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FERRAUS LIMITED
ROBERTSON RANGE (M52/1034)
Vegetation and Flora Report

Version 1

Providing sustainable environmental strategies, management and monitoring solutions to industry and government.

ecologia ENVIRONMENT

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Executive Summary

FerrAus Limited proposes to conduct a mining operation at its Robertson Range project area. The project will mine iron ore of direct shipping grade for export. An open pit mining operation is proposed to excavate the iron ore.

The area is located approximately 100 km south-east of Newman near the Jigalong Aboriginal Community. The 957.4 ha project area is covered by tenement M 52/1034. Robertson Range lies west of the centre of Beard's Eremaean Botanical Province and is close to the north-eastern border of the Gascoyne IBRA biogeographic region.

FerrAus Limited commissioned *ecologia* Environment (*ecologia*) to conduct a two phase vegetation and flora survey of the area to support the approvals process. The objectives of the survey were:

- To assess the vegetation and flora of Robertson Range to determine whether any ecological communities, vegetation units or flora species of conservation significance occur within it and if present, to indicate appropriate management options to prevent or minimise the impacts due to any disturbance.
- To determine and map the different vegetation types occurring within the Robertson Range project area.

The first phase of the survey was conducted in April 2007, and the second in June 2008. The two phases were carried out in different seasons and sample sites (quadrats) were located within the different habitats occurring in the project area. Seventy-seven quadrats were assessed over the two phases of the survey; 40 during phase one, 37 during phase two, and 11 during both phases. In addition to this, when the botanists walked from site to site opportunistic collections were made of any flora species not already recorded in the quadrats.

Vegetation within the Robertson Range project area were assessed on the basis of data analysis, landforms and habitats, and has been separated broadly into nine main units:

1. *Grevillea wickhamii* subsp. *hispidula* open tall-shrubland;
2. *Gompholobium polyzygum* low-shrubland;
3. *Acacia ancistrocarpa* tall-shrubland;
4. *Eucalyptus gamophylla* open mallee woodland, over *Triodia basedowii* mid-hummock grassland;
5. *Hakea* spp. scattered low trees, over open low-shrubland and open mid-hummock grassland;
6. *Hakea* spp. isolated low trees, over *Acacia dictyophleba* mid-shrubland, over open mid-hummock grassland;
7. Low regrowth shrubland;
8. *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) and *Triodia basedowii* low-hummock grassland;
9. *Acacia aneura* open low-woodland.

No threatened ecological communities were identified in the project area.

One hundred and ninety-six flora taxa, including subspecies, varieties and affinities were recorded over the two phases of the survey at Robertson Range; 151 in phase one and 140 in phase two. Of these 196 taxa, 94 were recorded in both phases of the survey, 57 in the

first phase only and 46 in the second phase only. The 196 taxa recorded were from 36 families and 89 genera. The most species rich plant families were the Poaceae (30 taxa) and Mimosaceae (24 taxa) while the most species rich genera were *Acacia* (24 taxa) and *Senna* (14 taxa); 12 families and 56 genera were represented by a single taxon.

No Rare or Priority Flora taxa were recorded within the Robertson Range project area.

No declared weed species were recorded within the Robertson Range project area.

One general weed species, **Portulaca oleracea*, was recorded at two sites within the Robertson Range project area.

Conformance of the Project to relevant EPA statements is addressed in Table S-1 of this summary. The conservation significance of the vegetation and flora of the project area, an assessment of potential impacts, and management recommendations are discussed in the body of the report.

Table S.1 – Conformance of project to relevant EPA statements.

Requirement	EPA Statement	Relevance to Project	Project Compliance
Impact on biodiversity	Position Statement No. 3	Where impact on biodiversity cannot be avoided, the proponent must demonstrate that the impact will not result in unacceptable loss.	No species of conservation significance were recorded during the survey.
State, national and international agreements, legislation and policy on biodiversity	Position Statement No. 3	Information gathered for environmental impact assessment in Western Australia meets state, national and international agreements, legislation and policy in regard to biodiversity conservation.	Impacts to species listed under relevant legislature are addressed in Sections 4, 5 and 6. The relevance of the project to principles outlined in the *Environmental Protection Act 1986* is discussed in Section 6.
EPA standards, requirements and protocols	Position Statement No. 3	The quality of information and scope of field surveys meets the standards, requirements and protocols as determined and published by the EPA.	The current survey conforms to a level two survey, comprising a reconnaissance survey, a comprehensive two phase vegetation and flora survey and mapping of the vegetation of the area, as per EPA Guidance Statement 51.
Biodiversity conservation and ecological function values	Position Statement No. 3	Sufficient information is provided to address biodiversity conservation and ecological function values.	Impacts to biodiversity and ecological function are discussed in Sections 4 and 5. The value of the vegetation associations occurring in the project area is also discussed in a bioregional context.
State biological databases	Position Statement No. 3	Terrestrial biological surveys will be made publicly available and will contribute to the bank of data available for the region.	Vouchers of selected specimens collected during the surveys will be lodged at the WA Herbarium. Information collated from this survey will be included in public documents available for use by others.
Sampling design and intensity at two levels – regional and area specific	Guidance Statement No. 51	Sites were assessed at the area specific level.	Data was collected on an area specific level. Adequate regional data is available from other surveys undertaken in the area. Two surveys were carried out and 77 quadrats were assessed.
Landform – scale, rarity, heterogeneity	Guidance Statement No. 51	Sites should be established in the different landforms occurring across the study area.	Sites were selected from aerial photography before going to the field. In the field, ground-truthing of the vegetation types occurring on the different landforms of the project area took place and sites were assessed in each of the landforms.
Habitat – scale, rarity, heterogeneity	Guidance Statement No. 51	Sites should be established in the different habitats occurring across the study area.	Sites were selected from aerial photography before going to the field and ground-truthing of the vegetation types occurring in the different habitats took place in the field. Sites were assessed in the different habitats of the project area.

Requirement	EPA Statement	Relevance to Project	Project Compliance
Potential for conservation significant flora to occur, based on habitat analysis	Guidance Statement No. 51	Sufficient information is to be provided to indicate the potential for significant flora to occur based on habitats in the area.	Lists of conservation significant taxa recorded in the vicinity of the project area are provided in Section 3. An analysis has been carried out on the likelihood of these taxa occurring in the area.
Information on adjacent areas – previous surveys and herbarium records	Guidance Statement No. 51	Adequate information was already available on the wider project area, as other surveys have been undertaken in the area.	Information was requested from relevant government databases and was collated from reports on surveys undertaken in the vicinity of the project area.
Vegetation structure, diversity and seasonality	Guidance Statement No. 51	Sufficient information is to be provided in the report on vegetation structure, diversity and seasonality.	The report details the results of a vegetation mapping exercise carried out over the survey area. It involved multivariate analysis of the data and digital mapping of the vegetation associations identified from the statistical analyses. The two phases of the survey were carried out in different seasons. The first in autumn (April) 2007 and the second in winter (June) 2008. In the five months before the first phase survey 171.8 mm of rain fell on the area 176.8 mm before the second phase. The different times of the survey ensured that the diversity and seasonality in the flora present in the project area was represented in the species list. To illustrate this, 41 annual species were recorded during the April survey and 16 during the June survey.
Results including species/area curves, species and ecosystem diversity and heterogeneity	Guidance Statement No. 51	Adequate information is provided in the report to comply with this requirement.	A vegetation map and detailed vegetation descriptions are provided for the project area. Details on the flora of the project area are included in the report.

