosed granite) or calcrete; this group dominates the Gorge Range physiographic region (as defined by Beard (1975)), which comprises a relatively large proportion of the Study Area; and
- Group 3 (VTs 14, 15) corresponds to vegetation associated with the main drainage features, including creeks and rivers. Group 3 is composed of taxa that are often restricted to such situations, and are not associated with a particular physiographic region.

Manual dissection of these groups defined 15 VTs. Table 12 presents a summary of the VTs occurring in the Study Area, including:

- VT description;
- Total area mapped within the Study Area and percentage of the Study Area the VT occupies;
- Number of quadrats and quadrat names established in the VT; and
- Average species richness of quadrats established in the VT.

An overview figure presenting the distribution of VTs in the Study Area is presented in Figure 6 (Section5.2). Appendix K (Figures 6.0 – 6.44) presents the VTs mapped within the Study Area in greater detail. Minor changes to the original VT mapping boundaries within the Stage 2 Development Envelope were made after inspection of these boundaries during the 2020 field survey. Updated VT boundaries and extents are presented in this report. Vegetation of the Stage 2 Development Envelope is presented on Figures 6.21, 6.22, 6.28 and 6.29of Appendix K.

Appendix M presents a list of vascular plant taxa recorded in each VT mapped in the Study Area (quadrat data only). Appendix N presents the quadrat classification dendrogram of the floristic analysis (Section 3.5), as per the PATN output (for quadrats which were manually moved please see Appendix H). Appendix O presents the two-way table associated with the dendrogram. Appendix P presents significant indicator taxa for each VT.

Table 12: Summary of Vegetation Types Mapped in the Study Area

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
1	Mid sparse shrubland dominated by mixed Acacia species over low sparse shrubland of mixed species including *Acacia stellaticeps, Pluchea tetranthera* and *Eremophila latrobei* subsp. *glabra* over low hummock grassland dominated by *Triodia epactia* on grey to brown sand to clay loam with occasional granite outcropping, on stoney plains, low hills or sandy dunes	**Study Area:** 349.6 ha 1.34 % Not mapped in Stage 2 Development Envelope 13.3 species per quadrat ± 6.6 SD	6 quadrats CD001, CD002, **CD045**, CD200, CE-105, CE-168	Indicator Taxa *Acacia levata* (P3)*; Goodenia* aff. *microptera; Sclerolaena densiflora; Triodia epactia* CS Flora Taxa *Acacia levata* (P3), *Eriocaulon pusillum, Schoenus coultasii* (P1), *Stylidium weeliwolli* (P3)	
2	Tall to mid open shrubland dominated by mixed Acacia species including *Acacia eriopoda* and *Acacia maitlandii* and over low sparse shrubland of mixed species including *Acacia stellaticeps*, *Corchorus parviflorus* and *Corchorus laniflorus* over low hummock grassland dominated mainly by *Triodia epactia* on red-brown sandy clay to clay loam, on granite outcrops to stoney plains and drainage lines with exposed granite	**Study Area:** 334.2 ha 1.28 % Not mapped in Stage 2 Development Envelope 17.5 species per quadrat ± 5.0 SD	13 quadrats CD167, CD171, **CD172**, CD203, CE-102, CE-104, CE-165, CE-166, CE-167, CE-169, CE-170, CE-171, CE-314	Indicator Taxa CS Flora Taxa *Cochlospermum macnamarae* (P1), *Eragrostis crateriformis* (P3), *Rothia indica* subsp. *australis* (P3)	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
3	Low open woodland of mixed species dominated by species including *Corymbia ferriticola*, *Ficus brachypoda*, *Terminalia canescens* over tall sparse shrubland usually dominated by *Acacia pruinocarpa* and *Acacia tumida* var. *pilbarensis* over low open mixed grassland dominated by *Triodia epactia*, *Cymbopogon ambiguus* and *Eriachne mucronata*, on red to brown sand to clay loam on ironstone or metamorphosed granite outcropping, in steep gorges, often with semi-permanent water	**Study Area:** 47.7 ha 0.18 % **Stage 2 Development Envelope:** 1.76 ha 0.76% 26.9 species per quadrat ± 6.2 SD	9 quadrats CD021, CD043, CD062, CD065, CD082, CD104, **CD304**, CE-083, CE-138	Indicator Taxa *Acacia pruinocarpa*; *Acacia tumida* var. *pilbarensis*; *Clerodendrum tomentosum*; *Corymbia ferriticola*; *Cymbopogon ambiguous*; *Cyperus cunninghamii* subsp. *cunninghamii*; *Cyperus hesperius*; *Eriachne mucronata*; *Ficus brachypoda*; *Santalum lanceolatum*; *Tinospora smilacina* CS Flora Taxa *Nicotiana umbratica* (P3)	
4	Low Open Woodland usually dominated by *Corymbia hamersleyana* over Tall Sparse Shrubland dominated by mixed Acacia species including *A. trachycarpa* and *A. ancistrocarpa* with *Dichrostachys spicata* over Low Hummock Grassland dominated by species including *Triodia wiseana* and *T. epactia* with *Eragrostis eriopoda* on brown sandy loams on plains and drainage lines	**Study Area:** 591.3 ha 2.27 % Not mapped in Stage 2 Development Envelope 19.7 species per quadrat ± 6.0 SD	15 quadrats CE-026, CE-037, CE-041, CE-049, CE-051, CE-054, CE-058, CE-073, CE-090, CE-092, CE-093, CE-178, **CE-180**, CE-183, CE-308	Indicator Taxa *Eragrostis eriopoda*; *Sida clementii* CS Flora Taxa *Heliotropium murinum* (P3)	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
5	Mid Sparse Shrubland of mixed Acacia species usually dominated by *A. synchronicia* over Low Hummock Grassland dominated by various Triodia species including *T. epactia*, *T. wiseana* and *T. longiceps* on brown clay loams on stony plains and base of low hills	**Study Area:** 844.4 ha 3.24 % Not mapped in Stage 2 Development Envelope 7.5 species per quadrat ± 4.9 SD	23 quadrats CD046, CE-022, CE-032, CE-035, CE-040, CE-045, CE-046, CE-052, CE-053, **CE-060**, CE-077, CE-086, CE-095, CE-119, CE-172, CE-173, CE-176, CE-177, CE-181, CE-301, CE-306a, CE-306b, CE-311	Indicator Taxa CS Flora Taxa *Eragrostis crateriformis* (P3)	
6	Tall hummock grassland dominated by *Triodia longiceps* with tall isolated shrubs of *Acacia synchronicia* on red or brown sandy to clay loams on stony plains, interspersed with low sparse forbland of mixed species including *Sida fibulifera, Rhynchosia minima, Tephrosia* sp. clay soils (S. van Leeuwen *et al.* PBS 0273), *Crotalaria dissitiflora* subsp. *benthamiana, Cullen graveolens* and *Eriachne flaccida* on brown cracking clay in clay pans	**Study Area:** 273.0 ha 1.05 % Not mapped in Stage 2 Development Envelope 12.5 species per quadrat ± 3.9 SD	6 quadrats **CE-033**, CE-184, CE-185, CE-307, CE-312, CE-313	Indicator Taxa *Abutilon malvifolium*; *Eriachne flaccida*; *Neptunia dimorphantha*; *Rhynchosia minima*; *Streptoglossa bubakii*; *Tephrosia* sp. clay soils (S. van Leeuwen *et al*. PBS 0273) CS Flora Taxa *Swainsona thompsoniana* (P3)	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
7	Tall sparse shrubland dominated by species including *Acacia bivenosa, Acacia synchronicia* and *Dichrostachys spicata* over mid hummock grassland dominated by *Triodia longiceps* over low sparse tussock grassland and chenopod shrubland dominated by *Cenchrus ciliaris* and *Sclerolaena hostilis* on brown clay loam on flats and in open depressions	**Study Area:** 124.9 ha 0.48 % Not mapped in Stage 2 Development Envelope 9.7 species per quadrat ± 4.8 SD	6 quadrats CD077, CE-043, **CE-044**, CE-091, CE-303, CE-309, CE-318	Indicator Taxa *Sclerolaena hostilis* CS Flora Taxa *Eragrostis crateriformis* (P3)	
8	Low isolated shrubs dominated by *Melaleuca glomerata* over mid hummock grassland dominated by *Triodia longiceps* over low mixed sedgeland, grassland and forbland of mixed species including *Schoenus falcatus*, *Trianthema cusackianum* and *Stemodia grossa* on white to brown clay to clayey sand with occasional calcrete and dolerite stones, at the head of drainage lines	**Study Area:** 65.6 ha 0.25 % Not mapped in Stage 2 Development Envelope 10.3 species per quadrat ± 2.1 SD	3 quadrats **CE-087**, CE-195, CE-197	Indicator Taxa *Cassytha capillaris*; *Cyperus vaginatus*; *Melaleuca glomerata*; *Pluchea rubelliflora*; *Sporobolus actinocladus* CS Flora Taxa	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
9	Low open woodland to isolated trees of *Eucalyptus leucophloia* subsp. *leucophloia* and/or *Corymbia hamersleyana* over tall sparse shrubland of mixed species usually dominated by *Acacia orthocarpa*, *Acacia monticola*, *Acacia tumida* var. *pilbarensis and Grevillea wickhamii* over low shrubland to sparse shrubland of mixed species dominated by *Acacia ptychophylla*, *Acacia spondylophylla*, *Goodenia stobbsiana*, *Dampiera candicans* and *Ptilotus calostachyus* over low hummock grassland dominated by *Triodia epactia* and occasionally *Triodia brizoides* on red to brown clay loam usually over ironstone or metamorphosed granite outcropping, on hill crests or occasionally low rises	**Study Area:** 2695.4 ha 10.36 % **Stage 2 Development Envelope:** 153.18 ha 66.57 % 14.6 species per quadrat ± 4.9 SD	39 quadrats CD020, CD022, CD023, CD024, CD025, CD032, CD035, CD038, CD041, **CD042**, CD061, CD063, CD069, CD070, CD083, CD084, CD102, CD108, CD115, CD123, CD129, CD130, CD133, CD137, CD138, CD142, CD148, CD152, CD301, CD306, CE-062, CE-081, CE-121, CE-123, CE-129, CE-136, CE-141, CE-193, CE-323	Indicator Taxa *Grevillea wickhamii* CS Flora Taxa *Nicotiana umbratica* (P3)	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
10	Isolated trees dominated by *Eucalyptus leucophloia* subsp. *leucophloia* and occasionally *Corymbia hamersleyana* over tall to mid sparse shrubland dominated by species including *Acacia bivenosa*, *Acacia inaequilatera*, *Acacia pyrifolia* var. *pyrifolia* and *Grevillea wickhamii* over low open to sparse shrubland of mixed species including *Indigofera monophylla*, *Acacia ptychophylla* and *Senna spp.* over low hummock grassland dominated by *Triodia brizoides*, *Triodia epactia* and/or *Triodia wiseana* over low sparse tussock grassland dominated by *Eriachne mucronata* on red or brown clay loam, usually over metamorphosed granite or occasionally dolerite, quartz or ironstone outcropping, on the upper slopes and crests of steep hills and ridges, or occasionally on low hills, undulating plains and outwashes	**Study Area:** 6625.7 ha 25.46 % **Stage 2 Development Envelope**: 62.50 ha 27.16 % 18.2 species per quadrat ± 6.3 SD	41 quadrats CD004, CD019, CD039, CD040, CD052, CD055, CD056, CD060, CD080, CD089, CD096, CD097, CD107, CD109, CD112, CD118, CD120, CD135, CD155, CD161, **CD163**, CD168, CD177, CD182, CD201, CD255, CD302, CD307, CD309, CD407, CE-071, CE-135, CE-137, CE-139, CE-143, CE-144, CE-145, CE-150, CE-160, CE-161, CE-163	Indicator Taxa CS Flora Taxa *Acacia levata* (P3), *Ptilotus mollis* (P4), *Rostellularia adscendens* var. *latifolia* (P3)	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
11	Low isolated trees of *Corymbia hamersleyana* over tall sparse shrubland dominated by *Acacia inaequilatera* and often *Grevillea pyramidalis* subsp. *leucadendron* over low sparse shrubland dominated by *Corchorus parviflorus*, *Indigofera monophylla* and *Senna glutinosa* subsp. *glutinosa* over low hummock grassland dominated by *Triodia wiseana* and/or *Triodia epactia* on red to brown clay loam often with dolerite or occasionally quartz or metamorphosed granite outcropping, on low hills, ridges and occasionally undulating plains	**Study Area:** 9783.2 ha 37.6 % **Stage 2 Development Envelope:** 8.42 ha 3.66 % 12.3 species per quadrat ± 4.8 SD	69 quadrats: CD008, CD009, CD011, CD015, CD016, CD018, CD027, CD036, CD047, CD049, CD050, CD054, CD058, CD068, CD074, CD079, CD088, CD092, CD098, CD099, CD117, CD145, CD158, CD164, CD165, CD166, CD176, CD183, CD202, CD311, CE-002, CE-005, CE-006, CE-010, CE-015, CE-017, CE-018, CE-029, **CE-030**, CE-047, CE-048, CE-055, CE-063, CE-064, CE-075, CE-078, CE-080, CE-082, CE-099, CE-107, CE-118, CE-122, CE-128, CE-131, CE-132, CE-133, CE-134, CE-148, CE-152, CE-155, CE-156, CE-159, CE-188, CE-189, CE-305, CE-315, CE-319, CE-321, CE-324	Indicator Taxa *Acacia inaequilatera; Bonamia pilbarensis; (Bonamia* sp. Dampier (A.A. Mitchell PRP 217)) CS flora taxa *Acacia levata* (P3), *Ptilotus mollis* (P4)	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
12	Low open woodland of *Corymbia hamersleyana* over mid sparse shrubland dominated by *Acacia bivenosa* over low sparse shrubland of mixed species including *Corchorus parviflorus*, *Heliotropium cunninghamii*, *Indigofera monophylla* and *Pluchea ferdinandi-muelleri* over low hummock grassland dominated by *Triodia wiseana* and/or *Triodia angusta* or *Triodia longiceps* on brown clay loam on stony undulating plains and low rises often with calcrete outcropping	**Study Area:** 1457.7 ha 5.60 % Not mapped in Stage 2 Development Envelope 14.4 species per quadrat ± 5.9 SD	53 quadrats: CD017, CD051, CD076, CD085, CD087, CD090, CD091, CD111, CD119, CD121, CD122, CD126, CD140, CD143, CD149, CD173,, CD174, CD251, CD252, CD253, CD310, CE-004, CE-011, CE-020, CE-021, CE-023, CE-025, CE-028, CE-038, CE-039, CE-042, CE-059, CE-069, CE-084, CE-094, CE-125, CE-126, **CE-146**, CE-149, CE-154, CE-158, CE-179,CE-182,CE-187, CE-190, CE-191, CE-192, CE-194,CE-196, CE-302, CE-304, CE-310, CE-322	Indicator Taxa Nil Significant Flora Taxa Nil	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
13	Isolated trees dominated by *Corymbia hamersleyana* over tall to mid sparse shrubland dominated by *Grevillea wickhamii* and *Acacia bivenosa* over low open to sparse shrubland dominated by *Acacia arrecta*, *Goodenia stobbsiana*, *Corchorus parviflorus* and *Heliotropium ovalifolium* over low hummock grassland dominated by *Triodia angusta* and often *Triodia wiseana* on brown clay loam on stony undulating plains, low hills and ridges with calcrete, dolerite and occasional granite or ironstone outcropping	**Study Area:** 694.9 ha 2.67 % Not mapped in Stage 2 Development Envelope 10.5 species per quadrat ± 3.3 SD	11 quadrats: CD131, CD134, CD136, CD156, CD160, CD180, CD181, CD254, **CD303**, CD305, CD308	Indicator Taxa *Acacia arrecta;* *Goodenia stobbsiana*; *Triodia angusta* Significant Flora Taxa *Ptilotus mollis* (P4)	
14	Mid open woodland of mixed species including *Eucalyptus victrix* and *Corymbia hamersleyana* over tall open to sparse shrubland of mixed species including *Acacia coriacea* subsp. *pendens, Acacia trachycarpa*, *Acacia pyrifolia* var. *pyrifolia*, *Acacia tumida* var. *pilbarensis* and *Melaleuca glomerata* over low sparse shrubland of mixed species including *Pluchea ferdinandi-muelleri*, *Cajanus pubescens* and *Stemodia grossa* over mid open grassland and sedgeland of mixed species dominated by **Cenchrus ciliaris*, *Triodia longiceps*, *Triodia*	**Study Area:** 1420.5 ha 5.46 % Stage 2 Development Envelope: 8.85 ha 1.67 % 28.6 species per quadrat ± 5.4 SD	46 quadrats: CD006, CD007, CD010, CD012, CD014, CD028, CD048, CD053, CD057, CD059, CD075, CD086, CD116, CD132, CD139, CD147, CD150, CD157, CD159, CD162, CD204, CD312, CE-003, CE-008, CE-019, CE-034, CE-036, CE-050, CE-057, CE-065, CE-072, CE-076, CE-079, **CE-100**, CE-120,	Indicator Taxa *Cajanus pubescens*; *Corchorus parviflorus*; *Eriachne tenuiculmis*; *Tephrosia rosea* var. *clementii*; *Themeda triandra*; *Triumfetta* aff. *appendiculata*; *Waltheria indica* Significant Flora Taxa *Abutilon* aff. *hannii*, *Portulaca* sp., *Ptilotus mollis* (P4)	