1 INTRODUCTION

FerrAus Limited (FerrAus) proposes to conduct a mining operation at its Robertson Range project area. The project will mine iron ore of direct shipping grade for export. An open pit mining operation is proposed to excavate the iron ore.

The Robertson Range project area is located approximately 100 km south-east of Newman near the Jigalong Aboriginal Community. The 957.4 ha project area is covered by tenement M 52/1034. FerrAus has been carrying out a drilling and exploration programme on the tenement since October 2005.

The Robertson Range project area is west of the centre of Beard's Eremaean Botanical Province and is close to the north-eastern border of the Gascoyne IBRA biogeographic region.

1.1 PROJECT LOCATION

The closest town to the Robertson Range project area is Newman, located approximately 100 km north-west of Robertson Range (Figure 1.1). The Robertson Range project area lies within the Jigalong Aboriginal Community Reserve.

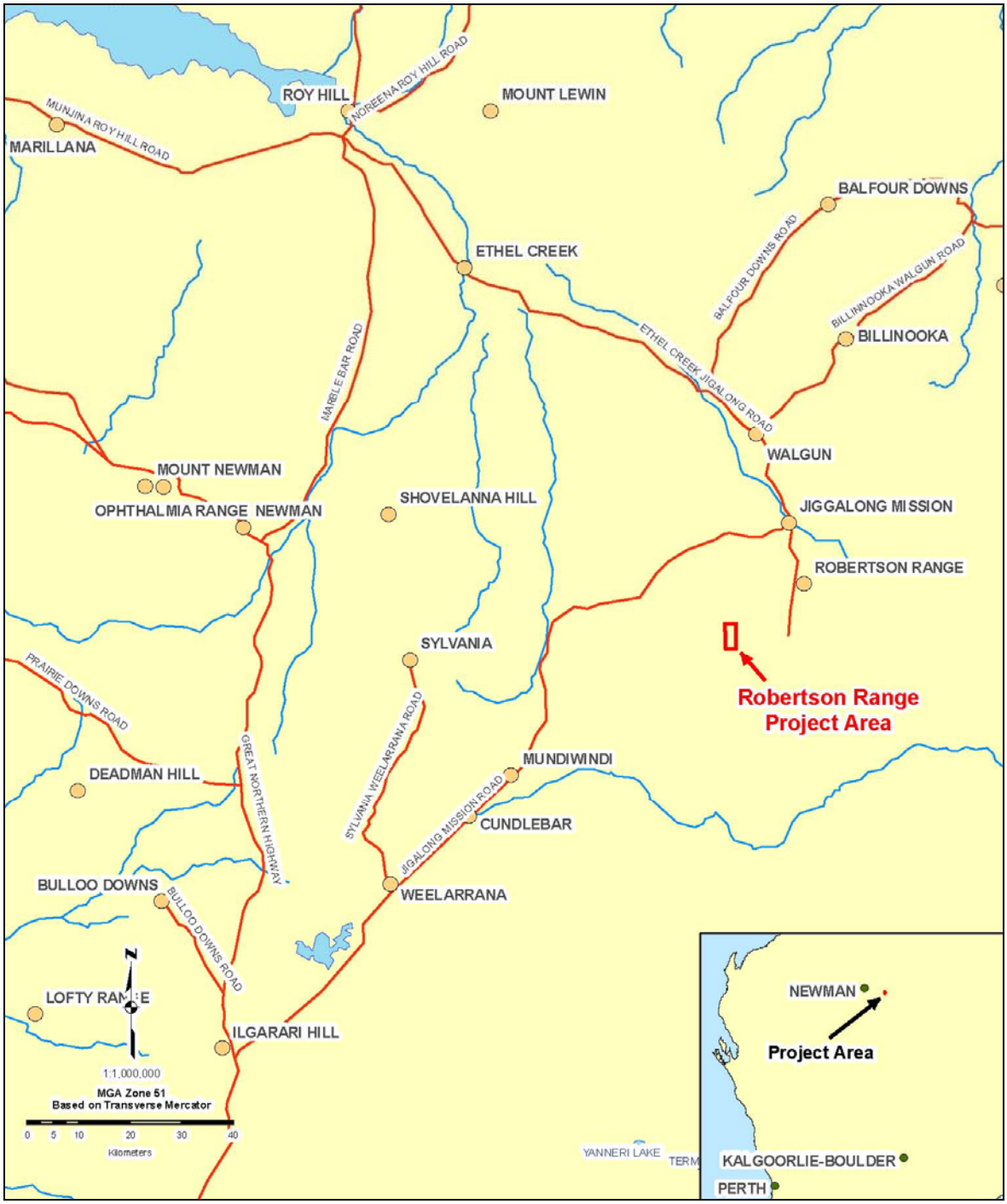

Figure 1.1 – Location of the Robertson Range project area.

1.2 LEGISLATIVE FRAMEWORK

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

The Precautionary Principle

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

The Principle of Intergenerational Equity

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

The Principle of the Conservation of Biological Diversity and Ecological Integrity

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

The scope of this report includes a discussion of the impacts on vegetation and flora of the project area. The following paragraphs discuss legislation in the EPBC and WC Acts relevant to this report.

The EPBC Act was developed to provide for the protection of the environment, particularly concerning biodiversity and matters of national environmental significance. The EPBC Act aims to protect biodiversity by promoting conservation and sustainable use of natural resources. The EPBC Act includes provisions to protect native species, particularly threatened species, by preventing extinction, and promoting recovery.

The WC Act was developed to provide for the conservation and protection of wildlife in Western Australia. Under Section 14 of this Act, all flora within Western Australia is protected. However, the Minister may, via a notice published in the *Government Gazette*, declare a list of flora taxa identified as likely to become extinct, rare, or otherwise in need of special protection. The current listing was gazetted on the 5th of August 2008.

Vegetation and Flora surveys undertaken as part of the Environmental Impact Assessment (EIA) process in Western Australia are required to address the Environmental Protection Authority's (EPA) Position Statement No. 3 (Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA, 2002)), Guidance Statement No. 51 (Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004)), and Position Statement No. 2 (Environmental Protection of Native Vegetation in Western Australia (EPA, 2000)).

1.3 SURVEY OBJECTIVES

FerrAus commissioned *ecologia* Environment (*ecologia*) to undertake a two phase biological investigation of the vegetation and flora of its Robertson Range project area.

The study was conducted to assist in assessing potential impacts of exploration activity on vegetation and flora of the area and this report provides:

(a) An inventory of:

- vascular flora species occurring in the study area, incorporating recent published and unpublished records;
- biologically significant species, including rare flora in the study area;
- vegetation associations and communities, including a map of vegetation units, occurring in the study area; and
- habitats and vegetation associations in the study area that are poorly represented, or that are essential to the survival of rare flora.

(b) A review of:

- regional and local conservation value of flora present, or likely to be present, in the study area;
- any species of particular conservation value, such as Declared Rare or Priority Flora species, likely to occur in the study area;
- invasive weed species found in the survey area;
- current impact of the land-use on vegetation associations;
- other potential impacts on the existing environment; and
- any previous surveys undertaken in the general area.

(c) Recommendations for:

- management of flora habitat and of under-represented vegetation associations;
- management of any Declared Rare Flora, Priority Flora and weeds; and
- management of current and future potential impacts on the existing environment.

2 EXISTING ENVIRONMENT

2.1 CLIMATE

The Robertson Range project area is situated in the north-eastern section of the Gascoyne bioregion. The Gascoyne bioregion lies in the Tropic of Capricorn and therefore has aspects of both a tropical-arid climate in the northern section, and a temperate-Mediterranean climate in the southern section.