VT	Description	Extent (ha); Percentage of Study Area; Species Richness	Number of Quadrats	Significant Indicator Taxa* and Presence of Significant Flora Taxa	Representative Photograph (taken at quadrat in bold)
	epactia, *Chrysopogon fallax* and *Cyperus vaginatus* on red to brown sand to sandy loam with riverstones in minor to medium drainage lines		CE-127, CE-130, CE-147, CE-151, CE-153, CE-157, CE-164, CE-186, CE-198, CE-316, CE-320		
15	Mid open forest to woodland dominated by *Eucalyptus camaldulensis* subsp. *refulgens* and occasionally *Eucalyptus victrix* over tall open shrubland dominated by species including *Acacia ampliceps*, *Melaleuca glomerata* and *Acacia pyrifolia* var. *pyrifolia* over mixed mid open grassland and sedgeland dominated by **Cenchrus ciliaris*, *Cyperus vaginatus* and *Triodia longiceps* on red to brown sandy to clay loam with riverstone in major drainage lines	**Study Area:** 517.5 ha 1.99 % Not mapped in Stage 2 Development Envelope 21.2 species per quadrat ± 7.1 SD	16 quadrats: CD013, CD073, CD169, CE-024, CE-027, CE-066, **CE-068**, CE-074, CE-096, CE-098, CE-108, CE-109, CE-110, CE-174, CE-175, CE-317	Indicator Taxa *Acacia coriacea* subsp. *pendens*; *Vigna lanceolata* var. *lanceolata* Significant Flora Taxa *Oldenlandia* sp., *Rostellularia adscendens* var. *latifolia* (P3)	

*Significant Indicator Taxa: taxa which were significant at P<0.05 *** = p <0.001; for a full list of significant taxa for each VT please see Appendix P)
Note: photograph representative of quadrat in bold

6.2 Other Mapped Areas

Significant areas where no vegetation occurred because of human disturbance were mapped as 'Cleared Land' (C), including the Hillside-Marble Bar Road, and major exploration tracks in the Study Area (Figure 7). Smaller tracks were not mapped as 'Cleared Land' because of their complexity and small size.

A total of 123.8 ha (0.47 % of Study Area) of 'Cleared Land' have been mapped, of which 0.39 ha (0.17% of the Stage 2 Development Envelope) was mapped within the Stage 2 Development Envelope.

6.3 Vegetation Condition Mapping

An overview of vegetation condition mapping is presented in Figure 7 (Section 5.5). The vegetation condition mapping is also presented in greater detail in Appendix L (Figures 7.0 – 7.44).

The majority of the vegetation in the Study Area (90.32 %) was ranked as being in 'Excellent' condition, with little to no disturbance and an absence or low levels of introduced flora taxa. The entire Stage 2 Development Envelope was mapped as being in Excellent condition. The majority of larger drainage features had lower condition scores as a result of the presence of high densities of aggressive introduced flora taxa, and high grazing and trampling impacts from cattle. These scores varied from 'Very Good' to 'Poor', depending on the levels of introduced taxa and trampling impacts recorded. These condition scores were often correlated with the size of the drainage feature, with large creeks and rivers tending to be ranked lower than smaller flow lines and creeks. Condition was also generally poorer in the far northern section of the Study Area close to Marble Bar.

Cenchrus ciliaris dominated the lower stratum at a number of quadrats, occasionally to the extent that native perennial grass taxa were almost entirely absent. *Aerva javanica* was also often frequent in the shrub layer in such quadrats. The presence of the significant introduced taxa *Calotropis procera* and *Argemone ochroleuca* subsp. *ochroleuca* also reflects the high level of disturbance caused by cattle in the areas where these taxa were recorded.

The areas in the Study Area mapped as 'Cleared Land' (see Section 6.2) were not allocated condition scores, as they are essentially completely cleared, with some regrowth occurring in the intervening years between road maintenance. Most of the exploration tracks were relatively free of introduced taxa however the disturbed verge of the Hillside-Marble Bar Road was noted as having relatively high levels of *Aerva javanica* and *Cenchrus ciliaris*.

6.4 Significant Vegetation

6.4.1 Regional Significance

None of the VTs mapped in the Study Area are considered to represent any TECs as classified by DBCA and endorsed by the Western Australian Minister for Environment (DBCA 2020c), or as listed under the EPBC Act (DoEE 2020a). None of the VTs mapped in the Study Area are considered to represent any DBCA-classified PECs (DBCA 2020a). As previously mentioned, no known locations of any DBCA-classified TECs, TECs listed under the EPBC Act, or DBCA-classified PECs, coincide with the Study Area (DoEE 2020a; DBCA 2020a).

There is no Pilbara-wide VT dataset to allow for determination of the regional extent of VTs. However, the previous floristic analysis of quadrats from the Study Area in conjunction with a number of other studies in the vicinity of the Study Area, as produced by Woodman Environmental (2014), provides a relatively geographically-widespread VT dataset with a reasonable level of context when considering the regional distribution and significance of VTs. Only VTs 3, 6, 7 and 8 are considered to be of potential regional significance due to their potential to be restricted in the wider region as a result of uncommon substrates or other factors. Table 13 presents a summary of significant VTs in the Study Area.

VT 1 is not considered to be of regional significance despite containing the only location of several significant taxa (*Stylidium weeliwolli* (P3), *Eriocaulon pusillum* (significantly disjunct record) and *Schoenus coultasii* (P1). The location containing these taxa is a seepage area of small size, and these significant flora taxa do not occur more widely through VT 1, or in other VTs.

No VTS of regional significance were mapped within the Stage 2 Development Envelope.

6.4.2 Local Significance

VTs may be locally significant due to their limited mapped extent within the Study Area, or due to the provision of suitable habitat for Threatened, P1, P2 or potentially undescribed flora taxa.

VTs 1, 2, 3, 4, 6, 7, 8 and 15 are considered to be of local significance in the context of the Study Area only, due to their limited mapped extent in the Study Area (they each represent close to or less than 1 % of the Study Area) and/or because each is habitat for conservation significant flora. Of these, only small pockets of VT 3 occur within the Stage 2 Development Envelope. However, when considered in a regional context, VTs 1, 2, 4 and 15 are likely to be well represented elsewhere.

Table 13: Significant Vegetation Types in the Study Area

VT	Local Significance	Known Regional Presence/Distribution	Potential Regional Significance
1	**Considered to be of local significance:** • Extent mapped is >1% of Study Area (1.34%) • Habitat for significant flora taxa *Schoenus coultasii* (P1); *Stylidium weeliwolli* (P3); *Acacia levata* (P3); *Eriocaulon pusillum*	• VT comprised of quadrats originally grouped into VTs 1, 2, 9 and 12 (Woodman Environmental 2014) • Has affinities with VT 1 as mapped by Woodman Environmental (2014) • Likely to be regionally widespread due to substrate	**Not considered to be of potential regional significance:** • Potentially widely distributed
2	**Considered to be of local significance:** • Habitat for the significant flora taxon *Cochlospermum macmanarae* (P1), which is entirely restricted to this VT in the Study Area. • Extent mapped is >1% of the Study Area (1.28%)	• Largely equivalent to VT 1 as mapped by Woodman Environmental (2014) • Likely to be regionally widespread due to substrate and presence in regional dataset (Woodman Environmental 2014)	**Not considered to be of potential regional significance:** • Potentially widely distributed
3	**Considered to be of local significance:** • Mapped over a restricted area of the Study Area over few occurrences, considered to be a refuge and contain unusual taxa, one of which is considered significant (*Acrostichum speciosum*). • Extent mapped is <1% of Study Area (0.19%)	• Equivalent to VT 6 as mapped by Woodman Environmental (2014) • Known from one quadrat within one other project: McPhee Creek Iron Ore Project	**Considered of potential regional significance:** • Known from one other small occurrence in the region • Likely to be a refuge in a regional context • VT 6 (Woodman Environmental 2014) noted to be of regional conservation significance due to refugia status
4	**Considered to be of local significance:** • Habitat for the significant flora taxon *Heliotropium murinum* (P3) • Extent mapped is >1% of Study Area (2.27%)	• Not equivalent to VTs mapped in Sanjiv Ridge by Woodman Environmental (2014), however similar to several sites in the regional dataset (Rail corridors) • Likely to be widespread due to substrate; is related to floodplains of riverine systems	**Not considered to be of potential regional significance:** • Potentially more widely distributed
5	**Not considered of local significance:** • Mapped over several relatively large occurrences in the Study Area. • Although is habitat for *Eragrostis crateriformis* (P3), this species is not limited to this VT	• Similar to VT 9 mapped in Sanjiv Ridge by Woodman Environmental (2014)	**Not considered to be of potential regional significance:** • Potentially more widely distributed

VT	Local Significance	Known Regional Presence/Distribution	Potential Regional Significance
6	**Considered to be of local significance:** • Mapped over a restricted area of the Study Area (1.05% of the Study Area). • Habitat for the significant flora taxon *Swainsona thompsoniana* (P3)	• Not equivalent to VTs mapped in Sanjiv Ridge by Woodman Environmental (2014) • Not similar to quadrats within the Woodman regional dataset, therefore regional extent unknown	**Considered of potential regional significance:** • Regional extent unknown and therefore potentially restricted within the region; • Occurs on claypan sites which are generally restricted in the region.
7	**Considered to be of local significance:** • Mapped over a restricted area of the Study Area over few occurrences. • Extent mapped is <1% of the Study Area (0.48%) • Habitat for the significant flora taxon *Eragrostis crateriformis* (P3)	• Not equivalent to VTs mapped in Sanjiv Ridge by Woodman Environmental (2014) • Not similar to quadrats within the Woodman regional dataset, therefore regional extent unknown	**Considered of potential regional significance:** • Regional extent unknown and therefore potentially restricted within the region
8	**Considered to be of local significance:** • Mapped over a restricted area of the Study Area over few occurrences. • Extent mapped is <1% of the Study Area (0.25%)	• Not equivalent to VTs mapped in Sanjiv Ridge by Woodman Environmental (2014), however similar to several sites in the regional dataset (Rail corridors) • Substrate and species composition unusual	**Considered of potential regional significance:** • Knowledge of potential regional extent is limited, existing occurrences are all small in area, and therefore is potentially restricted within the region
9	**Not considered of local significance:** Mapped over several relatively large occurrences in the Study Area. Habitat for the significant flora taxon *Nicotiana umbratica* (P3)	• Equivalent to VT16 (Woodman Environmental 2014) • Likely to be widespread due to substrate and presence in regional dataset (Woodman Environmental 2014)	**Not considered of potential regional significance** • Known from several other areas in the region, from multiple occurrences
10	**Not considered of local significance:** Mapped over several relatively large occurrences in the Study Area. Habitat for the significant flora taxa *Acacia levata* (P3), *Ptilotus mollis* (P4), *Rostellularia adscendens* var. *latifolia* (P3)	• Equivalent to VT14 (Woodman Environmental 2014) • Likely to be widespread due to substrate and presence in regional dataset (Woodman Environmental 2014)	**Not considered of potential regional significance:** • Known from several other areas in the region, from multiple occurrences
11	**Not considered of local significance:** Mapped over several relatively large occurrences in the Study Area. Habitat for the significant flora taxa *Acacia levata* (P3), *Ptilotus mollis* (P4)	• Equivalent to VT12 (Woodman Environmental 2014) • Likely to be widespread due to substrate and presence in regional dataset (Woodman Environmental 2014)	**Not considered of potential regional significance:** • Known from several other areas in the region, from multiple occurrences

VT	Local Significance	Known Regional Presence/Distribution	Potential Regional Significance
12	**Not considered of local significance:** Mapped over several relatively large occurrences in the Study Area.	• Equivalent to VT10 (Woodman Environmental 2014) • Likely to be widespread due to substrate and presence in regional dataset (Woodman Environmental 2014)	**Not considered of potential regional significance:** • Known from several other areas in the region, from multiple occurrences
13	**Not considered of local significance:** Mapped over several relatively large occurrences in the Study Area. Habitat for the significant flora taxon *Ptilotus mollis* (P4)	• Equivalent to VT11 (Woodman Environmental 2014) • Likely to be widespread due to substrate and presence in regional dataset (Woodman Environmental 2014)	**Not considered of potential regional significance:** • Known from several other areas in the region, from multiple occurrences
14	**Not considered of local significance:** Mapped over several relatively large occurrences in the Study Area. Habitat for the significant flora taxa *Abutilon* aff. *hannii*, *Portulaca* sp., *Ptilotus mollis* (P4)	• Equivalent to VT17 (Woodman Environmental 2014) • Likely to be widespread due to presence in regional dataset (Woodman Environmental 2014)	**Not considered of potential regional significance:** • Known from several other areas in the region, from multiple occurrences
15	**Considered to be of local significance:** Mapped over a restricted area of the Study Area over few occurrences. Habitat for the significant flora taxa *Oldenlandia* sp., *Rostellularia adscendens* var. *latifolia* (P3)	• Equivalent to VT19 (Woodman Environmental 2014) • Likely to be widespread due to presence in regional dataset (Woodman Environmental 2014)	**Not considered of potential regional significance:** • Known from several other areas in the region, from multiple occurrences

6.4.3 Groundwater Dependant Vegetation

Five VTs are considered to potentially represent GDV in the Study Area, either wholly or in part ((Woodman Environmental 2018, 2019a). However, it is considered that these occurrences can only be GDV if groundwater is located within 10 m of the ground surface, as per groundwater modelling (Woodman Environmental 2018). Table 1 provides a summary of the VTs of the Study Area with the potential to be GDV, as per Woodman Environmental (2019).

Table 14: Potential Groundwater Dependency of Vegetation Types in the Study Area (Woodman Environmental 2019a)

Vegetation Type	Description (includes characteristic taxa)	Phreatophyte Taxa Present	Emergent Macrophytes	GDV Type (Figure 1)
3	Low open woodland of mixed species dominated by species including *Corymbia ferriticola*, *Ficus brachypoda*, *Terminalia canescens* over tall sparse shrubland usually dominated by *Acacia pruinocarpa* and *Acacia tumida* var. *pilbarensis* over low open mixed grassland dominated by *Triodia epactia*, *Cymbopogon ambiguus* and *Eriachne mucronata*, on red to brown sand to clay loam on ironstone or metamorphosed granite outcropping, in steep gorges, often with semi-permanent water	*Melaleuca argentea* – obligate (known); *Eucalyptus camaldulensis* subsp. *refulgens* – obligate or facultative (known); *Atalaya hemiglauca* – facultative (presumed); *Melaleuca glomerata* – facultative (presumed).	*Schoenoplectus subulatus*; *Typha domingensis*.	Facultative or Obligate in locations containing *Melaleuca argentea* and / or *Eucalyptus camaldulensis* subsp. *refulgens*
4	Low open woodland usually dominated by *Corymbia hamersleyana* over tall sparse shrubland dominated by mixed Acacia species including *A. trachycarpa* and *A. ancistrocarpa* with *Dichrostachys spicata* over low hummock grassland dominated by species including *Triodia wiseana* and *T. epactia* with *Eragrostis eriopoda* on brown sandy loams on plains and drainage lines	*Atalaya hemiglauca* – facultative (presumed); *Corymbia flavescens* – facultative (presumed); *Eucalyptus victrix* – facultative (presumed).		Facultative