The tropical-arid climate experienced in the Robertson Range project area, is characterised by two distinct seasons; a hot summer (wet season) from October to April and a mild winter (dry season) from May to September.

Annual evaporation exceeds rainfall by as much as 500 mm per year and the rainfall is seasonally low and unpredictable. A bimodal rainfall distribution pattern results in two distinct rainfall periods. Sporadic rainfall is produced from January to March due to tropical cyclones moving south from northern Australian waters, and from May to June extensive cold fronts move easterly across the state and occasionally reach the northern Gascoyne (Beard, 1975).

The climate experienced throughout the year is usually very dry, as both high temperatures and humidity seldom occur simultaneously. The temperature range is large and maxima are high. Summer temperatures may reach as high as 46°C (average maximum ranging from 22.3 – 39.0^{o}C) and winter temperatures may drop to -2^{o}C (average minimum ranging from 8.1 - 25.3°C) (Bureau of Meteorology, 2009).

The closest current Bureau of Meteorology (BOM) weather station is located in Newman. This BOM weather station is located approximately 100 km west-north-west of the Robertson Range project area. Meteorological data from the Newman weather station provides an indication of climatic conditions that could be expected in the Robertson Range project area (Figure 2.1).

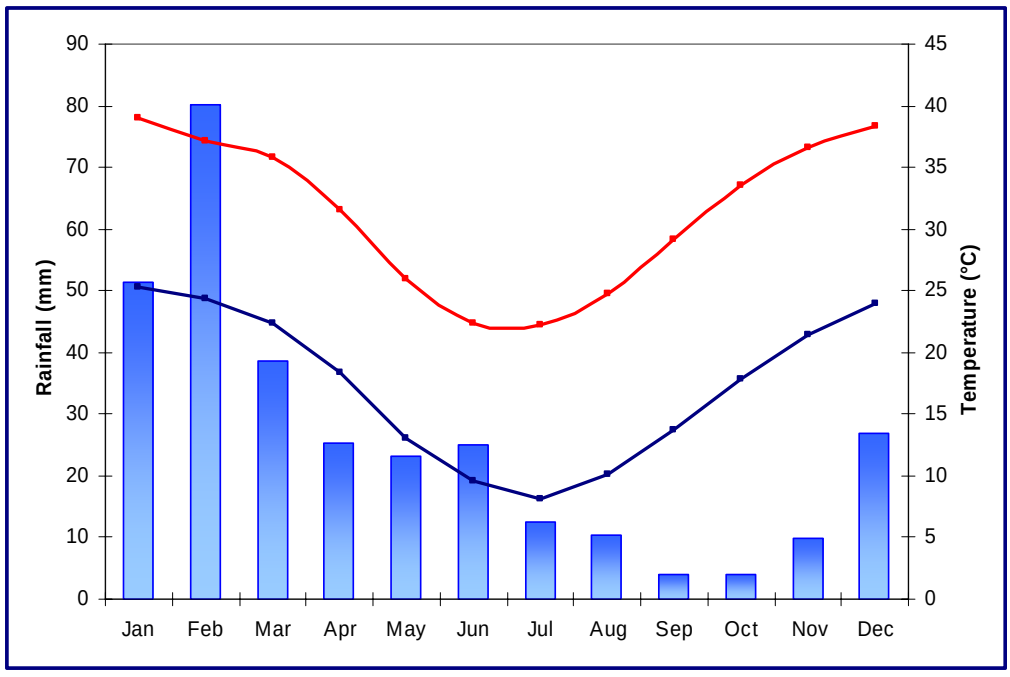

Figure 2.1 – Summary of long-term temperature and rainfall data for Newman.

Bars indicate rainfall, blue and red lines indicate minimum and maximum temperature respectively.
Data sourced from closed BOM Station- 'Newman' [007151]. Location 23.37°S 119.73°E, elevation 544m.
Mean temperatures calculated from 1965-1997, mean rainfall from 1965-2003 (BOM, 2009).

The calculated long-term average annual rainfall is 310.2 mm, which occurs over 45 rain days. It loosely follows the typical Pilbara and Gascoyne bimodal distribution pattern, with a peak between December and March and a smaller peak in May and June. Most of the rainfall occurs in the summer period, with over 55% of total annual precipitation falling between December and March (Table 2.1).

Table 2.1 – Long-term climate data for Newman.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (°C)													
Maximum	39.0	37.2	35.8	31.6	26	22.4	22.3	24.8	29.2	33.6	36.6	38.3	31.4
Minimum	25.3	24.4	22.4	18.4	13.0	9.6	8.1	10.1	13.7	17.9	21.4	23.9	17.3
Rainfall													
Rainfall (mm)	51.4	80.1	38.6	25.3	23.2	25	12.6	10.5	4.1	3.9	9.8	27	310.2
Days of rain	6.7	7.0	4.9	4.2	3.8	3.9	2.5	1.9	0.9	1.4	2.9	5.1	45.2

Note: Long-term averages are presented for each of the parameters. Maxima are highlighted in red and minima are highlighted in blue. Data source as for Figure 2.1.

The first phase (April 2007) of the survey was preceded by good rainfall at the beginning of the wet season (Table 2.2). Above average rains fell in Newman from September to December 2006. In September and October approximately nine and eight times the average for those months was recorded. In the six months preceding (October 2006 to March 2007) the survey area received 203.8 mm of rainfall, which was 7 mm less than the 210.8 mm long-term average for the same period.

Good rains fell before the June 2008 second phase survey also (Table 2.2). In February 2008, 124.6 mm of rain fell compared with a long-term average of 80.1 mm for the same month. In the six months prior to the phase 2 survey 205.6 mm of rain was recorded, which is 40 mm less than the 245.6 mm long-term average for the same six months.

Table 2.2 – Rainfall recorded at Newman in 2006, 2007 and 2008.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006					0	1.2	0	0	35.6	32	17.8	41.6
2007	41.2	6.6	64.6	**66**	0	0	7.2	0	0	2.8	2.2	28.8
2008	15.6	124.6	35.4	1.2	0	**34.6**						
Average	51.4	80.1	38.6	25.3	23.2	25	12.6	10.5	4.1	3.9	9.8	27

Note: Data in **bold** denotes months when surveys carried out.
Yearly rainfall data sourced from active BoM Station- 'Newman Aero' [007176].
Location 23.42°S 119.80°E, elevation 524m (BOM, 2009).
Average rainfall data sourced as for Figure 2.1.

2.2 GEOLOGY

The geology of the FerrAus Robertson Range project area has been mapped and described in detail by Williams and Tyler (1991). Five geological substrates were identified in the area and these are described in Table 2.3, below.

Table 2.3 – Geology of the Robertson Range project area.

Substrate	Composition	Location in Survey Area	Proportion of Survey Area (%)
1	Eolian sand; in sheets, longitudinal, chain and net dunes.	Southern flat area	93
2	Marra Mamba Iron Formation; chert, ferruginous chert and minor shale.	Raised, rocky northern section	3
3	Scree talus slope deposits - colluvium and minor alluvium; quartz pebble and rock fragments in silt and sand.	Adjacent to the Marra Mamba Iron Formation	2
4	Lateritic sands, with a ferruginous hard crust, massive, nodular, pebbly and pisolitic.	One small area towards the south	1
5	Quartz veins.	Adjacent to the Marra Mamba Iron Formation	1

The Marra Mamba Iron Formation features in the project area and is composed of chert, iron formation and shale. It is a basal member of the Hamersley Group, and is host to many high grade iron ore deposits in the surrounding area, including deposits in the region of Newman. Surrounding the raised Marra Mamba Iron Formation are extensive deposits of colluvium and alluvium that form scree talus slopes. Quaternary aeolian sand covers the majority of the flat region of the FerrAus lease, with one small section composed of lateritic sands.

East of the Robertson Range project area the Robertson Range forms a prominent north-north-easterly trending sandstone scarp up to 90 m high. The Range is part of the Coondra Formation of the Savory Group and is composed of coarse-grained sandstone. A belt of low hills to the west of the Robertson Range project area reach up to 150 m ASL and are part of the Archean Formation, composed of metagranite and metagranodionte (Williams & Tyler, 1991).

2.3 LAND SYSTEM CLASSIFICATION

An inventory of the land systems occurring in the Pilbara was undertaken by the West Australian Department of Agriculture (Van Vreeswyk *et al.,* 2004). The inventory aimed to provide a comprehensive description and mapping of the biophysical resources of the region, together with an evaluation of the condition of soils and vegetation throughout. Two main land systems occur in the Robertson Rang project area; the Divide and the Newman Land Systems. These are described in Table 2.4 and mapped in Figure 2.2, below. The Newman Land System contains iron ore deposits which are of current and future mining interest (Van Vreeswyk *et al.,* 2004).

Table 2.4 – Land systems of the Robertson Range project area.

Land System	Land Type	Geology	Vegetation	Proportion of Survey Area (%)
Divide (Div)	11. Sand plains	Sandplains and occasional dunes composed of quaternary aeolian sands.	Scattered shrubs and trees; including *Grevillea*, *Acacia* species and *Eucalyptus* species over hard spinifex (*T. basedowii*) grasslands.	95
Newman (New)	1. Hills and ranges	Rugged jaspilite plateaus, ridges and mountains. Contains iron ore deposits.	Scattered shrubs and trees; including *Acacia*, *Senna*, *Grevillea wickhamii* and *Eucalyptus leucophloia,* over hard spinifex grasslands.	5

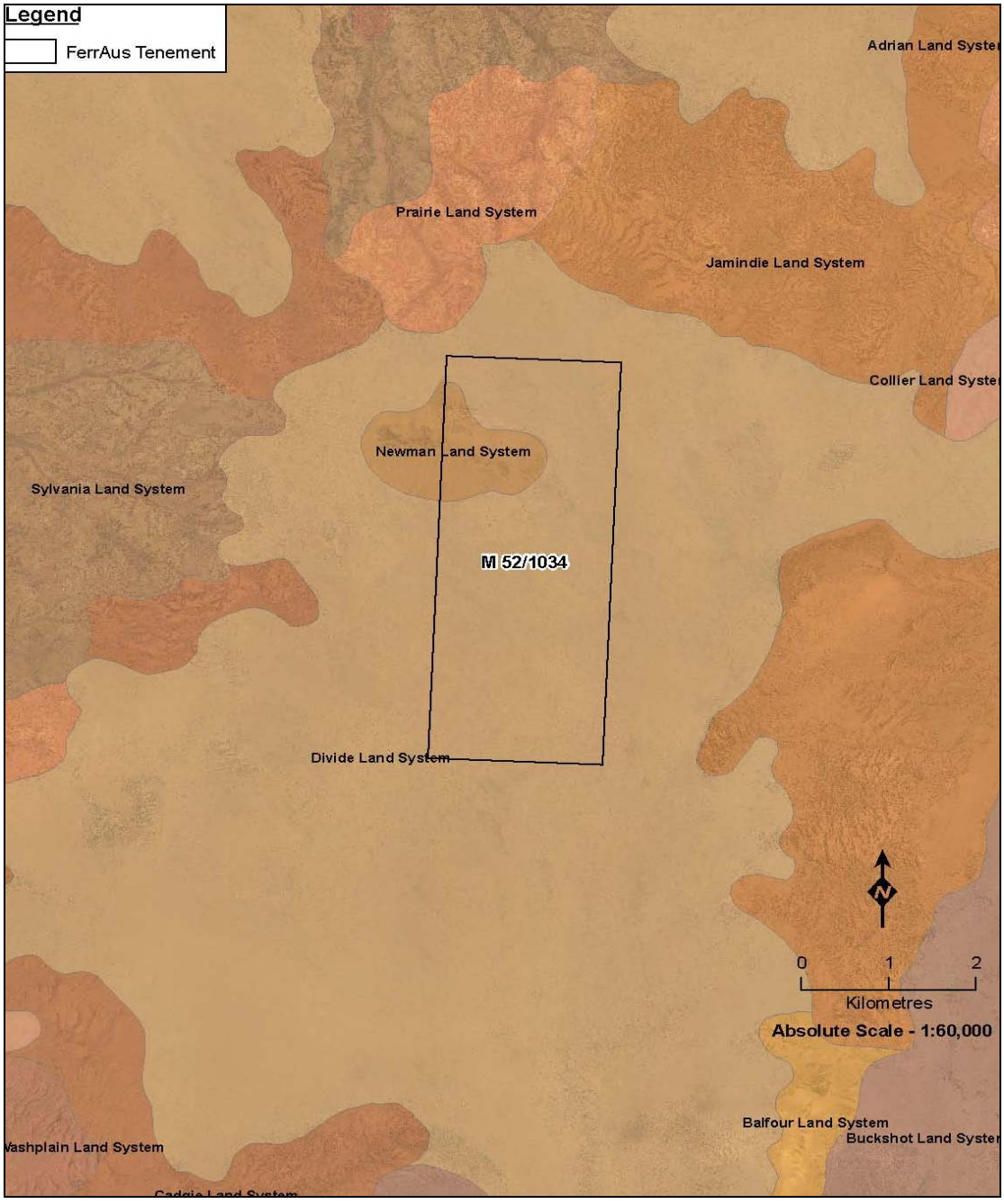

Figure 2.2 – Land systems of the Robertson Range project area.

2.4 SOILS

The soils of the Robertson Range project area have been determined as part of the land system classification, detailed by Van Vreeswyk *et al.* (2004). They range from red deep sands and red sandy earths of the Divide Land System, to stony soils with red shallow loams or sands (on the higher slopes), and stony soils with red loamy earths (on the lower slopes) of the Newman Land System.

2.5 BIOGEOGRAPHIC REGIONS

The Robertson Range project area is situated in the Augustus subregion of the Gascoyne biogeographic region (GAS3). It is 15 km south of the Pilbara's Fortescue Plains subregion (PIL2) and 10 km west of the Little Sandy Desert, Trainor subregion (LSD2) (Figure 2.3). These biogeographic regions are defined on the basis of climate, geology, landforms, vegetation and fauna as defined by the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway and Cresswell, 1995).

The plain vegetation of the survey area is more typical of the eastern section of the Pilbara's Fortescue Plains subregion, which is characterised by scattered *Eucalyptus gamophylla*, over hard spinifex. Mulga (*Acacia aneura*) woodlands are common in the Fortescue Plains subregion and Gascoyne bioregion, (Beard, 1975); however, mulga is not a dominant vegetation unit in the Robertson Range project area.

2.5.1 The Gascoyne Bioregion

The Gascoyne bioregion is divided into three subregions; the Ashburton (GAS1), Carnegie (GAS2) and Augustus (GAS3). The project area falls within the Augustus subregion, which is the largest of the three subregions and has an area of 10,687,739 ha (Figure 2.3). The project would impact approximately 0.009% of this subregion if the whole tenement were to be cleared.