Vegetation Type	Description (includes characteristic taxa)	Phreatophyte Taxa Present	Emergent Macrophytes	GDV Type (Figure 1)
8	Low isolated shrubs dominated by *Melaleuca glomerata* over mid hummock grassland dominated by *Triodia longiceps* over low mixed sedgeland, grassland and forbland of mixed species including *Schoenus falcatus*, *Trianthema cusackianum* and *Stemodia grossa* on white to brown clay to clayey sand with occasional calcrete and dolerite stones, at the head of drainage lines	*Acacia ampliceps* – facultative (presumed); *Eucalyptus victrix* – facultative (presumed); *Melaleuca glomerata* – facultative (presumed).		Facultative
14	Mid open woodland of mixed species including *Eucalyptus victrix* and *Corymbia hamersleyana* over tall open to sparse shrubland of mixed species including *Acacia coriacea* subsp. *pendens, Acacia trachycarpa*, *Acacia pyrifolia* var. *pyrifolia*, *Acacia tumida* var. *pilbarensis* and *Melaleuca glomerata* over low sparse shrubland of mixed species including *Pluchea ferdinandi-muelleri*, *Cajanus pubescens* and *Stemodia grossa* over mid open grassland and sedgeland of mixed species dominated by **Cenchrus ciliaris*, *Triodia longiceps*, *Triodia epactia*, *Chrysopogon fallax* and *Cyperus vaginatus* on red to brown sand to sandy loam with riverstones in minor to medium drainage lines	*Eucalyptus camaldulensis* subsp. *refulgens* – obligate or facultative (known); *Acacia ampliceps* – facultative (presumed); *Atalaya hemiglauca* – facultative (presumed); *Eucalyptus victrix* – facultative (presumed); *Melaleuca glomerata* – facultative (presumed); *Melaleuca linophylla* – facultative (presumed).	*Schoenoplectus subulatus*; *Typha domingensis*.	Facultative or Obligate in locations containing *Melaleuca argentea* and / or *Eucalyptus camaldulensis* subsp. *refulgens*
15	Mid open forest to woodland dominated by *Eucalyptus camaldulensis* subsp. *refulgens* and occasionally *Eucalyptus victrix* over tall open shrubland dominated by species including *Acacia ampliceps*, *Melaleuca glomerata* and *Acacia pyrifolia* var. *pyrifolia* over mixed mid open grassland and sedgeland dominated by **Cenchrus ciliaris*, *Cyperus vaginatus* and *Triodia longiceps* on red to brown sandy to clay loam with riverstone in major drainage lines	*Melaleuca argentea* – obligate (known); *Eucalyptus camaldulensis* subsp. *refulgens* – obligate or facultative (known); *Sesbania formosa* – obligate (presumed); *Acacia ampliceps* – facultative (presumed); *Atalaya hemiglauca* – facultative (presumed); *Eucalyptus victrix* – facultative (presumed); *Melaleuca glomerata* – facultative (presumed); *Melaleuca linophylla* – facultative (presumed)	*Potamogeton tricarinatus*; *Schoenoplectus subulatus*; *Typha domingensis.*	Obligate

Ground truthing of GDV conducted during the 2020 survey identified two locations where potential GDV could occur within the Stage 2 Development Envelope. Both locations occurred within areas mapped as VT3 and were characterised by the presence of the obligate phreatophyte *Melaleuca argentea.* One of the two locations (GDV A), where *Eucalyptus camaldulensis* subsp. *refulgens* was also present in the upper stratum, also presented as a permanent or semi-permanent surface water feature. Further assessment against ground water modelling will be required to determine if these locations represent GDVs. Figure 8 presents the location of the GDV found within the Stage 2 Development Envelope, representative photos are presented in Appendix Q.

VT 3 occurs exclusively in gorges within the range at Sanjiv Ridge and contains sites that host the obligate phreatophyte *Melaleuca argentea* and potentially obligate *Eucalyptus camaldulensis*, the presumed facultative phreatophytes *Atalaya hemiglauca* and *Melaleuca glomerata* as well as the emergent macrophytes *Typha domingensis* and *Schoenoplectus subulatus*. However, occurrences of these species are generally restricted to isolated expressions of surface water within this VT and the characteristic taxa of this VT are not known or presumed phreatophytes. Therefore, the full extent of vegetation in VT 3 is unlikely to be groundwater dependent; rather there is likely to be isolated occurrences of obligate GDV areas within this VT supported by expressions of aquifers within the range or perched waterholes (Woodman Environmental 2019a). These would include areas where *Melaleuca argentea* is present.

774000 775000 776000 777000 778000

7633000 7632000 7631000 7630000 7629000 7628000

GDV A

GDV A

GDV B

GDV B

9 10 14 3 11 C

Legend

- Stage 2 Development Envelope
- Vegetation Types
- Groundwater Dependent Vegetation

WOODMAN ENVIRONMENTAL

This map should only be used in conjunction with WEC project Atlas20-14-01.

N

Groundwater Dependent Vegetation of the Stage 2 Development Envelope

Revision: A - 22 January 2021 Scale: 1:17,000 (A3)

Author: Marco Pratissoli

WEC Ref: Atlas20-14-01

Filename: Atlas20-14-01-f08

Projection: GDA 1994 MGA Zone 50

Figure

8

7 DISCUSSION AND CONCLUSIONS

7.1 Flora of the Study Area

A total of 413 discrete vascular flora taxa, one known hybrid and one putative hybrid were recorded within the Study Area during surveys in 2014 – 2016. This total is higher than the estimate made using the Chao-2 estimator for taxon richness for the Study Area however this estimate only considers quadrat data and not opportunistic collections. The Study Area is considered to be of moderate floristic diversity. The taxon total is lower than that of the nearby, McPhee Creek Haul Road Project Study Area, however that study area includes a linear corridor that traverse far greater geographic distances than the more compact Study Area (see Figure 1). The total is higher than from the nearby Mount Webber DSO Project Study Area, McPhee Creek Iron Ore Project Study Area and McPhee Creek Rail Spur Project Study Area. It is considered that this survey captured a relatively high number of ephemeral taxa with over 140 annual taxa recorded.

A total of 17 taxa recorded in the Study Area are considered to be significant flora taxa. This includes 11 DBCA-classified Priority flora taxa, three potentially undescribed taxa, two taxa whose records are significantly disjunct from their known distributions and one taxon considered of taxonomic interest. A comprehensive targeted search was conducted only within the Stage 2 Development Envelope. None of the significant taxa are considered to have been comprehensively surveyed for in the remainder of the Study Area, although some opportunistic searching was undertaken for particular taxa. It is considered likely that further locations of the majority of significant flora taxa would be found in the Study Area if targeted survey was undertaken. However, for the significant taxa *Cochlospermum macnamarae* (P1), *Stylidium weeliwolli* (P2), *Acacia levata* (P3), *Schoenus coultasii* and *Eriocaulon pusillum* (significantly disjunct record), which all occur in association with granite-derived soils, further searching is unlikely to significantly increase their distributions in the Study Area.

Of the significant flora taxa known from the Study Area, *Oldenlandia* sp. (potentially undescribed), *Portulaca* sp. (potentially undescribed) and *Schoenus coultasii* (P1) are not currently known from elsewhere in Western Australia. These taxa are hence considered to be of the highest significance of the significant flora taxa known from the Study Area.

The remaining significant flora taxa known from the Study Area are all known from elsewhere in Western Australia; most are known from multiple localities over relatively wide distributions, however *Cochlospermum macnamarae* (P1) and *Abutilon* aff. *hannii* (potentially undescribed) are known from few localities over relatively restricted distributions and are not known from conservation reserves. As such these taxa are also considered of higher significance.

Acrostichum speciosum and *Eriocaulon pusillum* are widely distributed in the Kimberley region of Western Australia, and extend into the Northern Territory and Queensland, however the records of these taxa in the Study Area are significantly disjunct. Given the habitat that these taxa were recorded in the Study Area, it is considered unlikely that they will be particularly common in the region surrounding the Study Area. These taxa are therefore also considered of higher significance.

Several other collections from the Study Area may represent undescribed taxa, however these taxa are not considered to be significant flora taxa. These are generally widespread and common in the Study Area, or are known from other localities in the region where they are common. All such taxa (as well as the significant taxa *Oldenlandia* sp., *Portulaca* sp. and *Abutilon* aff. *hannii*) are from taxonomically complex groups that are currently undergoing or require revision by taxonomists; it is therefore unlikely that their taxonomic status will be resolved in the immediate future.

No listed Threatened or Priority species were found to occur within the Stage 2 Development Envelope during the targeted search conducted in 2020. One taxon of taxonomic interest (*Triumfetta aff. appendiculata*) was recorded within the Stage 2 Development Envelope. Although it is considered to be of taxonomic interest, it is not considered to be of significance, given that it is common over a relatively wide area of the Study Area, and is likely to occur elsewhere in the region based on the landforms it occurs on.

A total of 18 introduced flora taxa were recorded by the survey of the Study Area. Records of such taxa were often associated with drainage features that appear to be preferentially grazed by cattle over other areas. *Cenchrus ciliaris* (Buffel Grass) and *Aerva javanica* (Kapok Bush) were the most widespread and common taxa, with *Cenchrus ciliaris* often dominating the understorey at many locations. Both taxa are considered to be highly invasive and to cause significant impacts to vegetation. The remaining introduced flora taxa were recorded from a small number of locations and were generally not present in excessive numbers. One exception was *Passiflora foetida* var. *hispida*; this taxon, although only recorded at two locations in gorges, was common at both locations, and had germinated profusely following recent fire at one of the locations, where it was covering large areas of native vegetation. None of the introduced flora recorded in the Study Area are currently listed as Declared Pests in Western Australia (DPIRD 2020).

7.2 Vegetation of the Study Area

The floristic analysis of quadrat data from the Study Area identified 13 VTs that were then manually dissected to identify 15 VTs. A second analysis included quadrat data from several other studies conducted in the vicinity of the Study Area by Woodman Environmental over a range of years, and this was used to determine the potential distribution of VTs in the wider area.

Of the 15 VTs mapped within the Study Area, four were mapped over small areas within the Study Area, two were not represented in the broader regional dataset indicating they are potentially of regional significance. The diversity of VTs within the Study Area as a whole is considered to be low, as there are a limited number of topographical and soil types present, and there is a high degree of floristic similarity across the analysed dataset. The number of VTs mapped in the Study Area is lower than the nearby McPhee Creek Rail Spur Project Study Area (Woodman Environmental 2014c), where 18 VTs were mapped, with the McPhee Creek Rail Spur Project Study Area being smaller in size than the Study Area, however covering a much larger geographical distance.

In addition to potentially affecting the results of the floristic analysis, the effects of fire are also considered to have affected the confidence in the accuracy of VT mapping polygons to

an extent. However, it is considered that the VT mapping polygons presented in this report adequately characterise the vegetation of the Study Area based on available data, and are suitable for use in future impact assessments related to the Study Area.

None of the VTs mapped in the Study Area are considered to represent any TECs as classified by DBCA and endorsed by the Western Australian Minister for Environment or as listed under the EPBC Act, or any PECs as classified by DBCA. Eight VTs are considered to be of local significance, primarily because of their limited extent in the Study Area and also because they form habitat for conservation significant flora. Of these, four VTs (VTs 3, 6, 7 and 8) are also considered to be potentially regionally significant when considered in the context of the regional VT dataset.

VTs 3, 6, 7 and 8 are known from few occurrences in the Study Area, and are only known from a small number of further occurrences elsewhere in the region that are likewise small in size. All are likely to be present outside of surveyed areas based on the landforms they occur on. VT 3 in particular occurs in large gorges, often with at least semi-permanent water, a landform that, while likely to be present elsewhere, is relatively uncommon in the region. VT 8 has the potential to be a groundwater dependent ecosystem as it is dominated by taxa that prefer wet environments, however it is positioned near the base of the range and at the headwater of a creek system and not directly associated with a larger water reservoir or aquifer such as occur below rivers.

VT 2 appears to be exclusive habitat for *Cochlospermum macnamarae* (P1), both within the Study Area and elsewhere in the region (Woodman Environmental 2014c), and hence is considered to be of local significance in the Study Area. However, this VT is known from numerous occurrences regionally, many of which do not support *Cochlospermum macnamarae* (P1). It is therefore considered that this VT is not of regional significance in the context of being 'key habitat' for threatened species as outlined in EPA (2016).

VT 1 is not considered to be of local or regional significance despite containing the only location of several significant taxa (*Stylidium weeliwolli* (P3), *Eriocaulon pusillum* (significantly disjunct record) and *Schoenus coultasii* (P1)). This location is a seepage area of small size, and the significant flora taxa listed above do not occur elsewhere within this VT, as no other seepage areas were located. Such seepage areas are not common in the region in general, and are not restricted to this VT, occurring in a variety of habitats associated with rocky areas (Woodman Environmental field observations), including granite outcrops and gorges derived from other substrates such as ironstone.

The majority of the vegetation in the Study Area was ranked as being in Excellent condition, with little to no human disturbance and an absence or low levels of introduced flora taxa. However, the majority of larger drainage features, including creeks and flow lines, had lower condition scores as a result of the presence of high densities of aggressive introduced species and high grazing and trampling impacts from cattle. There was also a general trend towards poorer vegetation in drainage features in the south-western corner of the Study Area and also in closer proximity to Marble Bar in the north, with grazing impacts in drainage features appearing higher than in most other parts of the Study Area. This is likely because the locations of these areas are in lower parts of the landscape with flatter topography compared

to the remainder of the Study Area which consists of steep hills. Flatter topography is more accessible to cattle and is likely preferentially grazed.

7.3 Identification of Groundwater Dependent Vegetation

Based on the presence of the obligate phreatophytes *Melaleuca argentea* and *Eucalyptus camaldulensis*, as well as the facultative phreatophyte *Eucalyptus victrix*, and the potential facultative phreatophyte *Melaleuca glomerata* and *Atalaya hemiglauca*, there is the potential that all areas of vegetation in the Study Area mapped as VT 3, 4, 8, 14 and 15 are GDVs. VT 14 is characterised by the presence of *Eucalyptus victrix* and occasionally *Eucalyptus camaldulensis* as the dominant tree in the upper stratum, with *Eucalyptus camaldulensis*, or a combination of *Eucalyptus victrix* and *Melaleuca argentea*, often dominating the upper stratum of VT 15. *Eucalyptus victrix* and *Melaleuca glomerata* also both occur in VT 8 with *Eucalyptus victrix* and *Atalaya hemiglauca* occurring in VT 4. VT 3 occurs primarily in deep rocky gorges and as such probably is supplied by perched runoff water and therefore not a true GDV. It is considered desirable for all areas of VTs 14 and 15 to be considered potential GDVs until groundwater levels in the Study Area are known.

It is certain that vegetation containing *Melaleuca argentea* is a GDV, as this species is known to be an obligate phreatophyte and has a root system adapted to areas of very shallow groundwater (2-3 m below ground level) (Department of Water 2010). In the Study Area, this species has only been recorded in rocky gorges, including the two locations newly recorded within the Stage 2 Development Envelope, and in the Coongan River channel in VT 15, to the east of the Stage 2 Development Envelope. It has been recorded along the length of the Coongan River channel, along with *Eucalyptus camaldulensis* and *Eucalyptus victrix*. These areas are therefore considered to be the most significant in terms of potential impacts to GDV health if groundwater drawdown occurs.

It is also highly likely that several other areas of VTs 14 and 15 are GDVs, based on the presence of *Eucalyptus camaldulensis*. This species is usually an obligate phreatophyte, being found in riparian zones; however, it has been found higher in the landscape on floodplains where the groundwater is up to 21 m below ground level (Department of Water 2010). This species has a bimorphic root system (surface lateral roots and a tap root) capable of utilising both groundwater and soil water from the unsaturated soil profile and is likely to be a facultative phreatophyte in these areas.

The potential facultative phreatophytes *Atalaya hemiglauca* and *Ficus aculeata* also occur in other VTs in the Study Area, including VTs 5, 6, 7, 10, 11 and 12. However, upon examination of the locations of these taxa in these VTs, it has been determined that these species are unlikely to be phreatophytic at these locations, as they occur in areas where the groundwater is unlikely to be close enough to the surface to be accessible by vegetation (outcrops and hillslopes). Rather, the locations that they occur at in these VTs are areas that receive a relatively high volume of seasonal run-off. They also do not occur with the obligate phreatophytes *Eucalyptus camaldulensis* and *Melaleuca argentea*, and the facultative phreatophyte *Eucalyptus victrix*. Therefore, these areas are not considered to be GDVs.

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Appendix A: Results of Search of the Department of the Environment and Energy Species Profile and Threats (SPRAT) Database (DoEE 2020)

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

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

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

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

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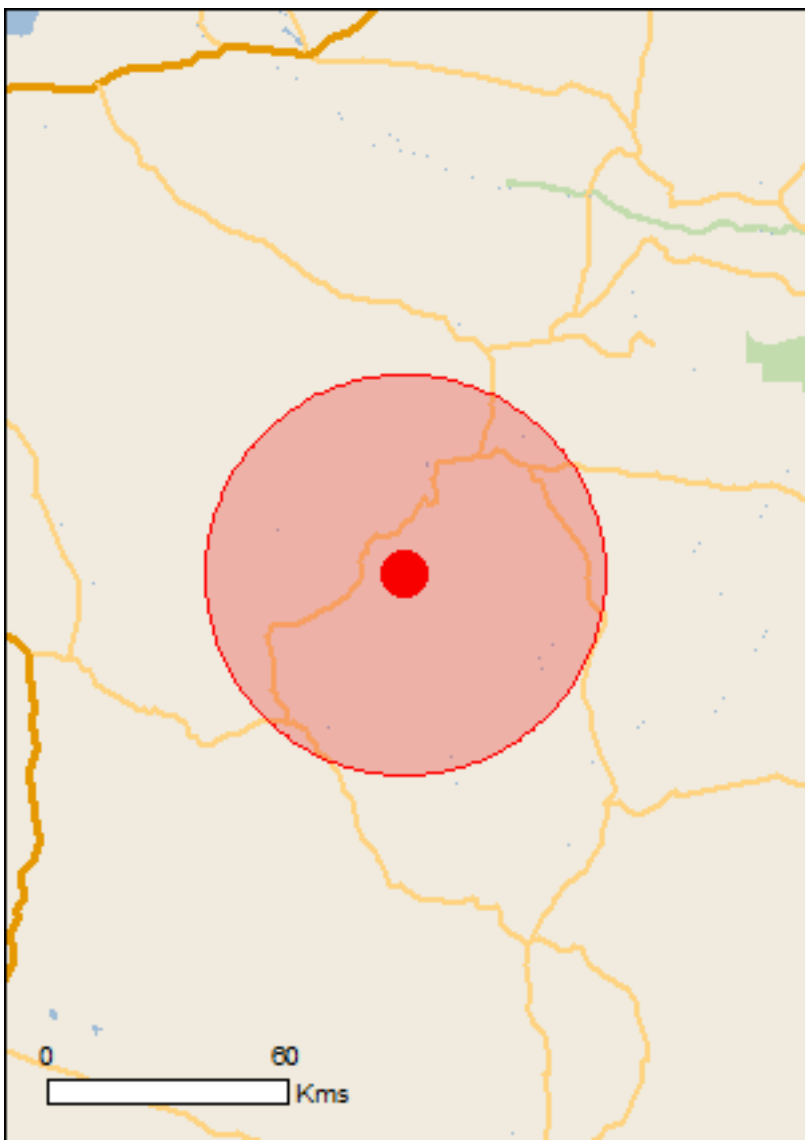

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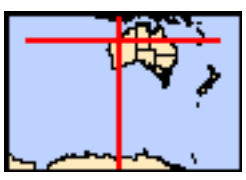
Coordinates
Buffer: 50.0Km



Summary

Matters of National Environmental Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	9
Listed Migratory Species:	11

Other Matters Protected by the EPBC Act

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

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

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

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	17
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	12
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Pezoporus occidentalis		
Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Breeding known to occur within area
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Roosting known to occur within area
Plants		
Pityrodia sp. Marble Bar (G.Woodman & D.Coultas GWDC Opp 4)		
[88310]	Endangered	Species or species habitat likely to occur within area
Reptiles		
Liasis olivaceus barroni		
Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Hirundo rustica		
Barn Swallow [662]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
[Motacilla cinerea](#) Grey Wagtail [642]		Species or species habitat may occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat known to occur within area
Migratory Wetlands Species		
[Actitis hypoleucos](#) Common Sandpiper [59309]		Species or species habitat known to occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area
[Charadrius veredus](#) Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
[Glareola maldivarum](#) Oriental Pratincole [840]		Species or species habitat may occur within area
[Pandion haliaetus](#) Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

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

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

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

Name	Threatened	Type of Presence
Birds		
[Actitis hypoleucos](#) Common Sandpiper [59309]		Species or species habitat known to occur within area
[Apus pacificus](#) Fork-tailed Swift [678]		Species or species habitat likely to occur within area
[Ardea alba](#) Great Egret, White Egret [59541]		Species or species habitat known to occur within area
[Ardea ibis](#) Cattle Egret [59542]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Reptiles		
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat may occur within area

Caveat

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

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

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

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

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

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

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-21.41119 119.66117

Acknowledgements

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

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

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

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

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Appendix B: Definitions, Categories and Criteria for Threatened and Priority Ecological Communities (DBCA 2013)

1. GENERAL DEFINITIONS

Ecological Community: A naturally occurring biological assemblage that occurs in a particular type of habitat.

Note: The scale at which ecological communities are defined will often depend on the level of detail in the information source, therefore no particular scale is specified.

A **threatened ecological community** (TEC) is one which is found to fit into one of the following categories; "presumed totally destroyed", "critically endangered", "endangered" or "vulnerable".

Possible threatened ecological communities that do not meet survey criteria are added to DEC's Priority Ecological Community Lists under Priorities 1, 2 and 3. Ecological Communities that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

An **assemblage** is a defined group of biological entities.

Habitat is defined as the areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (eg. substrate and topography), and the biotic factors.

Occurrence: a discrete example of an ecological community, separated from other examples of the same community by more than 20 metres of a different ecological community, an artificial surface or a totally destroyed community.

By ensuring that every discrete occurrence is recognised and recorded future changes in status can be readily monitored.

Adequately Surveyed is defined as follows:
"An ecological community that has been searched for thoroughly in most likely habitats, by relevant experts."

Community structure is defined as follows:
"The spatial organisation, construction and arrangement of the biological elements comprising a biological assemblage" (eg. *Eucalyptus salmonophloia* woodland over scattered small shrubs over dense herbs; structure in a faunal assemblage could refer to trophic structure, eg. dominance by feeders on detritus as distinct from feeders on live plants).

Definitions of Modification and Destruction of an ecological community:
Modification: "changes to some or all of ecological processes (including abiotic processes such as hydrology), species composition and community structure as a direct or indirect result

of human activities. The level of damage involved could be ameliorated naturally or by human intervention."

Destruction: "modification such that reestablishment of ecological processes, species composition and community structure within the range of variability exhibited by the original community is unlikely within the foreseeable future even with positive human intervention."

Note: Modification and destruction are difficult concepts to quantify, and their application will be determined by scientific judgement. Examples of modification and total destruction are cited below:

Modification of ecological processes: The hydrology of Toolibin Lake has been altered by clearing of the catchment such that death of some of the original flora has occurred due to dependence on fresh water. The system may be bought back to a semblance of the original state by redirecting saline runoff and pumping waters of the rising underground watertable away to restore the hydrological balance. Total destruction of downstream lakes has occurred due to hydrology being altered to the point that few of the original flora or fauna species are able to tolerate the level of salinity and/or water logging.

Modification of structure: The understorey of a plant community may be altered by weed invasion due to nutrient enrichment by addition of fertiliser. Should the additional nutrients be removed from the system the balance may be restored, and the original plant species better able to compete. Total destruction may occur if additional nutrients continue to be added to the system causing the understorey to be completely replaced by weed species, and death of overstorey species due to inability to tolerate high nutrient levels.

Modification of species composition: Pollution may cause alteration of the invertebrate species present in a freshwater lake. Removal of pollutants may allow the return of the original inhabitant species. Addition of residual highly toxic substances may cause permanent changes to water quality, and total destruction of the community.

Threatening processes are defined as follows:
"Any process or activity that threatens to destroy or significantly modify the ecological community and/or affect the continuing evolutionary processes within any ecological community."

Examples of some of the continuing threatening processes in Western Australia include: general pollution; competition, predation and change induced in ecological communities as a result of introduced animals; competition and displacement of native plants by introduced species; hydrological changes; inappropriate fire regimes; diseases resulting from introduced microorganisms; direct human exploitation and disturbance of ecological communities.

Restoration is defined as returning an ecological community to its pre-disturbance or natural state in terms of abiotic conditions, community structure and species composition.

Rehabilitation is defined as the re-establishment of ecological attributes in a damaged ecological community although the community will remain modified.

2. DEFINITIONS AND CRITERIA FOR PRESUMED TOTALLY DESTROYED, CRITICALLY ENDANGERED, ENDANGERED AND VULNERABLE ECOLOGICAL COMMUNITIES

Presumed Totally Destroyed (PD)
An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant **and either** of the following applies (A or B):

A) Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats **or**

B) All occurrences recorded within the last 50 years have since been destroyed

Critically Endangered (CR)
An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.

An ecological community will be listed as **Critically Endangered** when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting **any one or more** of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% **and either or both** of the following apply (i or ii):

i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years);

ii) modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, **and one or more** of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years);

ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes;

iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes.

C) The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).

Endangered (EN)
An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.

An ecological community will be listed as **Endangered** when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting **any one or more** of the following criteria (A, B, or C):

A) The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement **and either or both** of the following apply (i or ii):

i) the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years);

ii) modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, **and one or more** of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years);

ii) there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes;

iii) there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes.

C) The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).

Vulnerable (VU)
An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into

a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.

An ecological community will be listed as **Vulnerable** when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium (within approximately 50 years) to long-term future. This will be determined on the basis of the best available information by it meeting **any one or more** of the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated.

B) The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

3. DEFINITIONS AND CRITERIA FOR PRIORITY ECOLOGICAL COMMUNITIES PRIORITY ECOLOGICAL COMMUNITY LIST

Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community Lists under Priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community. Ecological Communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly-known ecological communities:

Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly-known ecological communities:

Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). At least some occurrences are not believed to be under immediate threat (within approximately 10 years) of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities:

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) Communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat (within approximately 10 years), or;

(iii) Communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, inappropriate fire regimes, clearing, hydrological change etc.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities:

Communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for a higher threat category.

(iii) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities:

Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Current as of January 2013

Appendix C: Conservation Codes for Western Australian Flora and Fauna (DBCA 2020)

Threatened, Extinct and Specially Protected fauna or flora[1] are species[2] which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such.

The *Wildlife Conservation (Specially Protected Fauna) Notice 2018* and the *Wildlife Conservation (Rare Flora) Notice 2018* have been transitioned under regulations 170, 171 and 172 of the *Biodiversity Conservation Regulations 2018* to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016.*

Categories of Threatened, Extinct and Specially Protected fauna and flora are:

T Threatened species

Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act).

Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for Threatened Fauna.

Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the *Wildlife Conservation (Rare Flora) Notice 2018* for Threatened Flora.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

CR Critically endangered species

Threatened species considered to be "*facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines*".

Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for critically endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for critically endangered flora.

EN Endangered species

Threatened species considered to be "*facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines*".

Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the *Wildlife*

Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for endangered flora.

VU Vulnerable species

Threatened species considered to be "*facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines*".

Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for vulnerable fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for vulnerable flora.

Extinct species

Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.

EX Extinct species

Species where "*there is no reasonable doubt that the last member of the species has died*", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).

Published as presumed extinct under schedule 4 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018* for extinct fauna or the *Wildlife Conservation (Rare Flora) Notice 2018* for extinct flora.

EW Extinct in the wild species

Species that *"is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form*", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).

Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.

Specially protected species

Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.

Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.

MI Migratory species

Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).

Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the *Convention on the Conservation of Migratory Species of Wild Animals* (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species.

Published as migratory birds protected under an international agreement under schedule 5 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

CD Species of special conservation interest (conservation dependent fauna)

Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act).

Published as conservation dependent fauna under schedule 6 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

OS Other specially protected species

Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).

Published as other specially protected fauna under schedule 7 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2018*.

P Priority species

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Priority 1: Poorly-known species

Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

Priority 2: Poorly-known species

Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

Priority 3: Poorly-known species

Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

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

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands.
(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent.

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

Notes:
[1] The definition of flora includes algae, fungi and lichens
[2]Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Last updated 3 January 2019

Appendix D: Ecological Impact and Invasiveness Ratings from the Department of Parks and Wildlife Pilbara Region Species Prioritisation Process 2014 (DBCA 2014)

FIELD	DESCRIPTION	CODE	
Ecological Impact	Impact of species within the Region, from low impact (causes minimal disruption to ecological processes or loss of biodiversity) to high (causes acute disruption of ecological processes, dominates and/or significantly alters vegetation structure, composition and function of ecosystems). Examples of impact attributes to consider: - changed fire regime - changed nutrient conditions - changed hydrological patterns - changed soil erosion patterns - changed geomorphological processes - changed biomass distribution - changed light distribution - loss of biodiversity - substantially reduces regeneration opportunities of native plants - allelopathic effects	L M H U	Low Medium High Unknown

FIELD	DESCRIPTION	CODE	
Invasiveness	Rate of spread of a weed in native vegetation, encompassing factors of establishment, reproduction and long distance dispersal (>100m). Examples of establishment factors include: - ability to outcompete (light, moisture, nutrients, rapid root growth) - sexual or asexual establishment - need for disturbance to establish Examples of reproduction factors include: - time to seeding - seed production - vegetative reproduction Examples of long distance dispersal mechanisms include: - wind - water - flying/ground animals - deliberate/accidental human spread - vehicles - produce contaminant	S M R U	Slow Moderate Rapid Unknown

Appendix E: Vegetation Condition Scale for the Eremaean and Northern Botanical Provinces (adapted from Keighery (1994), for the Pilbara Biological Survey (McKenzie *et al.* (2009))

Condition Ranking	Description
E (Excellent)	Pristine or nearly so, no obvious signs of damage caused by human activities since European settlement.
VG (Very Good)	Some relatively slight signs of damage caused by human activities since European settlement. For example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds, or occasional vehicle tracks.
G (Good)	More obvious signs of damage caused by human activities since European settlement, including some obvious impact on the vegetation structure such as that caused by low levels of grazing or slightly aggressive weeds.
P (Poor)	Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of human activities since European settlement, such as grazing, partial clearing, frequent fires or aggressive weeds.
VP (Very Poor)	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species present including very aggressive species.
D (Completely Degraded)	Areas that are completely or almost completely without native species in the structure of their vegetation; i.e. areas that are cleared or 'parkland cleared' with their flora comprising of weed or crop species with isolated native trees or shrubs.

Appendix F: Vascular Plant Taxa Amalgamated in or Omitted From the Floristic Analysis

Description	Taxon	Reasoning
Omitted Taxa	*Abutilon* sp. (unidentified)	Taxonomy unclear
	Acacia ampliceps x *sclerosperma subsp. sclerosperma*	Known hybrid
	Acacia ancistrocarpa x *tumida var. pilbarensis*	Putative hybrid
	Acacia arida (variant?)	Likely to be a hybrid
	Acacia eriopoda x *trachycarpa*	Known hybrid
	Acacia ?eriopoda	Taxonomy unclear
	Acacia ?holosericea	Taxonomy unclear
	Acacia ?hilliana x *stellaticeps*	Known hybrid
	Acacia monticola x	Putative hybrid
	Acacia monticola x *trachycarpa*	Known hybrid
	Acacia monticola x *tumida var. pilbarensis*	Known hybrid
	Acacia sphaerostachya	Known hybrid
	Acacia trachycarpa x *tumida var. pilbarensis*	Known hybrid
	Acacia trachycarpa x?	Putative hybrid
	Acacia tumida var. *pilbarensis* x ?*ancistrocarpa*	Putative hybrid
	Acacia ?tumida x	Putative hybrid
	Acacia sp. (hybrid)	Putative hybrid
	Acacia sp. indet	Taxonomy unclear
	Amyema preissii	Parasitic, random occurrence
	Amyema sanguinea var. *sanguinea*	Parasitic, random occurrence
	Amyema ?sanguinea var. *sanguinea*	Parasitic, random occurrence
	?*Bonamia* sp.	Taxonomy unclear
	Cheilanthes brownii	Geophyte perennial
	Cheilanthes ?lasiophylla	Geophyte perennial
	Cheilanthes sieberi subsp. *pseudovellea*	Geophyte perennial
	Cheilanthes sieberi subsp. *sieberi*	Geophyte perennial
	Cheilanthes sp.	Geophyte perennial
	?*Chrysopogon fallax*	Taxonomy unclear
	Corchorus sp. (unidentified)	Taxonomy unclear
	Crotalaria novae-hollandiae subsp. *novae-hollandiae*	Short-lived perennial, occurring in recently burnt areas only
	?*Crotalaria* sp.	Taxonomy unclear
	Cullen martinii	Short-lived perennial, occurring in recently burnt areas only
	Cullen pogonocarpum	Short-lived perennial, occurring in recently burnt areas only
	?*Cyperus difformis*	Taxonomy unclear
	Cyperus ?iria	Taxonomy unclear
	Cyperus pulchellus	Geophyte perennial
	Eragrostis sp.	Taxonomy unclear
	Eriachne ?helmsii	Taxonomy unclear