The Augustus subregion is characterised by rugged, low, Proterozoic sedimentary and granite ranges. Broad flat valleys divide the ranges associated with the headwaters of the Fortescue River and Ashburton and Gascoyne catchment areas.

Mulga (*Acacia aneura*) woodlands and *Triodia* and mulga parkland characterise the Augustus subregion. They occur in shallow stony loams/rises and in shallow earthy loams/hardpans of the plains respectively (Desmond *et al*., 2003).

2.5.2 The Little Sandy Desert

The Little Sandy Desert is divided into the Rudall (LSD1) and Trainor (LSD2) subregions. The Trainor subregion is adjacent to and east of the Ashburton subregion (Figure 2.3), it is the larger of the two subregions and covers an area of 11,114,705 ha.

The Trainor subregion is characterized by geology of red Quaternary dune fields and Proterozoic sandstone ranges. This bioregion occurs at the western end of the red centre desert.

On sandy surfaces a shrub steppe of *Acacia* species, *Aluta maisonneuvei* and *Grevillea* species over *Triodia schinzii* are common in this subregion, while a sparse shrub-steppe over *Triodia basedowii* typically occurs on stony hills. The stony hill vegetation type is associated with eucalypt/coolabah communities and bunch grasslands on alluvial deposits and drainage lines (Desmond *et al*., 2003).

2.5.3 The Pilbara

The Pilbara biogeographic region is divided into –the Chichester (PIL1), Fortescue Plains (PIL2), Hamersley (PIL3) and Roebourne (PIL4) subregions. The Fortescue Plains subregion is adjacent to and north of the Ashburton subregion (Figure 2.3). This is the smallest subregion contributing to only 10% of the Pilbara bioregion with an area of 2, 041, 914 ha.

The Fortescue Plains is a long, skinny subregion that laterally divides the two larger subregions - the Chichester to the north and Hamersley to the south. Due to its shape the Fortescue Plains subregion has variable geology and associated vegetation communities.

The project area is close to the eastern Fortescue which has many alluvial plains. This is most probably a result of the extensive calcrete aquifer in the central Fortescue. The eastern Fortescue is characterised by extensive salt marsh, mulga-bunch grass, and short grass communities (Desmond *et al*., 2003).

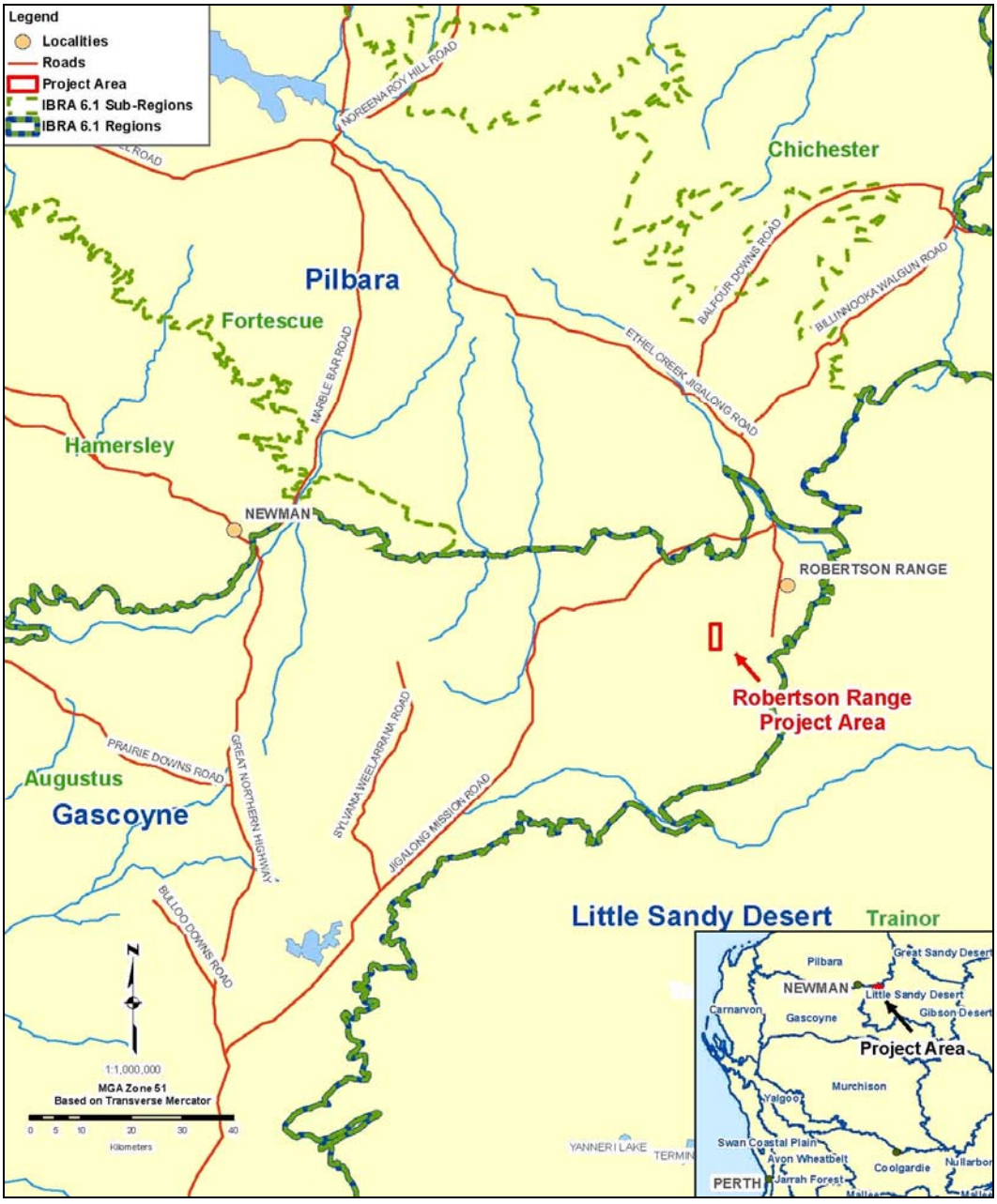

Figure 2.3 – IBRA Biogeographic regions and subregions of and surrounding the Robertson Range project area.

2.6 PREVIOUS BIOLOGICAL SURVEYS

Early flora survey work was carried out by Royce (1948) and Burbidge (1959), while broad scale vegetation mapping was first carried out by Burbidge (1945) and later refined by Beard (1975). Site-specific detailed flora and fauna surveys have only been conducted in the Pilbara region during the last 30 years concurrent with the increased development of mineral resources in the region. In this time, numerous surveys by private consultants and government organisations have been conducted in the area, with particular emphasis on the mineral-rich ranges.

No fine-scale studies of the vegetation and flora of the Robertson Range area have been conducted or published to date. However, vegetation and flora surveys, primarily in association with exploration and mining development, have been carried out in the surrounding areas by *ecologia*. Flora surveys have been carried out at:

- Davidson Creek approximately 18 km north-west of the Robertson Range project area (*ecologia,* 2007);
- Orebody 18 approximately 70 km north-west of Robertson Range (*ecologia*, 1995a, 2004d);
- Orebody 23 approximately 90 km north-west of Robertson Range (*ecologia*, 1998a; 1998b);
- Orebody 25 approximately 95 km north-west of Robertson Range (*ecologia*, 1995b); and
- Orebody 24 approximately 100 km north-west of Robertson Range (*ecologia*, 2004b).