Description	Taxon	Reasoning
Omitted Taxa cont.	*Fimbristylis dichotoma*	Geophyte perennial
	Gomphrena sp. (inadequate material)	Taxonomy unclear
	Heliotropium skeleton	Short-lived perennial, occurring in recently burnt areas only
	Heliotropium sp.	Taxonomy unclear
	?*Hibiscus* sp.	Taxonomy unclear
	?*Seringia* sp.	Taxonomy unclear
	?*Maireana* sp.	Taxonomy unclear
	Marsilea hirsuta	Geophyte perennial
	?*Mollugo molluginea*	Taxonomy unclear
	?*Pluchea rubelliflora*	Taxonomy unclear
	Pterocaulon ?*serrulatum*	Taxonomy unclear
	Pterocaulon sp.	Taxonomy unclear
	Ptilotus nobilis subsp. *nobilis*	Geophyte perennial
	?*Schoenoplectus laevis*	Taxonomy unclear
	?*Sclerolaena* sp.	Taxonomy unclear
	Senna artemisioides subsp. *helmsii* x *oligophylla*	Putative hybrid
	Senna artemisioides subsp. *oligophylla* x ?*symonii*	Putative hybrid
	Senna artemisioides subsp. *oligophylla* x ?	Putative hybrid
	Senna glutinosa subsp. x *luerssenii*	Known hybrid
	Senna ?*glutinosa* hybrid	Putative hybrid
	Senna notabilis	Short-lived perennial, generally occurring in recently burnt areas only
	Senna symonii ?x	Putative hybrid
	Sida ?*arenicola*	Taxonomy unclear
	Sida sp. (unidentified)	Taxonomy unclear
	Stemodia sp.	Taxonomy unclear
	Streptoglossa ?*bubakii*	Taxonomy unclear
	Streptoglossa ?*odora*	Taxonomy unclear
	Streptoglossa sp.	Taxonomy unclear
	Swainsona formosa	Short-lived perennial, occurring in recently burnt areas only
	Tephrosia stipuligera	Short-lived perennial, occurring in recently burnt areas only
	Tribulus hirsutus	Short-lived perennial, occurring in recently burnt areas only
	Tribulus platypterus	Short-lived perennial, occurring in recently burnt areas only
	Tribulus sp. long-styled eichlerianus (A.S. George 10666)	Short-lived perennial, occurring in recently burnt areas only
	Trichodesma zeylanicum	Short-lived perennial, occurring in recently burnt areas only
	Triumfetta clementii	Short-lived perennial, occurring in recently burnt areas only
	Velleia connata	Short-lived perennial, occurring in recently burnt areas only
	Zornia albiflora	Geophyte perennial

Description	Taxon	Reasoning
Omitted Taxa cont.	*Zornia muelleriana* subsp. *congesta*	Geophyte perennial
Amalgamated Taxa	*Abutilon* ?*lepidum*	Amalgamated with *Abutilon lepidum*
	Acacia bivenosa x *sclerosperma* subsp. *sclerosperma*	Known hybrid
	Acacia colei var. colei	Amalgamated with *Acacia colei* – taxonomy unclear in the field
	Acacia pyrifolia var. *morrisonii*	Amalgamated with *Acacia pyrifolia* var. *pyrifolia* – unlikely to be *Acacia pyrifolia* var. *morrisonii*, more likely to be a non-pruinose variant of *Acacia pyrifolia* var. *pyrifolia*
	Bonamia ?*alatisemina*	Amalgamated with *Bonamia alatisemina*
	Bonamia ?*erecta*	Amalgamated with *Bonamia erecta*
	Clerodendrum floribundum var. *angustifolium*; *Clerodendrum floribundum* var. *floribundum*	Amalgamated with *Clerodendrum floribundum* – taxonomy often unclear in the field, no correlation between variants and VTs
	Clerodendrum tomentosum var. *lanceolatum; Clerodendrum tomentosum* var. *tomentosum*	Amalgamated with *Clerodendrum tomentosum* – taxonomy often unclear in the field, no correlation between variants and VTs
	Corchorus ?*sidoides* subsp. *sidoides*	Amalgamated with *Corchorus sidoides* subsp. *sidoides*
	Corymbia candida subsp. *lautifolia*	Amalgamated with *Corymbia flavescens*
	Corymbia ?*ferriticola*	Amalgamated with *Corymbia ferriticola*
	Eragrostis ?*eriopoda*	Amalgamated with *Eragrostis eriopoda*
	Eriachne aff. *benthamii*	Amalgamated with *Eriachne benthamii* – taxonomy previously confused/unclear
	Eriachne aff. *festucacea*	Amalgamated with *Eriachne benthamii* – taxonomy previously confused/unclear
	Eucalyptus camaldulensis subsp. *refulgens*	Amalgamated with *Eucalyptus camaldulensis* - taxonomy often unclear in the field
	Eucalyptus ?*xerothermica*	Amalgamated with *Eucalyptus xerothermica*
	Euphorbia alsiniflora	Amalgamated with *Euphorbia trigonosperma* – changes in taxonomy
	Goodenia ?*muelleriana*	Amalgamated with *Goodenia muelleriana*
	Goodenia ?*nuda*	Amalgamated with *Goodenia nuda*
	Goodenia ?*stobbsiana*	Amalgamated with *Goodenia stobbsiana*
	Grevillea wickhamii subsp. *aprica*; *Grevillea wickhamii* subsp. *hispidula*; *Grevillea wickhamii* subsp. *macrodonta*	Amalgamated with *Grevillea wickhamii* - taxonomy often unclear in the field, no correlation between variants and VTs
	Melhania aff. *oblongifolia*	Amalgamated with *Melhania oblongifolia*
	Neptunia ?*dimorphantha*	Amalgamated with *Neptunia dimorphantha*
	Pluchea ?*dentex*	Amalgamated with *Pluchea dentex*
	Pluchea ?*rubelliflora*	Amalgamated with *Pluchea rubelliflora*
	Pterocaulon ?*sphaeranthoides*	Amalgamated with *Pterocaulon sphaeranthoides*
	Sida ?*clementii*	Amalgamated with *Sida clementii*

Description	Taxon	Reasoning
Amalgamated Taxa cont.	*Sida* ?*echinocarpa*	Amalgamated with *Sida echinocarpa*
	Sida ?*fibulifera*; *Sida* aff. *fibulifera*	Amalgamated with *Sida fibulifera*
	Sida ?*macropoda* (complex)	Amalgamated with *Sida macropoda*
	Solanum ?*cleistogamum*	Amalgamated with *Solanum cleistogamum*
	Solanum ?*phlomoides*	Amalgamated with *Solanum phlomoides*
	Stemodia ?*grossa*	Amalgamated with *Stemodia grossa*
	Streptoglossa ?*decurrens*	Amalgamated with *Streptoglossa decurrens*
	Triodia ?*brizoides*	Amalgamated with *Triodia brizoides*

Appendix G: OptimClass Combinations Tested for Classification Analysis

Clustering	Resemblance	Transformation
Average Linkage (UPGMA)	Bray-Curtis	none
Average Linkage (UPGMA)	Bray-Curtis	log(2)
Average Linkage (UPGMA)	Bray-Curtis	power 0.333
Average Linkage (UPGMA)	Bray-Curtis	power 0
Average Linkage (UPGMA)	Jaccard	none
Average Linkage (UPGMA)	Jaccard	log(2)
Average Linkage (UPGMA)	Jaccard	power 0.333
Average Linkage (UPGMA)	Jaccard	power 0
Beta flexible (□ = -0.25)	Bray-Curtis	none
Beta flexible (□ = -0.25)	Bray-Curtis	log(2)
Beta flexible (□ = -0.25)	Bray-Curtis	power 0.333
Beta flexible (□ = -0.25)	Bray-Curtis	power 0
Beta flexible (□ = -0.25)	Jaccard	none
Beta flexible (□ = -0.25)	Jaccard	log(2)
Beta flexible (□ = -0.25)	Jaccard	power 0.333
Beta flexible (□ = -0.25)	Jaccard	power 0
Beta flexible (□ = -0.1)	Bray-Curtis	none
Beta flexible (□ = -0.1)	Bray-Curtis	log(2)
Beta flexible (□ = -0.1)	Bray-Curtis	power 0.333
Beta flexible (□ = -0.1)	Bray-Curtis	power 0
Beta flexible (□ = -0.1)	Jaccard	none
Beta flexible (□ = -0.1)	Jaccard	log(2)
Beta flexible (□ = -0.1)	Jaccard	power 0.333
Beta flexible (□ = -0.1)	Jaccard	power 0
Beta flexible (□ = -0.4)	Bray-Curtis	none
Beta flexible (□ = -0.4)	Bray-Curtis	log(2)
Beta flexible (□ = -0.4)	Bray-Curtis	power 0.333
Beta flexible (□ = -0.4)	Bray-Curtis	power 0
Beta flexible (□ = -0.4)	Jaccard	none
Beta flexible (□ = -0.4)	Jaccard	log(2)
Beta flexible (□ = -0.4)	Jaccard	power 0.333
Beta flexible (□ = -0.4)	Jaccard	power 0
Ward's method (= ISS)	Chord (= normalised ED)	none
Ward's method (= ISS)	Chord (= normalised ED)	log(2)
Ward's method (= ISS)	Chord (= normalised ED)	power 0.333
Ward's method (= ISS)	Chord (= normalised ED)	power 0
Ward's method (= ISS)	Euclid	none
Ward's method (= ISS)	Euclid	log(2)
Ward's method (= ISS)	Euclid	power 0.333
Ward's method (= ISS)	Euclid	power 0
Furthest neighbour (CLC)	Bray-Curtis	none
Furthest neighbour (CLC)	Bray-Curtis	log(2)
Furthest neighbour (CLC)	Bray-Curtis	power 0.333
Furthest neighbour (CLC)	Bray-Curtis	power 0
Furthest neighbour (CLC)	Jaccard	none
Furthest neighbour (CLC)	Jaccard	log(2)
Furthest neighbour (CLC)	Jaccard	power 0.333
Furthest neighbour (CLC)	Jaccard	power 0

Appendix H: Misclassified Quadrats Manually Reassigned within the Floristic Classification

Quadrat	Original Dendrogram VT	Reallocation VT	Reasoning
CD-045	VT 2	VT 1	Quadrat placed within an ecotone
CD-086	VT 2	VT 12	Quadrat placed within an ecotone
CD-109	VT 1	VT 10	Quadrat placed within an ecotone
CD-112	VT 1	VT 10	Quadrat placed within an ecotone
CD-139	VT 2	VT 12	Quadrat placed within an ecotone
CD-155	VT 2	VT 10	Quadrat placed within an ecotone
CD-168	VT 2	VT 10	Quadrat placed within an ecotone
CD-200	VT 2	VT 1	Quadrat placed within an ecotone
CD-255	VT 1	VT 10	Quadrat placed within an ecotone
CD-407	VT 2	VT 10	Quadrat placed within an ecotone
CE-022	VT 2	VT 5	Quadrat placed within an ecotone
CE-034	VT 2	VT 12	Quadrat placed within an ecotone
CE-035	VT 1	VT 5	Species-poor quadrat
CE-040	VT 1	VT 5	Species-poor quadrat
CE-045	VT 1	VT 5	Species-poor quadrat
CE-072	VT 2	VT 12	Quadrat placed within an ecotone
CE-086	VT 2	VT 5	Quadrat placed within an ecotone, recently burnt
CE-137	VT 1	VT 10	Quadrat placed within an ecotone
CE-139	VT 1	VT 10	Quadrat placed within an ecotone
CE-145	VT 1	VT 10	Quadrat placed within an ecotone
CE-150	VT 2	VT 10	Quadrat placed within an ecotone, recently burnt
CE-152	VT 1	VT 11	Species-poor quadrat
CE-172	VT 1	VT 5	Species-poor quadrat
CE-176	VT 1	VT 5	Species-poor quadrat
CE-188	VT 1	VT 11	Species-poor quadrat
CE-306B	VT 2	VT 5	Quadrat placed within an ecotone, recently burnt

Appendix I: Vascular Plant Taxa Recorded in the Study Area, 2014 and 2016

Note: * denotes introduced taxon

FAMILY	TAXON
Acanthaceae	*Rostellularia adscendens* var. *latifolia* (P3)
Aizoaceae	*Trianthema cusackianum* *Trianthema oxycalyptrum* var. *oxycalyptrum* *Trianthema pilosum* *Trianthema triquetrum* *Zaleya galericulata* subsp. *galericulata*
Amaranthaceae	**Aerva javanica* *Alternanthera angustifolia* *Alternanthera nana* *Amaranthus cuspidifolius* *Amaranthus undulatus* *?*Amaranthus viridis* *Gomphrena cunninghamii* *Gomphrena leptoclada* subsp. *leptoclada* *Ptilotus astrolasius* *Ptilotus auriculifolius* *Ptilotus axillaris* *Ptilotus calostachyus* *Ptilotus clementii* *Ptilotus fusiformis* *Ptilotus gomphrenoides* *Ptilotus incanus* *Ptilotus mollis* (P4) *Ptilotus murrayi* *Ptilotus nobilis* subsp. *nobilis* *Ptilotus obovatus*
Apocynaceae	**Calotropis procera* *Carissa lanceolata* *Cynanchum floribundum* *Marsdenia angustata* *Sarcostemma viminale* subsp. *australe* *Tylophora flexuosa*
Araliaceae	*Trachymene oleracea* subsp. *oleracea*
Asteraceae	Asteraceae sp. *Blumea tenella* *Centipeda minima* subsp. *macrocephala* **Flaveria trinervia*

Asteraceae cont.	*Pentalepis trichodesmoides* subsp. *trichodesmoides*
	Peripleura virgata
	Pluchea dentex
	Pluchea ferdinandi-muelleri
	Pluchea rubelliflora
	Pluchea tetranthera
	Podolepis capillaris
	Pterocaulon sphacelatum
	Pterocaulon sphaeranthoides
	**Sonchus oleraceus*
	Streptoglossa bubakii
	Streptoglossa decurrens
	Streptoglossa liatroides
Bixaceae	*Cochlospermum macnamarae* (P1)
Boraginaceae	*Ehretia saligna* var. *saligna*
	Heliotropium chrysocarpum
	Heliotropium crispatum
	Heliotropium cunninghamii
	Heliotropium heteranthum
	Heliotropium murinum (P3)
	Heliotropium ovalifolium
	Heliotropium pachyphyllum
	Heliotropium skeleton
	Heliotropium tanythrix
	Heliotropium tenuifolium
	Trichodesma zeylanicum
Brassicaceae	?*Lepidium pholidogynum*
Campanulaceae	*Lobelia arnhemiaca*
	Wahlenbergia tumidifructa
Capparaceae	*Capparis spinosa* var. *nummularia*
Caryophyllaceae	*Polycarpaea corymbosa*
	Polycarpaea holtzei
	Polycarpaea involucrata
	Polycarpaea longiflora
Celastraceae	*Stackhousia muricata*
Chenopodiaceae	*Dysphania rhadinostachya* subsp. *rhadinostachya*
	Dysphania sphaerosperma
	Salsola australis
	Sclerolaena costata
	Sclerolaena densiflora

Chenopodiaceae cont.	*Sclerolaena hostilis*
Cleomaceae	*Cleome viscosa*
Combretaceae	*Terminalia canescens*
Commelinaceae	*Commelina ensifolia*
Convolvulaceae	*Bonamia alatisemina* *Bonamia erecta* *Bonamia media* *Bonamia pannosa* *Bonamia pilbarensis* *Bonamia* aff. *pilbarensis* *Evolvulus alsinoides* var. *villosicalyx* *Ipomoea coptica* *Ipomoea lonchophylla* *Ipomoea muelleri* *Ipomoea polymorpha* *Operculina aequisepala* *Polymeria ambigua*
Cucurbitaceae	*Austrobryonia pilbarensis* *Cucumis melo* *Cucumis variabilis* *Trichosanthes cucumerina*
Cyperaceae	*Bulbostylis barbata* *Cyperus bifax* *Cyperus blakeanus* *Cyperus cunninghamii* subsp. *cunninghamii* *Cyperus difformis* *Cyperus hesperius* *Cyperus iria* *Cyperus ixiocarpus* *Cyperus pulchellus* *Cyperus squarrosus* *Cyperus vaginatus* *Eleocharis geniculata* *Fimbristylis dichotoma* *Fimbristylis elegans* *Fimbristylis microcarya* *Fimbristylis simulans* *Fuirena ciliaris* *Lipocarpha microcephala* *Schoenoplectus subulatus* *Schoenus falcatus*

Cyperaceae cont.	*Schoenus coultasii* (P1)
Droseraceae	*Drosera finlaysoniana*
Elatinaceae	*Bergia ammannioides* *Bergia pedicellaris* *Bergia trimera*
Eriocaulaceae	*Eriocaulon pusillum*
Euphorbiaceae	*Adriana tomentosa* var. *tomentosa* *Euphorbia australis* var. *subtomentosa* *Euphorbia biconvexa* *Euphorbia boophthona* *Euphorbia careyi* *Euphorbia coghlanii* *Euphorbia tannensis* subsp. *eremophila* *Euphorbia trigonosperma* *Euphorbia vaccaria* var. *vaccaria*
Fabaceae	*Acacia acradenia* *Acacia ampliceps* *Acacia ancistrocarpa* *Acacia ancistrocarpa* x *tumida* var. *pilbarensis* *Acacia aptaneura* *Acacia arrecta* *Acacia bivenosa* *Acacia colei* var. *colei* *Acacia coriacea* subsp. *pendens* *Acacia eriopoda* *Acacia hilliana* *Acacia inaequilatera* *Acacia levata* (P3) *Acacia maitlandii* *Acacia monticola* *Acacia orthocarpa* *Acacia pruinocarpa* *Acacia ptychophylla* *Acacia pyrifolia* var. *pyrifolia* *Acacia retivenea* subsp. *clandestina* *Acacia sclerosperma* subsp. *sclerosperma* *Acacia sphaerostachya* *Acacia spondylophylla* *Acacia stellaticeps* *Acacia synchronicia* *Acacia trachycarpa* *Acacia tumida* var. *pilbarensis*

Fabaceae cont.	*Alysicarpus muelleri*
	Cajanus cinereus
	Cajanus pubescens
	Crotalaria cunninghamii
	Crotalaria medicaginea var. *neglecta*
	Crotalaria novae-hollandiae
	Crotalaria dissitiflora subsp. *benthamiana*
	Cullen graveolens
	Cullen lachnostachys
	Cullen leucanthum
	Cullen martinii
	Cullen pogonocarpum
	Cullen stipulaceum
	Desmodium filiforme
	Dichrostachys spicata
	Erythrina vespertilio
	Gastrolobium grandiflorum
	Indigastrum parviflorum
	Indigofera colutea
	Indigofera linifolia
	Indigofera linnaei
	Indigofera monophylla
	Indigofera rugosa
	Indigofera trita subsp. *trita*
	Isotropis atropurpurea
	Lotus australis var. *australis*
	Neptunia dimorphantha
	Petalostylis labicheoides
	Rhynchosia minima
	Rothia indica subsp. *australis* (P3)
	Senna artemisioides subsp. *helmsii*
	Senna artemisioides subsp. *oligophylla*
	Senna glutinosa subsp. *glutinosa*
	Senna glutinosa subsp. *pruinosa*
	Senna glutinosa subsp. x *luerssenii*
	Senna notabilis
	Senna symonii
	Senna venusta
	Sesbania cannabina
	Sesbania formosa
	Swainsona decurrens
	Swainsona formosa
	Swainsona thompsoniana (P3)
	Tephrosia clementii
	Tephrosia rosea var. *clementii*

Fabaceae cont.	*Tephrosia stipuligera*
	Tephrosia supina
	Tephrosia virens
	Tephrosia sp. Bungaroo Creek (M.E. Trudgen 11601)
	Tephrosia sp. clay soils (S. van Leeuwen et al. PBS 0273)
	Tephrosia sp. Fortescue (A.A. Mitchell 606)
	Tephrosia sp. NW Eremaean (S. van Leeuwen et al. PBS 0356)
	**Vachellia farnesiana*
	Vigna lanceolata subsp. *lanceolata*
	Zornia albiflora
Goodeniaceae	*Dampiera candicans*
	Goodenia cusackiana
	Goodenia lamprosperma
	Goodenia microptera
	Goodenia aff. *microptera*
	Goodenia muelleriana
	Goodenia stobbsiana
	Goodenia triodiophila
	Scaevola amblyanthera var. *centralis*
	Scaevola browniana subsp. *browniana*
	Scaevola spinescens
Gyrostemonaceae	*Codonocarpus cotinifolius*
Haloragaceae	*Gonocarpus ephemerus*
Lamiaceae	*Clerodendrum floribundum* var. *angustifolium*
	Clerodendrum tomentosum
	Clerodendrum tomentosum var. *lanceolatum*
Lauraceae	*Cassytha capillaris*
Loganiaceae	*Mitrasacme connata*
Loranthaceae	*Amyema preissii*
	Amyema sanguinea var. *sanguinea*
Lythraceae	*Ammannia baccifera*
	Ammannia multiflora
	Rotala diandra
Malvaceae	*Abutilon macrum*
	Abutilon malvifolium
	Abutilon aff. *hannii*
	Abutilon sp.
	Abutilon sp. Dioicum (A.A. Mitchell PRP 1618)
	Abutilon sp. Pilbara (W.R. Barker 2025)

Malvaceae cont.	*Corchorus laniflorus*
	Corchorus parviflorus
	Corchorus tridens
	Corchorus aff. *walcottii*
	Gossypium australe
	Gossypium robinsonii
	Hibiscus austrinus var. *austrinus*
	Hibiscus coatesii
	Hibiscus goldsworthii
	Hibiscus leptocladus
	Hibiscus sturtii var. *campylochlamys*
	Seringia nephrosperma
	**Malvastrum americanum*
	Melhania oblongifolia
	Melhania aff. *oblongifolia*
	Sida clementii
	Sida echinocarpa
	Sida fibulifera
	Sida macropoda
	Sida rohlenae subsp. *rohlenae*
	Sida spinosa
	Sida sp. Articulation below (A.A. Mitchell PRP 1605)
	Sida sp. Excedentifolia (J.L. Egan 1925)
	Sida sp. Pilbara (A.A. Mitchell PRP 1543)
	Sida sp. spiciform panicles (E. Leyland s.n. 14/8/90)
	Sida sp. verrucose glands (F.H. Mollemans 2423)
	Triumfetta aff. *appendiculata*
	Triumfetta chaetocarpa
	Triumfetta clementii
	Triumfetta maconochieana
	Waltheria indica
	Waltheria virgata
Marsileaceae	*Marsilea hirsuta*
Menispermaceae	*Tinospora smilacina*
Molluginaceae	*Mollugo cerviana*
	Mollugo molluginea
Moraceae	*Ficus aculeata* subsp. *indecora*
	Ficus brachypoda
	Ficus platypoda
Myrtaceae	*Corymbia ferriticola*
	Corymbia flavescens
	Corymbia hamersleyana

Myrtaceae cont.	*Eucalyptus camaldulensis* subsp. *refulgens*
	Eucalyptus leucophloia subsp. *leucophloia*
	Eucalyptus victrix
	Eucalyptus xerothermica
	Melaleuca argentea
	Melaleuca glomerata
	Melaleuca linophylla
Nyctaginaceae	*Boerhavia burbidgeana*
	Boerhavia coccinea
	Boerhavia gardneri
Onagraceae	*Ludwigia perennis*
Orobanchaceae	*Buchnera linearis*
	Striga squamigera
Papaveraceae	**Argemone ochroleuca* subsp. *ochroleuca*
Passifloraceae	**Passiflora foetida* var. *hispida*
Pedaliaceae	*Josephinia ?eugeniae*
Phrymaceae	*Peplidium* sp. E Evol. Fl. Fauna Arid Aust. (A.S. Weston 12768)
Phyllanthaceae	*Flueggea virosa* subsp. *melanthesoides*
	Notoleptopus decaisnei
	Phyllanthus erwinii
	Phyllanthus exilis
	Phyllanthus maderaspatensis
Plantaginaceae	*Stemodia grossa*
	Stemodia viscosa
Poaceae	*Aristida contorta*
	Aristida holathera var. *holathera*
	Cynodon convergens
	Cynodon prostratus
	**Cenchrus ciliaris*
	**Cenchrus setiger*
	**Chloris barbata*
	Chrysopogon fallax
	Cymbopogon ambiguus
	**Cynodon dactylon*
	Dactyloctenium radulans
	Dichanthium fecundum
	Dichanthium sericeum subsp. *humilius*
	Digitaria brownii
	Digitaria ctenantha

Poaceae cont.	**Echinochloa colona* *Enneapogon caerulescens* *Enneapogon lindleyanus* *Enneapogon polyphyllus* *Enteropogon ramosus* *Eragrostis crateriformis* (P3) *Eragrostis cumingii* *Eragrostis desertorum* *Eragrostis dielsii* *Eragrostis eriopoda* *Eragrostis falcata* *Eragrostis setifolia* *Eragrostis speciosa* *Eragrostis tenellula* *Eriachne aristidea* *Eriachne benthamii* *Eriachne ciliata* *Eriachne flaccida* *Eriachne mucronata* *Eriachne obtusa* *Eriachne pulchella* subsp. *dominii* *Eriachne tenuiculmis* *Eulalia aurea* *Heteropogon contortus* *Iseilema dolichotrichum* *Leptochloa fusca* subsp. *fusca* *Panicum decompositum* *Paraneurachne muelleri* *Paspalidium basicladum* *Paspalidium clementii* *Paspalidium rarum* *Paspalidium tabulatum* *Perotis rara* *Schizachyrium fragile* **Setaria verticillata* *Sporobolus actinocladus* *Sporobolus australasicus* *Themeda avenacea* *Themeda triandra* *Triodia angusta* *Triodia brizoides* *Triodia epactia* *Triodia longiceps* *Triodia secunda* *Triodia wiseana*

Poaceae cont.	*Tripogon loliiformis*
	Yakirra australiensis subsp. *australiensis*
Polygalaceae	*Polygala glaucifolia*
	Polygala isingii
Portulacaceae	*Calandrinia pumila*
	Calandrinia quadrivalvis
	Portulaca conspicua
	Portulaca cyclophylla
	Portulaca oleracea
	**Portulaca pilosa*
	Portulaca sp. (potentially undescribed)
Potamogetonaceae	*Potamogeton tricarinatus*
Proteaceae	*Grevillea pyramidalis* subsp. *leucadendron*
	Grevillea wickhamii
	Grevillea wickhamii subsp. *hispidula*
	Hakea lorea subsp. *lorea*
Pteridaceae	*Acrostichum speciosum*
	Cheilanthes brownii
	Cheilanthes sp.
Rubiaceae	*Oldenlandia crouchiana*
	Oldenlandia galioides
	Oldenlandia sp. (potentially undescribed)
	Synaptantha tillaeacea
Santalaceae	*Santalum lanceolatum*
Sapindaceae	*Atalaya hemiglauca*
	Dodonaea coriacea
Scrophulariaceae	*Eremophila latrobei* subsp. *glabra*
	Eremophila longifolia
Solanaceae	*Nicotiana ?benthamiana*
	Nicotiana benthamiana
	Nicotiana umbratica (P3)
	Solanum cleistogamum
	Solanum diversiflorum
	Solanum horridum
	**Solanum nigrum*
	Solanum phlomoides
Stylidiaceae	*Stylidium fluminense*
	Stylidium weeliwolli (P3)

Typhaceae	*Typha domingensis*
Violaceae	*Hybanthus aurantiacus*
Zygophyllaceae	*Tribulopis angustifolia* *Tribulus hirsutus* *Tribulus platypterus* *Tribulus suberosus* **Tribulus terrestris*

Conservation Significant Taxa	= 13	
Common Native Taxa	= 383	
Hybrid Taxa	= 2	(1x known, 1x putative)
Introduced Taxa	= 17	
Total Taxa	**415**	

Appendix J: Location Details of Conservation Significant Flora and Introduced Flora Recorded within the Study Area and Surrounds

All coordinates were recorded in GDA94 (Zone 50)

Taxon	Status	Easting	Northing	Record Location	Source	Count
Abutilon aff. *hannii*	Potentially undescribed	777834	7617186	Opportunistic	WEC	NA
Abutilon aff. *hannii*	Potentially undescribed	773038	7622945	Opportunistic	WEC	NA
Abutilon aff. *hannii*	Potentially undescribed	775932	7615042	Opportunistic	WEC	20
Acacia levata	P3	765907	7629283	Opportunistic	WEC	5
Acacia levata	P3	765683	7629226	Opportunistic	WEC	2
Acacia levata	P3	766058	7629234	Opportunistic	WEC	10
Acacia levata	P3	766282	7629289	Opportunistic	WEC	2
Acacia levata	P3	765380	7631615	CD001	WEC	1
Acacia levata	P3	766194	7629225	CD045	WEC	24
Acacia levata	P3	765173	7633064	CD002	WEC	1
Acacia levata	P3	765751	7631578	Opportunistic	WEC	10
Acacia levata	P3	766704	7632293	Opportunistic	WEC	1
Acacia levata	P3	765620	7632151	Opportunistic	WEC	30
Acacia levata	P3	765600	7631777	Opportunistic	WEC	100
Acacia levata	P3	765220	7631809	Opportunistic	WEC	50
Acacia levata	P3	764782	7631698	Opportunistic	WEC	20
Acacia levata	P3	765112	7632747		DPaW	1
Acacia levata	P3	765401	7633137		DPaW	1
Acacia levata	P3	765428	7632855		DPaW	1
Acacia levata	P3	765452	7632371		DPaW	1
Acacia levata	P3	765546	7633196		DPaW	1
Acacia levata	P3	766129	7633253		DPaW	1
Acrostichum speciosum	Significantly Disjunct Record	776743	7623790	Opportunistic	WEC	3
Cochlospermum macnamarae	P1	773611	7612913	Opportunistic	WEC	76
Cochlospermum macnamarae	P1	773050	7612700	Opportunistic	WEC	3
Cochlospermum macnamarae	P1	773321	7614165	CD172	WEC	1
Cochlospermum macnamarae	P1	773471	7612880	CD171	WEC	4
Cochlospermum macnamarae	P1	773586	7613897	Opportunistic	WEC	20
Cochlospermum macnamarae	P1	773166	7613915	Opportunistic	WEC	25
Cochlospermum macnamarae	P1	773139	7614145	Opportunistic	WEC	10
Cochlospermum macnamarae	P1	773400	7614328	Opportunistic	WEC	15
Eragrostis crateriformis	P3	779729	7636023	Opportunistic	WEC	1
Eragrostis crateriformis	P3	779662	7636134	Opportunistic	WEC	40
Eragrostis crateriformis	P3	779892	7633917	Opportunistic	WEC	10
Eragrostis crateriformis	P3	779756	7634904	Opportunistic	WEC	10

Taxon	Status	Easting	Northing	Record Location	Source	Count
Eragrostis crateriformis	P3	779770	7634585	Opportunistic	WEC	3
Eragrostis crateriformis	P3	779606	7635630	CE-091	WEC	50
Eragrostis crateriformis	P3	779833	7634211	Opportunistic	WEC	6
Eragrostis crateriformis	P3	779761	7634570	Opportunistic	WEC	2
Eragrostis crateriformis	P3	779751	7634578	Opportunistic	WEC	12
Eragrostis crateriformis	P3	779735	7635063	Opportunistic	WEC	75
Eragrostis crateriformis	P3	779721	7634992	Opportunistic	WEC	55
Eragrostis crateriformis	P3	779816	7634193	Opportunistic	WEC	1
Eragrostis crateriformis	P3	779861	7634267	Opportunistic	WEC	2
Eragrostis crateriformis	P3	779832	7634212	Opportunistic	WEC	5
Eriocaulon pusillum		764847	7631929	Opportunistic	WEC	10
Heliotropium murinum	P3	780467	7636043	CE-090	WEC	1
Heliotropium murinum	P3	780031	7637239	CE-073	WEC	1
Heliotropium murinum	P3	780004	7636551	Opportunistic	WEC	1
Nicotiana umbratica	P3	776155	7620711	Opportunistic	WEC	15
Nicotiana umbratica	P3	778008	7634123	Opportunistic	WEC	100
Oldenlandia sp.	Potentially undescribed	780526	7638975	CE-068	WEC	1
Portulaca sp.	Potentially undescribed	770630	7630790	Opportunistic	WEC	NA
Ptilotus mollis	P4	779672	7625913	Opportunistic	WEC	5
Ptilotus mollis	P4	779469	7626616	Opportunistic	WEC	5
Ptilotus mollis	P4	779661	7625880	CE-160	WEC	30
Ptilotus mollis	P4	779430	7625977	CE-161	WEC	35
Ptilotus mollis	P4	777580	7622000	Opportunistic	WEC	30
Ptilotus mollis	P4	777350	7623650	Opportunistic	WEC	20
Ptilotus mollis	P4	775870	7611749	Opportunistic	WEC	30
Ptilotus mollis	P4	776408	7611657	Opportunistic	WEC	20
Ptilotus mollis	P4	776811	7611657	Opportunistic	WEC	20
Ptilotus mollis	P4	776829	7611489	Opportunistic	WEC	10
Ptilotus mollis	P4	776960	7611863	Opportunistic	WEC	10
Ptilotus mollis	P4	777790	7612796	Opportunistic	WEC	10
Ptilotus mollis	P4	776820	7613050	Opportunistic	WEC	25
Ptilotus mollis	P4	777053	7613010	Opportunistic	WEC	30
Ptilotus mollis	P4	777060	7613113	Opportunistic	WEC	20
Ptilotus mollis	P4	777872	7621616	Opportunistic	WEC	30
Ptilotus mollis	P4	777228	7616201	CD159	WEC	1
Ptilotus mollis	P4	777044	7612906	CD308	WEC	50
Ptilotus mollis	P4	777151	7622284	CD131	WEC	30
Ptilotus mollis	P4	777338	7615581	CD160	WEC	3
Ptilotus mollis	P4	776985	7616107	Opportunistic	WEC	30
Ptilotus mollis	P4	776876	7616166	Opportunistic	WEC	150
Ptilotus mollis	P4	777047	7615951	Opportunistic	WEC	30
Ptilotus mollis	P4	777666	7616053	Opportunistic	WEC	20