A review of the flora of Orebodies 18, 23 and 15 was undertaken in 2004 (*ecologia*, 2004c).

In addition larger scale vegetation and flora surveys have been carried out at the East Ophthalmia Orebody (*ecologia*, 2004a) and the Jimblebar, Wheelarra Hill, East Jimblebar and Hashimoto mining areas approximately 50 km to the west (*ecologia,* 1996; 1999; 2005a; 2005b; 2006).

2.7 LAND USE HISTORY

Mineral exploration in the Pilbara began in 1888 when gold was found in the Pilbara Creek, and although this did not prove productive, more consistent deposits were subsequently discovered at Marble Bar. Tin was discovered in 1899 and manganese and asbestos have also been mined in the Pilbara. Massive iron ore deposits were discovered, with exploitation expanding immensely in the 1960s when the Commonwealth embargo on exporting iron-ore was relaxed. Subsequently, the construction of several mining towns, including Newman, was undertaken.

Newman was developed in the early 1970s to provide accommodation for workers at the Mt. Whaleback iron-ore mine. Ports, such as Port Hedland and Dampier, and standard gauge railways from Mt. Tom Price and Paraburdoo to Dampier, Pannawonica to Cape Lambert, and Mt. Goldsworthy and Mt. Newman to Port Hedland, also were constructed. The development of the iron ore industry has resulted in activity within the Pilbara increasing from cattle and sheep stations and small coastal ports to a large mining economic base with a commensurate increase in population.

Tourism is a smaller but rapidly developing industry within the region and the closest conservation reserve to Robertson Range is Rudall River National Park, which is located approximately 105 km to the north east.

The closest active mining areas are at Wheelarra Hill, Jimblebar, and Hashimoto. Exploration for iron ore in the Robertson Range area has been undertaken since 1999, while FerrAus has been carrying out an exploration programme within their tenements in the area since October 2005.

3 VEGETATION AND FLORA

3.1 SURVEY METHODS

The survey methods used were developed to meet the Environmental Protection Authority's Guidance Statement 51 (Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia; EPA, 2004) and Position Statement Number 3 (Terrestrial Biological Surveys as an element of Biodiversity Protection; EPA, 2002).

The Robertson Range project area occurs in the Gascoyne biogeographic region, and based on the location, scale and nature of the proposed development, Guidance Statement No. 51 (EPA, 2004) indicates that a Level 2, or detailed field survey, is required. A detailed field survey builds on the a reconnaissance survey (Level 1). Therefore the detailed survey verifies background study accuracy, outlines vegetation units present in the survey area and identifies impacts. Its purpose is to "enhance the level of knowledge at the locality scale". The detailed survey involves multiple site visits in differing seasons (including one in the main flowering season), replication of survey plots in vegetation units and greater coverage and displacement of plots over the target area. Position Statement Number 3 (EPA, 2002) aims to identify the conservation and functional values of the site into a local-regional context".

To achieve this, the EPA (2004) states that the site visits must be made by suitably qualified personnel, who undertake selective, low intensity sampling of the flora and vegetation, and produce maps of vegetation units and vegetation condition at an appropriate scale.

The survey included the following:

- detailed site/association assessments; and
  broad-scale vegetation mapping.

3.1.1 Survey Timing

To ensure the optimum sampling of flora in a survey area, the EPA suggests that surveys are timed to follow the season which normally contributes the most rainfall in the bioregion. In the Gascoyne/Pilbara this is the wet season (October to April). Subsequent surveys should be timed in a different season, taking into account short-term climatic fluctuations and the quality of the initial survey.

The vegetation and flora of the Robertson Range project area was surveyed in two seasons. The first phase survey was undertaken between the 23rd and 29th of April 2007 in summer and towards the end of the wet season; 12 person days were spent on this survey. The second phase survey was carried out between the 12th and 16th of June 2008 in autumn; 10 person days were spent on this survey. Relatively good rains fell before each of these surveys (see Section 2.0 for details).

3.1.2 Floristic Survey Sites

The floristic field survey involved systematic flora sampling in quadrats approximately 50 m by 50 m, or of an equivalent area (2,500 m^2) at sites that were less than 50 m wide (e.g. along creeks). These quadrats contribute to the accurate mapping of small-scale vegetation units and to a comprehensive floristic inventory of the project area.

Quadrat sites were chosen on the basis of topography, interpretation and ground truthing of aerial photographs, and also on field observations of vegetation structure, floristics and

condition. The sites chosen for the second phase survey were based on the vegetation mapping exercise carried out following the first phase of the survey. Forty flora quadrats were surveyed during phase one and 37 during phase two; 11 sites were surveyed during both surveys. The number of quadrats established was determined by the size and the heterogeneity of the study area (Figure 3.1). The data collected at each of these sites is presented in Appendix A.1.

3.1.3 Opportunistic Collections

In addition to the quadrat sites, opportunistic collections were carried out while walking from site to site. Opportunistic collections target species that occur within the survey area but outside the quadrats surveyed. This practice results in a more comprehensive species list being recorded in a survey area.

3.1.4 Vegetation Mapping

Vegetation mapping is the delineation of plant communities into groups or associations. The distinctive characteristics that these groups or associations share include features such as species dominance, stratum structure and species composition (Heddle *et al.,* 1980).

Data collected at each quadrat was analysed using the multivariate statistical programme PATN^{TM}. This programme uses presence/absence records to produce a dendrogram that statistically groups sites by similarity. This method provides an objective means of defining boundaries between vegetation types for mapping. However, it is constrained by the limited number of quadrats that can be surveyed. Notes made in the field on vegetation community boundaries, are used to ground-truth and supplement the data collected at quadrat sites.

Phase one data was used in the statistical analysis because it followed a higher rain fall season. The vegetation associations were plotted using 1:5000 aerial photography to define the boundaries.

3.1.5 Survey Limits and Constraints

According to the Environmental Protection Authority (EPA) Guidance Statement for Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA, 2004), flora and vegetation surveys may be limited by a number of constraints. These potential constraints and their relevance to this biological survey are detailed and addressed in Table 3.1.

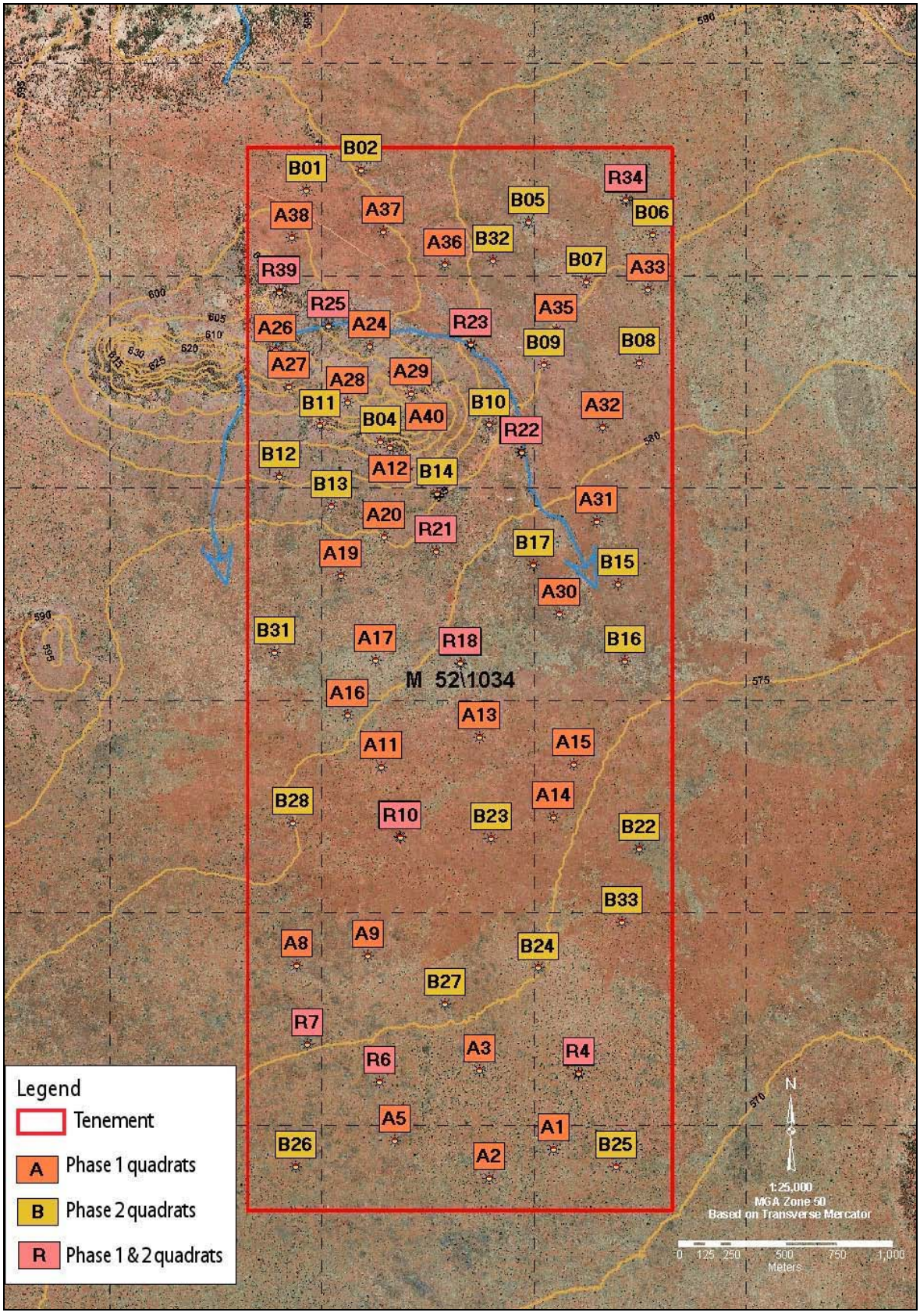

Figure 3.1 – Sites surveyed at the Robertson Range project area.

Table 3.1 – Flora survey constraints and their relevance to the survey.

Aspect	Constraint	Comment
Sources of information and availability of contextual information *(i.e.* pre-existing background versus new material)	No	Several flora surveys have been carried out within 50-100 km of the Robertson Range project area by (see section 2.6 Previous Biological Surveys). Large scale vegetation mapping of the area has been completed in the past. This includes flora and vegetation surveys by Burbidge (1945) and Beard (1975). The land systems of the area have been mapped also (Van Vreeswyck *et al*., 2004)
The scope *(i.e*. what life forms were sampled)	No	Vegetation communities and vascular flora of the project area were sampled at the Robertson Range project area. The survey scope was prepared in consultation with the relevant government agencies (via FerrAus), and was designed to comply with EPA requirements.
Proportion of flora collected and identified (based on sampling, timing and intensity)	No	Approximately 760 voucher specimens were collected during the two phases of this survey and the following identifications were made from these specimens. Taxa identified to species, subspecies, variety, affinity: 196. Identified to family only: 1 taxon. Identified to genus only: 5 taxa. Approximately 350 specimens were collected in the first phase survey resulting in a species list of 151 taxa. Four hundred and seven collections were made in the second phase survey resulting in a species list of 140 taxa. Forty-one annual plant species were recorded during the first phase of the survey following rains, and 16 annual plant species were recorded during the second phase.
Completeness and further work which might be needed *(e.g.* was the relevant area fully surveyed)	No	Aerial photography was used to determine different areas to be sampled during the survey. This ensured that all areas displaying potentially different or unique vegetation were surveyed. In addition, the botanists undertaking the survey ground-truthed the vegetation associations occurring in the sites chosen from the aerial photography and added or removed sites depending on the vegetation encountered while traversing the survey areas. The second phase sites were chosen following the mapping of the vegetation after the first phase of the survey.
Mapping reliability	No	The vegetation associations were mapped following the first survey. Further ground-truthing of the initial mapping occurred during the second phase of the survey. This improved the quality and reliability of the vegetation mapped over the area. Additionally, good aerial imagery was used to select sites to be sampled during the survey and to produce the digitized map of the vegetation associations occurring in the study area.
Timing/weather/season/cycle	No	The first phase survey was carried out during the wet season (April 2007), and 203.8 mm of rainfall was recorded at Newman six months prior to the survey. The long-term average for the same period is 210.8 mm. Most of the rainfall occurred at the beginning of the wet season before the first survey providing good conditions for growth. In the six months preceding the second phase survey (June 2008) 205.6 mm of rain fell at Newman. Although this is below the long-term average of

Aspect	Constraint	Comment
		245.6 mm for this period, in February 2008 124.6 mm of rain fell compared with the long-term average of 80.1 mm for February.
Disturbances *(e.g.* fire, flood, accidental human intervention)	Yes-negligible	An exploration drilling programme has been carried out in the north-western section of the Robertson Range project area. The vegetation of approximately 50% of the area had been affected by fire from one to five years before the phase one survey.
Intensity (in retrospect, was the intensity adequate?)	No	The intensity of the survey was good as 77 quadrats were assessed over the 957 ha tenement. This equates to one quadrat per 12.5 ha, which is a good coverage.
Resources	No	Resources were adequate for the survey and 12 person days were invested in the first phase survey and 10 in the second.
Access problems	No	Because of the exploration activities that have taken place on the tenement and a pre-existing north-south track running along the eastern section of the tenement, access was not a problem. Also, the tenement is less than 1 km wide and all areas were accessible on foot from the main access track.
Experience levels (*e.g.* degree of expertise in plant identification to taxon level)	No	Christina Cox, Melissa Hay and Carmel Winton are experienced field botanists and have had appropriate training, experience and mentoring in flora surveys. They have carried out many surveys in the Pilbara bioregion.

3.2 VEGETATION ASSEMBLAGES

3.2.1 Vegetation Described by Beard (1975)

Beard (1975) has described the vegetation within the Robertson Range project area as shrub steppe on sandplains, and more specifically as:

- *Eucalyptus gamophylla* sparse shrubland, over *Triodia basedowii* open hummock grassland ($e_{25}Srt_2Hi$).

Beard's mapping of the vegetation of the Robertson Range project area and surrounds is shown in Figure 3.2.

The vegetation surrounding the Robertson Range project area has been mapped by Beard as:

- *Acacia aneura* low woodland, continuous (a_1Li); and
- *Acacia aneura* trees in groves or patches (a_1Lp).