Taxon	Status	Easting	Northing	Record Location	Source	Count
Ptilotus mollis	P4	775405	7614918	Opportunistic	WEC	20
Ptilotus mollis	P4	777272	7615533	Opportunistic	WEC	25
Ptilotus mollis	P4	777150	7615700	Opportunistic	WEC	7
Ptilotus mollis	P4	776195	7615583	Opportunistic	WEC	10
Ptilotus mollis	P4	777408	7616617	Opportunistic	WEC	30
Ptilotus mollis	P4	776829	7621294	Opportunistic	WEC	10
Ptilotus mollis	P4	777548	7621645	Opportunistic	WEC	15
Ptilotus mollis	P4	777377	7623303	Opportunistic	WEC	6
Ptilotus mollis	P4	777449	7623464	Opportunistic	WEC	2
Ptilotus mollis	P4	777270	7622380	Opportunistic	WEC	10
Ptilotus mollis	P4	777370	7622310	Opportunistic	WEC	10
Ptilotus mollis	P4	776660	7620745	Opportunistic	WEC	20
Ptilotus mollis	P4	776820	7612770	Opportunistic	WEC	10
Ptilotus mollis	P4	777010	7612600	Opportunistic	WEC	15
Ptilotus mollis	P4	776647	7620903	Opportunistic	WEC	15
Ptilotus mollis	P4	776594	7620955	Opportunistic	WEC	10
Ptilotus mollis	P4	776662	7621022	Opportunistic	WEC	10
Rostellularia adscendens var. *latifolia*	P3	780101	7647302	CE-024	WEC	1
Rostellularia adscendens var. *latifolia*	P3	771121	7624361	Opportunistic	WEC	100
Rothia indica subsp. *australis*	P3	779626	7633791	Opportunistic	WEC	40
Rothia indica subsp. *australis*	P3	779573	7633939	CE-171	WEC	50
Rothia indica subsp. *australis*	P3	779604	7633871	Opportunistic	WEC	10
Rothia indica subsp. *australis*	P3	779630	7633925	Opportunistic	WEC	6
Rothia indica subsp. *australis*	P3	779645	7633819	Opportunistic	WEC	1
Rothia indica subsp. *australis*	P3	779640	7633808	Opportunistic	WEC	1
Rothia indica subsp. *australis*	P3	779649	7633787	Opportunistic	WEC	1
Rothia indica subsp. *australis*	P3	779612	7633916	Opportunistic	WEC	2
Rothia indica subsp. *australis*	P3	779614	7633774	Opportunistic	WEC	28
Rothia indica subsp. *australis*	P3	779626	7633780	Opportunistic	WEC	50
Rothia indica subsp. *australis*	P3	779623	7633748	Opportunistic	WEC	10
Rothia indica subsp. *australis*	P3	779616	7633915	Opportunistic	WEC	55
Rothia indica subsp. *australis*	P3	779559	7633815	Opportunistic	WEC	1
Schoenus coultasii	P1	764847	7631929	Opportunistic	WEC	50
Stylidium weeliwolli	P3	764847	7631929	Opportunistic	WEC	2
Swainsona thompsoniana	P3	779007	7645788	CE-313	WEC	1
Swainsona thompsoniana	P3	777102	7642373	CE-312	WEC	1
Swainsona thompsoniana	P3	777607	7642887	CE-184	WEC	1
**Aerva javanica*	Introduced	784798	7654054		WEC	5
**Aerva javanica*	Introduced	780101	7647302	CE-024	WEC	1
**Aerva javanica*	Introduced	780467	7636043	CE-090	WEC	1
**Aerva javanica*	Introduced	780321	7635264	CE-096	WEC	1
**Aerva javanica*	Introduced	780735	7632288	CE-125	WEC	1

Taxon	Status	Easting	Northing	Record Location	Source	Count
*Aerva javanica	Introduced	780346	7633136	CE-109	WEC	1
*Aerva javanica	Introduced	778958	7630978	CE-119	WEC	1
*Aerva javanica	Introduced	779722	7634373	CE-098	WEC	1
*Aerva javanica	Introduced	778711	7637904	CE-057	WEC	2
*Aerva javanica	Introduced	780472	7638136	CE-066	WEC	25
*Aerva javanica	Introduced	778730	7642133	CE-036	WEC	6
*Aerva javanica	Introduced	783611	7647768	CE-019	WEC	5
*Aerva javanica	Introduced	778066	7644349	CE-020	WEC	8
*Aerva javanica	Introduced	780949	7647694	CE-316	WEC	1
*Aerva javanica	Introduced	779260	7636140	CE-304	WEC	1
*Aerva javanica	Introduced	779661	7625880	CE-160	WEC	30
*Aerva javanica	Introduced	779430	7625977	CE-161	WEC	10
*Aerva javanica	Introduced	780040	7628779	CE-135	WEC	1
*Aerva javanica	Introduced	779491	7626442	CE-157	WEC	1
*Aerva javanica	Introduced	779711	7630352	CE-130	WEC	1
*Aerva javanica	Introduced	779668	7627761	CE-153	WEC	5
*Aerva javanica	Introduced	779759	7627767	CE-154	WEC	4
*Aerva javanica	Introduced	778865	7626061	CE-147	WEC	100
*Aerva javanica	Introduced	780674	7633422	CE-110	WEC	1
*Aerva javanica	Introduced	780455	7633140	CE-108	WEC	2
*Aerva javanica	Introduced	780515	7634167	CE-174	WEC	3
*Aerva javanica	Introduced	780577	7634122	CE-175	WEC	1
*Aerva javanica	Introduced	783350	7647039	CE-186	WEC	1
*Aerva javanica	Introduced	788618	7656043	CE-187	WEC	50
*Aerva javanica	Introduced	783652	7648286		WEC	15
*Aerva javanica	Introduced	766373	7635064	CD007	WEC	1
*Aerva javanica	Introduced	768455	7633834	CD012	WEC	1
*Aerva javanica	Introduced	766757	7632162	CD004	WEC	1
*Aerva javanica	Introduced	766106	7627797	CD048	WEC	2
*Aerva javanica	Introduced	770355	7624917	CD086	WEC	1
*Aerva javanica	Introduced	770630	7630790	CD053	WEC	4
*Aerva javanica	Introduced	769899	7631106	CD059	WEC	2
*Aerva javanica	Introduced	771614	7634302	CD017	WEC	1
*Aerva javanica	Introduced	777834	7617186	CD162	WEC	5
*Aerva javanica	Introduced	772955	7622263	CD119	WEC	1
*Aerva javanica	Introduced	773247	7621393	CD120	WEC	10
*Aerva javanica	Introduced	775561	7614882	CD168	WEC	1
*Aerva javanica	Introduced	777228	7616201	CD159	WEC	1
*Aerva javanica	Introduced	773763	7617828	CD147	WEC	1
*Aerva javanica	Introduced	773717	7614557	CD163	WEC	1
*Aerva javanica	Introduced	774646	7614528	CD157	WEC	1
*Aerva javanica	Introduced	774692	7623980	CD204	WEC	1
*Aerva javanica	Introduced	776995	7621447	CD132	WEC	1

Taxon	Status	Easting	Northing	Record Location	Source	Count
**Aerva javanica*	Introduced	774987	7621749	CD126	WEC	1
**Aerva javanica*	Introduced	777617	7616945	Opportunistic	WEC	10
**Aerva javanica*	Introduced	776250	7615404	Opportunistic	WEC	15
**Aerva javanica*	Introduced	766445	7629469	Opportunistic	WEC	1
**Aerva javanica*	Introduced	776631	7616060	Opportunistic	WEC	25
**Aerva javanica*	Introduced	774194	7623914	Opportunistic	WEC	5
**Aerva javanica*	Introduced	776964	7616056	Opportunistic	WEC	150
**Aerva javanica*	Introduced	777612	7616077	Opportunistic	WEC	30
**Aerva javanica*	Introduced	772936	7631445	Opportunistic	WEC	3
**Aerva javanica*	Introduced	774939	7612753	Opportunistic	WEC	5
**Aerva javanica*	Introduced	774749	7612819	Opportunistic	WEC	10
**Aerva javanica*	Introduced	777408	7616617	Opportunistic	WEC	10
**Aerva javanica*	Introduced	776470	7615430	Opportunistic	WEC	20
**Aerva javanica*	Introduced	772306	7629472	Opportunistic	WEC	3
**Aerva javanica*	Introduced	772346	7629278	Opportunistic	WEC	5
**Aerva javanica*	Introduced	771330	7628127	Opportunistic	WEC	5
**Aerva javanica*	Introduced	771146	7627895	Opportunistic	WEC	5
**Aerva javanica*	Introduced	771341	7627573	Opportunistic	WEC	10
**Aerva javanica*	Introduced	771310	7627456	Opportunistic	WEC	7
**Aerva javanica*	Introduced	771296	7626191	Opportunistic	WEC	20
**Aerva javanica*	Introduced	776648	7615661	Opportunistic	WEC	20
**Aerva javanica*	Introduced	773646	7623886	Opportunistic	WEC	30
**Aerva javanica*	Introduced	773725	7623870	Opportunistic	WEC	20
**?Amaranthus viridis*	Introduced	774692	7623980	CD204	WEC	1
**?Amaranthus viridis*	Introduced	772927	7630998	CD073	WEC	1
**Argemone ochroleuca* subsp. *ochroleuca*	Introduced	778730	7642133	CE-036	WEC	7
**Argemone ochroleuca* subsp. *ochroleuca*	Introduced	777834	7617186	CD162	WEC	1
**Calotropis procera*	Introduced	780455	7633140	CE-108	WEC	4
**Calotropis procera*	Introduced	779728	7631449	Opportunistic	WEC	1
**Calotropis procera*	Introduced	780256	7635243	Opportunistic	WEC	1
**Calotropis procera*	Introduced	780562	7639510	Opportunistic	WEC	4
**Calotropis procera*	Introduced	780555	7639475	Opportunistic	WEC	11
**Calotropis procera*	Introduced	780923	7639453	Opportunistic	WEC	3
**Calotropis procera*	Introduced	780882	7638661	Opportunistic	WEC	4
**Calotropis procera*	Introduced	780667	7638468	Opportunistic	WEC	4
**Calotropis procera*	Introduced	780462	7638887	Opportunistic	WEC	2
**Calotropis procera*	Introduced	773038	7622945	CD116	WEC	1
**Calotropis procera*	Introduced	766373	7635064	CD007	WEC	1
**Calotropis procera*	Introduced	773032	7622913	Opportunistic	WEC	20
**Calotropis procera*	Introduced	777482	7616330	Opportunistic	WEC	5
**Calotropis procera*	Introduced	772952	7631042	Opportunistic	WEC	1
**Cenchrus ciliaris*	Introduced	777359	7637042	Opportunistic	WEC	20

Taxon	Status	Easting	Northing	Record Location	Source	Count
*Cenchrus ciliaris	Introduced	777895	7637065	Opportunistic	WEC	10000
*Cenchrus ciliaris	Introduced	778881	7641231	Opportunistic	WEC	2000
*Cenchrus ciliaris	Introduced	780417	7638181	Opportunistic	WEC	50000
*Cenchrus ciliaris	Introduced	780129	7635572	Opportunistic	WEC	50000
*Cenchrus ciliaris	Introduced	779821	7633607	CE-166	WEC	1
*Cenchrus ciliaris	Introduced	779350	7633943	CE-170	WEC	100
*Cenchrus ciliaris	Introduced	779935	7633464	CE-167	WEC	1
*Cenchrus ciliaris	Introduced	779573	7633939	CE-171	WEC	5
*Cenchrus ciliaris	Introduced	780515	7634167	CE-174	WEC	10000
*Cenchrus ciliaris	Introduced	780577	7634122	CE-175	WEC	100
*Cenchrus ciliaris	Introduced	779900	7634639	CE-177	WEC	5
*Cenchrus ciliaris	Introduced	781186	7640516	CE-178	WEC	25000
*Cenchrus ciliaris	Introduced	780230	7637634	CE-180	WEC	1000
*Cenchrus ciliaris	Introduced	778739	7640918	CE-182	WEC	200
*Cenchrus ciliaris	Introduced	777890	7643829	CE-185	WEC	4
*Cenchrus ciliaris	Introduced	783350	7647039	CE-186	WEC	20000
*Cenchrus ciliaris	Introduced	778920	7641058	CE-183	WEC	1000
*Cenchrus ciliaris	Introduced	785828	7653997	CE-189	WEC	5
*Cenchrus ciliaris	Introduced	788618	7656043	CE-187	WEC	300
*Cenchrus ciliaris	Introduced	783045	7645054	CE-195	WEC	50
*Cenchrus ciliaris	Introduced	777640	7643779	CE-192	WEC	5
*Cenchrus ciliaris	Introduced	780674	7633422	CE-110	WEC	1
*Cenchrus ciliaris	Introduced	780455	7633140	CE-108	WEC	50
*Cenchrus ciliaris	Introduced	780093	7635667	CE-093	WEC	10
*Cenchrus ciliaris	Introduced	778865	7626061	CE-147	WEC	1
*Cenchrus ciliaris	Introduced	779759	7627767	CE-154	WEC	60
*Cenchrus ciliaris	Introduced	779069	7625791	CE-150	WEC	10
*Cenchrus ciliaris	Introduced	779668	7627761	CE-153	WEC	1000
*Cenchrus ciliaris	Introduced	782640	7645033	CE-197	WEC	100
*Cenchrus ciliaris	Introduced	782983	7646502	CE-198	WEC	15000
*Cenchrus ciliaris	Introduced	777381	7641619	CE-309	WEC	1
*Cenchrus ciliaris	Introduced	777666	7641117	CE-307	WEC	1
*Cenchrus ciliaris	Introduced	777276	7640107	CE-308	WEC	1
*Cenchrus ciliaris	Introduced	787895	7651890	CE-317	WEC	1
*Cenchrus ciliaris	Introduced	780949	7647694	CE-316	WEC	1
*Cenchrus ciliaris	Introduced	787733	7651712	CE-320	WEC	1
*Cenchrus ciliaris	Introduced	787864	7651847	CE-318	WEC	1
*Cenchrus ciliaris	Introduced	779744	7628317	CE-151	WEC	1
*Cenchrus ciliaris	Introduced	779491	7626442	CE-157	WEC	1
*Cenchrus ciliaris	Introduced	779661	7625880	CE-160	WEC	1
*Cenchrus ciliaris	Introduced	779694	7635691	CE-303	WEC	1
*Cenchrus ciliaris	Introduced	778619	7642661	CE-033	WEC	20
*Cenchrus ciliaris	Introduced	783611	7647768	CE-019	WEC	250

Taxon	Status	Easting	Northing	Record Location	Source	Count
*Cenchrus ciliaris	Introduced	778066	7644349	CE-020	WEC	40
*Cenchrus ciliaris	Introduced	785442	7654274	CE-003	WEC	1
*Cenchrus ciliaris	Introduced	778730	7642133	CE-036	WEC	200
*Cenchrus ciliaris	Introduced	778940	7642151	CE-037	WEC	1
*Cenchrus ciliaris	Introduced	778553	7640889	CE-041	WEC	12500
*Cenchrus ciliaris	Introduced	780472	7638136	CE-066	WEC	1
*Cenchrus ciliaris	Introduced	780526	7638975	CE-068	WEC	3
*Cenchrus ciliaris	Introduced	779557	7642056	CE-044	WEC	150
*Cenchrus ciliaris	Introduced	778711	7637904	CE-057	WEC	7500
*Cenchrus ciliaris	Introduced	778907	7637888	CE-058	WEC	12500
*Cenchrus ciliaris	Introduced	779724	7646499	CE-026	WEC	1
*Cenchrus ciliaris	Introduced	779697	7646560	CE-027	WEC	1
*Cenchrus ciliaris	Introduced	782408	7652412	CE-008	WEC	1
*Cenchrus ciliaris	Introduced	780101	7647302	CE-024	WEC	1
*Cenchrus ciliaris	Introduced	777159	7636133	CE-076	WEC	1
*Cenchrus ciliaris	Introduced	780031	7637239	CE-073	WEC	1
*Cenchrus ciliaris	Introduced	780126	7636768	CE-074	WEC	1
*Cenchrus ciliaris	Introduced	779298	7638112	CE-065	WEC	1
*Cenchrus ciliaris	Introduced	779656	7642090	CE-043	WEC	1
*Cenchrus ciliaris	Introduced	777876	7639625	CE-049	WEC	1
*Cenchrus ciliaris	Introduced	777135	7639253	CE-050	WEC	1
*Cenchrus ciliaris	Introduced	777239	7639650	CE-051	WEC	1
*Cenchrus ciliaris	Introduced	777127	7639091	CE-054	WEC	1
*Cenchrus ciliaris	Introduced	780321	7635264	CE-096	WEC	1
*Cenchrus ciliaris	Introduced	779797	7635710	CE-092	WEC	1
*Cenchrus ciliaris	Introduced	779660	7634998	CE-095	WEC	1
*Cenchrus ciliaris	Introduced	779606	7635630	CE-091	WEC	1
*Cenchrus ciliaris	Introduced	780467	7636043	CE-090	WEC	1
*Cenchrus ciliaris	Introduced	777705	7636285	CE-077	WEC	1
*Cenchrus ciliaris	Introduced	777958	7636079	CE-079	WEC	1
*Cenchrus ciliaris	Introduced	779340	7631368	CE-127	WEC	1
*Cenchrus ciliaris	Introduced	780735	7632288	CE-125	WEC	1
*Cenchrus ciliaris	Introduced	778958	7630978	CE-119	WEC	1
*Cenchrus ciliaris	Introduced	780346	7633136	CE-109	WEC	1
*Cenchrus ciliaris	Introduced	781044	7636408	CE-100	WEC	1
*Cenchrus ciliaris	Introduced	779722	7634373	CE-098	WEC	1
*Cenchrus ciliaris	Introduced	782349	7645044	Opportunistic	WEC	20
*Cenchrus ciliaris	Introduced	783590	7648347	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	784798	7654054	Opportunistic	WEC	20
*Cenchrus ciliaris	Introduced	785663	7655746	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	785767	7655874	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	785585	7654805	Opportunistic	WEC	1
*Cenchrus ciliaris	Introduced	772271	7629171	Opportunistic	WEC	1000

Taxon	Status	Easting	Northing	Record Location	Source	Count
*Cenchrus ciliaris	Introduced	774749	7612819	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	775932	7615042	Opportunistic	WEC	100
*Cenchrus ciliaris	Introduced	777408	7616617	Opportunistic	WEC	100
*Cenchrus ciliaris	Introduced	776229	7615590	Opportunistic	WEC	100
*Cenchrus ciliaris	Introduced	776470	7615430	Opportunistic	WEC	100
*Cenchrus ciliaris	Introduced	771341	7627573	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	771670	7628737	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	773725	7623870	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	766818	7627871	Opportunistic	WEC	1000
*Cenchrus ciliaris	Introduced	771296	7626191	Opportunistic	WEC	100
*Cenchrus ciliaris	Introduced	772970	7620750	CD121	WEC	1
*Cenchrus ciliaris	Introduced	773080	7625998	CD075	WEC	1
*Cenchrus ciliaris	Introduced	764504	7631690	CD312	WEC	1
*Cenchrus ciliaris	Introduced	770777	7632729	CD014	WEC	1000
*Cenchrus ciliaris	Introduced	768310	7634924	CD010	WEC	2000
*Cenchrus ciliaris	Introduced	774692	7623980	CD204	WEC	1
*Cenchrus ciliaris	Introduced	773038	7622945	CD116	WEC	10000
*Cenchrus ciliaris	Introduced	776995	7621447	CD132	WEC	1
*Cenchrus ciliaris	Introduced	766373	7635064	CD007	WEC	1
*Cenchrus ciliaris	Introduced	768455	7633834	CD012	WEC	1000
*Cenchrus ciliaris	Introduced	765505	7633350	CD006	WEC	1
*Cenchrus ciliaris	Introduced	767901	7626778	CD057	WEC	1
*Cenchrus ciliaris	Introduced	769227	7628358	CD087	WEC	1
*Cenchrus ciliaris	Introduced	766106	7627797	CD048	WEC	2000
*Cenchrus ciliaris	Introduced	770355	7624917	CD086	WEC	1
*Cenchrus ciliaris	Introduced	770630	7630790	CD053	WEC	2000
*Cenchrus ciliaris	Introduced	769899	7631106	CD059	WEC	1000
*Cenchrus ciliaris	Introduced	772927	7630998	CD073	WEC	1
*Cenchrus ciliaris	Introduced	774646	7614528	CD157	WEC	100
*Cenchrus ciliaris	Introduced	769649	7624093	CD085	WEC	1
*Cenchrus ciliaris	Introduced	773183	7613496	CD169	WEC	1
*Cenchrus ciliaris	Introduced	777228	7616201	CD159	WEC	1
*Cenchrus ciliaris	Introduced	773763	7617828	CD147	WEC	1
*Cenchrus ciliaris	Introduced	771679	7634520	CD013	WEC	1
*Cenchrus ciliaris	Introduced	777834	7617186	CD162	WEC	500
*Cenchrus ciliaris	Introduced	774788	7623946	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	774971	7623804	Opportunistic	WEC	20
*Cenchrus ciliaris	Introduced	776631	7616060	Opportunistic	WEC	200
*Cenchrus ciliaris	Introduced	776964	7616056	Opportunistic	WEC	15
*Cenchrus ciliaris	Introduced	775284	7614789	Opportunistic	WEC	50
*Cenchrus ciliaris	Introduced	766265	7629508	Opportunistic	WEC	30
*Cenchrus ciliaris	Introduced	766368	7629867	Opportunistic	WEC	100
*Cenchrus ciliaris	Introduced	766401	7629473	Opportunistic	WEC	50

Taxon	Status	Easting	Northing	Record Location	Source	Count
**Cenchrus ciliaris*	Introduced	777612	7616077	Opportunistic	WEC	200
**Cenchrus ciliaris*	Introduced	777617	7616945	Opportunistic	WEC	100
**Cenchrus ciliaris*	Introduced	776648	7615661	Opportunistic	WEC	100
**Cenchrus setiger*	Introduced	780455	7633140	CE-108	WEC	1
**Chloris barbata*	Introduced	782640	7645033	CE-197	WEC	10
**Chloris barbata*	Introduced	780526	7638975	CE-068	WEC	1
**Chloris barbata*	Introduced	772927	7630998	CD073	WEC	1
**Cynodon dactylon*	Introduced	780455	7633140	CE-108	WEC	1
**Cynodon dactylon*	Introduced	780526	7638975	CE-068	WEC	1
**Cynodon dactylon*	Introduced	780321	7635264	CE-096	WEC	1
**Cynodon dactylon*	Introduced	779697	7646560	CE-027	WEC	1
**Cynodon dactylon*	Introduced	778730	7642133	CE-036	WEC	1
**Cynodon dactylon*	Introduced	780256	7635243	Opportunistic	WEC	1
**Cynodon dactylon*	Introduced	768455	7633834	CD012	WEC	1
**Cynodon dactylon*	Introduced	773038	7622945	CD116	WEC	3
**Echinochloa colona*	Introduced	780321	7635264	CE-096	WEC	1
**Echinochloa colona*	Introduced	779697	7646560	CE-027	WEC	1
**Echinochloa colona*	Introduced	780101	7647302	CE-024	WEC	1
**Echinochloa colona*	Introduced	780455	7633140	CE-108	WEC	1
**Flaveria trinervia*	Introduced	780455	7633140	CE-108	WEC	2
**Flaveria trinervia*	Introduced	774670	7623941	Opportunistic	WEC	5
**Flaveria trinervia*	Introduced	772927	7630998	CD073	WEC	2
**Flaveria trinervia*	Introduced	774692	7623980	CD204	WEC	10
**Malvastrum americanum*	Introduced	773038	7622945	CD116	WEC	12
**Malvastrum americanum*	Introduced	773247	7621393	CD120	WEC	2
**Malvastrum americanum*	Introduced	775932	7615042	Opportunistic	WEC	1
**Passiflora foetida* var. *hispida*	Introduced	777050	7629044	CD082	WEC	1
**Passiflora foetida* var. *hispida*	Introduced	776606	7627440	CD065	WEC	1
**Portulaca pilosa*	Introduced	765380	7631615	CD001	WEC	1
**Setaria verticillata*	Introduced	772927	7630998	CD073	WEC	1
**Solanum nigrum*	Introduced	780455	7633140	CE-108	WEC	1
**Sonchus oleraceus*	Introduced	780101	7647302	CE-024	WEC	1
**Sonchus oleraceus*	Introduced	772927	7630998	CD073	WEC	1
**Tribulus terrestris*	Introduced	780472	7638136	CE-066	WEC	1
**Vachellia farnesiana*	Introduced	780343	7633189	Opportunistic	WEC	1

Appendix K: Figures 6.0 – 6.44

Sanjiv Ridge Project Project Study Area

Significant Flora Taxa and Vegetation Types Legend and Detailed Figures

Legend

Study Area

Vegetation Types

1 Mid sparse shrubland dominated by mixed Acacia species over low sparse shrubland of mixed species including *Acacia stellaticeps, Pluchea tetranthera* and *Eremophila latrobei* subsp. *glabra* over low hummock grassland dominated by *Triodia epactia* on grey to brown sand to clay loam with occasional granite outcropping, on stoney plains, low hills or sandy dunes

2 Tall to mid open shrubland dominated by mixed Acacia species including *Acacia eriopoda* and *Acacia maitlandii* and over low sparse shrubland of mixed species including *Acacia stellaticeps*, *Corchorus parviflorus* and *Corchorus laniflorus* over low hummock grassland dominated mainly by *Triodia epactia* on red-brown sandy clay to clay loam, on granite outcrops to stoney plains and drainage lines with exposed granite

3 Low open woodland of mixed species dominated by species including *Corymbia ferriticola*, *Ficus brachypoda*, *Terminalia canescens* over tall sparse shrubland usually dominated by *Acacia pruinocarpa* and *Acacia tumida* var. *pilbarensis* over low open mixed grassland dominated by *Triodia epactia*, *Cymbopogon ambiguus* and *Eriachne mucronata*, on red to brown sand to clay loam on ironstone or metamorphosed granite outcropping, in steep gorges, often with semi-permanent water

4 Low Open Woodland usually dominated by *Corymbia hamersleyana* over Tall Sparse Shrubland dominated by mixed Acacia species including *A. trachycarpa* and *A. ancistrocarpa* with *Dichrostachys spicata* over Low Hummock Grassland dominated by species including *Triodia wiseana* and *T. epactia* with *Eragrostis eriopoda* on brown sandy loams on plains and drainage lines

5 Mid Sparse Shrubland of mixed Acacia species usually dominated by *A. synchronicia* over Low Hummock Grassland dominated by various Triodia species including *T. epactia*, *T. wiseana* and *T. longiceps* on brown clay loams on stoney plains and base of low hills

6 Tall hummock grassland dominated by *Triodia longiceps* with tall isolated shrubs of *Acacia synchronicia* on red or brown sandy to clay loams on stony plains, interspersed with low sparse forbland of mixed species including *Sida fibulifera, Rhynchosia minima, Tephrosia* sp. clay soils (S. van Leeuwen et al. PBS 0273), *Crotalaria dissitiflora* subsp. *benthamiana, Cullen graveolens* Â and *Eriachne flaccida* on brown cracking clay in clay pans

7 Tall sparse shrubland dominated by species including *Acacia bivenosa, Acacia synchronicia* and *Dichrostachys spicata* over mid hummock grassland dominated by *Triodia longiceps* over low sparse tussock grassland and chenopod shrubland dominated by *Cenchrus ciliaris* and *Sclerolaena hostilis* on brown clay loam on flats and in open depressions

8 Low isolated shrubs dominated by *Melaleuca glomerata* over mid hummock grassland dominated by *Triodia longiceps* over low mixed sedgeland, grassland and forbland of mixed species including *Schoenus falcatus*, *Trianthema cusackianum* and *Stemodia grossa* on white to brown clay to clayey sand with occasional calcrete and dolerite stones, at the head of drainage lines

9 Low open woodland to isolated trees of *Eucalyptus leucophloia* subsp. *leucophloia* and/or *Corymbia hamersleyana* over tall shrubland to sparse shrubland of mixed species dominated by *Acacia orthocarpa*, *Acacia monticola*, *Acacia tumida* var. *pilbarensis*, *Grevillea wickhamii* and occasionally *Acacia retivenea* subsp. *clandestina* over low shrubland to sparse shrubland of mixed species dominated by *Acacia ptychophylla*, *Acacia spondylophylla*, *Goodenia stobbsiana*, *Dampiera candicans* and *Ptilotus calostachyus* over low hummock grassland dominated by *Triodia epactia* and occasionally *Triodia brizoides* on red or brown clay loam with ironstone or metamorphosed granite stones, usually over ironstone or metamorphosed granite outcropping, on hill crests or occasionally low rises

10 Isolated trees dominated by *Eucalyptus leucophloia* subsp. *leucophloia* and occasionally *Corymbia hamersleyana* over tall to mid sparse shrubland dominated by species including *Acacia bivenosa*, *Acacia inaequilatera*, *Acacia pyrifolia* var. *pyrifolia* and *Grevillea wickhamii* over low open to sparse shrubland of mixed species including *Indigofera monophylla*, *Acacia ptychophylla* and *Senna spp.* over low hummock grassland dominated by *Triodia brizoides*, *Triodia epactia* and/or *Triodia wiseana* over low sparse tussock grassland dominated by *Eriachne mucronata* on red or brown clay loam, usually over metamorphosed granite or occasionally dolerite, quartz or ironstone outcropping, on the upper slopes and crests of steep hills and ridges, or occasionally on low hills, undulating plains and outwashes

11 Low isolated trees of *Corymbia hamersleyana* over tall sparse shrubland dominated by *Acacia inaequilatera* and often *Grevillea pyramidalis* subsp. *leucadendron* over low sparse shrubland dominated by *Corchorus parviflorus*, *Indigofera monophylla* and *Senna glutinosa* subsp. *glutinosa* over low hummock grassland dominated by *Triodia wiseana* and/or *Triodia epactia* on red to brown clay loam often with dolerite or occasionally quartz or metamorphosed granite outcropping, on low hills, ridges and occasionally undulating plains

12 Low open woodland of *Corymbia hamersleyana* over mid sparse shrubland dominated by *Acacia bivenosa* over low sparse shrubland of mixed species including *Corchorus parviflorus*, *Heliotropium cunninghamii*, *Indigofera monophylla* and *Pluchea ferdinandi-muelleri* over low hummock grassland dominated by *Triodia wiseana* and/or *Triodia angusta* or *Triodia longiceps* on brown clay loam Â on stony undulating plains and low rises often with calcrete outcropping

13 Isolated trees dominated by *Corymbia hamersleyana* over tall to mid sparse shrubland dominated by *Grevillea wickhamii* Â and *Acacia bivenosa* over low open to sparse shrubland dominated by *Acacia arrecta*, *Goodenia stobbsiana*, *Corchorus parviflorus* and *Heliotropium ovalifolium* over low hummock grassland dominated by *Triodia angusta* and often *Triodia wiseana* on brown clay loam on stony undulating plains, low hills and ridges with calcrete and dolerite outcropping

14 Mid open woodland of mixed species including *Eucalyptus victrix* and *Corymbia hamersleyana* over tall open to sparse shrubland of mixed species including *Acacia coriacea* subsp. *pendens, Acacia trachycarpa*, *Acacia pyrifolia* var. *pyrifolia*, *Acacia tumida* var. *pilbarensis* and *Melaleuca glomerata* over low sparse shrubland of mixed species including *Pluchea ferdinandi-muelleri*, *Cajanus pubescens* and *Stemodia grossa* over mid open grassland and sedgeland of mixed species dominated by **Cenchrus ciliaris*, *Triodia longiceps*, *Triodia epactia*, *Chrysopogon fallax* and *Cyperus vaginatus* on red to brown sand to sandy loam with riverstones in minor to medium drainage lines

15 Mid open forest to woodland dominated by *Eucalyptus camaldulensis* subsp. *refulgens* and occasionally *Eucalyptus victrix* over tall open shrubland dominated by species including *Acacia ampliceps*, *Melaleuca glomerata* and *Acacia pyrifolia* var. *pyrifolia* over mixed mid open grassland and sedgeland dominated by * *Cenchrus ciliaris*, *Cyperus vaginatus* and *Triodia longiceps* on red to brown sandy to clay loam with riverstone in major drainage lines

C Cleared Land

NS Not Surveyed

Significant Flora

Aah	*Abutilon* aff. *hannii*	Osp	*Oldenlandia sp.*
Acsp	*Acrostichum speciosum*	Pmo	*Ptilotus mollis* (P4)
Alev	*Acacia levata* (P3)	Psp	*Portulaca sp.*
Alev	*Acacia levata* (P3) - DBCA Records	Radl	*Rostellularia adscendens* var. *latifolia* (P3)
Cmac	*Cochlospermum macnamarae* (P1)	Rin	*Rothia indica* subsp. *australis* (P3)
Ecr	*Eragrostis crateriformis* (P3)	SspM	*Schoenus coultasii* (P1)
Epus	*Eriocaulon pusillum*	Swe	*Stylidium weeliwolli* (P3)
Hmur	*Heliotropium murinum* (P3)	Swt	*Swainsona thompsoniana* (P3)
Num	*Nicotiana umbratica* (P3)	Taa	*Triumfetta* aff. *appendiculata*

WOODMAN ENVIRONMENTAL

N

This map should only be used in conjunction with WEC report Atlas20-14-01.

Sanjiv Ridge
Vegetation Types and Significant Flora

Revision: A - 22 January 2021 Scale: 1:9,990 (A3)

Author: Marco Pratissoli

WEC Ref: Atlas20-14-01

Filename: Atlas20-14-01-f06-Legend

Projection: GDA 1994 MGA Zone 50

Figure

6.0