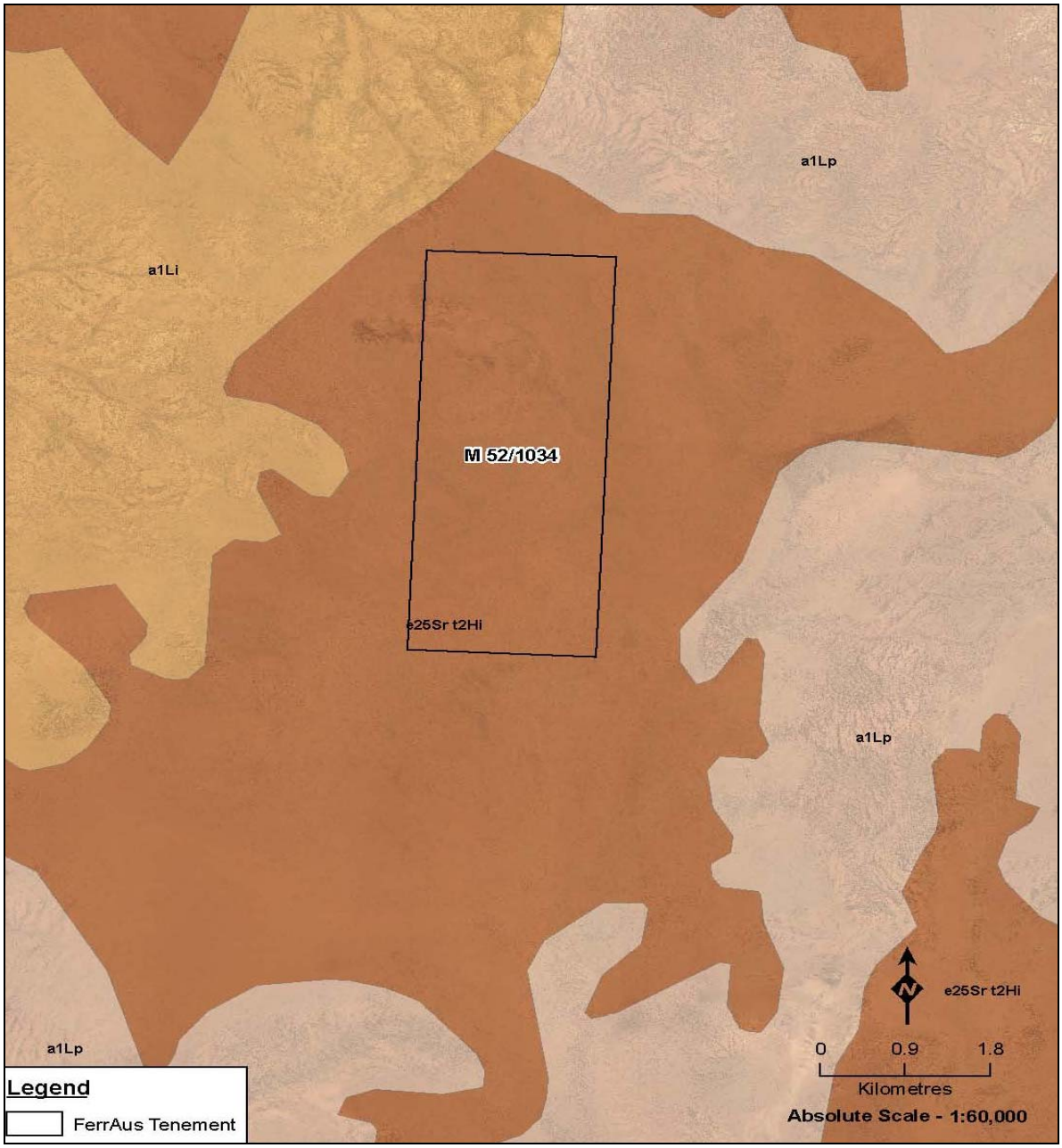

Figure 3.2 – Beard's vegetation of the Robertson Range project area and surrounds.

3.2.2 Vegetation Units of the Survey Area

The vegetation occurring within the Robertson Range project area has been separated broadly into nine main units (Table 3.2).

1: *Grevillea wickhamii* subsp. *hispidula* open tall-shrubland.

2: *Gompholobium polyzygum* low-shrubland.

3: *Acacia ancistrocarpa* tall-shrubland.

4: *Eucalyptus gamophylla* open mallee woodland, over *Triodia basedowii* mid-hummock grassland.

5: *Hakea* spp. scattered low trees, over open low-shrubland and open mid-hummock grassland.

6: *Hakea* spp. isolated low trees, over *Acacia dictyophleba* mid-shrubland, over open mid-hummock grassland.

7: Low regrowth shrubland.

8: *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) and *Triodia basedowii* low-hummock grassland.

9: *Acacia aneura* open low-woodland.

The cluster dendrogram produced from PATN™ analysis of the presence / absence data, is included as Figure 3.3. The vegetation of the Robertson Range project area was mapped at a scale of 1:5,000 (Figure 3.4). Not all vegetation communities visible at ground level and grouped by the multivariate analysis could be reliably discriminated on the aerial photography. As a result the boundaries between some community subtypes could not be reliably extrapolated to areas not ground-truthed and have not been mapped as discrete units, but are described in the following text.

Given the limitations of mapping large areas based on information collected in quadrats, it is likely that further community subtypes, not readily discernible using aerial photography, are present within the survey area. However, the scope of the survey and scale of aerial photography available for interpretation was sufficient to enable all major community types to be adequately described.

The vegetation of the survey area was mapped into nine vegetation units, with one unit further classified into subunits based on structure and species composition of the dominant strata (Table 3.2). The vegetation descriptions presented in Table 3.2 are based on the National Vegetation Information System (NVIS) which has been developed to standardise vegetation data collection in Australia (NVIS, 2003) and information on the height and structural formation classes used to describe the vegetation, and based on NVIS, is included as Appendix A.2.

Table 3.2 – Vegetation Units recorded during the Robertson Range survey.

Vegetation Description	Associated Species Frequently Found In Lower Numbers	Habitat	Quadrats Surveyed	Photograph
1: *Grevillea wickhamii* subsp. *hispidula* open tall-shrubland.				
Corymbia hamersleyana and *Corymbia deserticola* subsp. *deserticola* open low-woodland, over *Grevillea wickhamii* subsp. *hispidula* open tall-shrubland, over *Gompholobium polyzygum* open low-shrubland, over *Triodia melvillei* and *Triodia basedowii* open mid-hummock grassland, over *Aristida holathera* var. *holathera*, *Eulalia aurea* and *Paraneurachne muelleri* sparse low-tussock grassland.	*Acacia ancistrocarpa* *Hybanthus aurantiacus* *Petalostylis cassioides* *Dodonaea coriacea* *Acacia dictyophleba* *Dicrastylis cordifolia* *Mirbelia viminalis* *Scaevola parvifolia* subsp. *pilbarae* *Sida arenicola*	Minor drainage channels on the flats	**Phase 1** 22, 23, 24 **Phase 2** R22, R23	
2: *Gompholobium polyzygum* low-shrubland.				
Corymbia deserticola subsp. *deserticola*, *Corymbia hamersleyana* and *Hakea chordophylla* isolated trees, over *Acacia dictyophleba* and *Grevillea wickhamii* subsp. *hispidula* sparse mid-shrubland, over *Gompholobium polyzygum*, *Dicrastylis georgei*, *Bonamia rosea* and *Leptosema chambersii* open low-shrubland, over *Paraneurachne muelleri* sparse low-tussock grassland and *Triodia basedowii* and *Triodia schinzii* open low regrowth hummock grassland.	*Dampiera candicans* *Eremophila forrestii* subsp. *forrestii* *Goodenia triodiophila* *Scaevola parvifolia* subsp. *pilbarae* *Petalostylis cassioides* *Corchorus sidoides* subsp. *sidoides*	Recently burnt depression areas on the sandy plains	**Phase 1** 32, 35, 36, 37 **Phase 2** B2, B32	

Vegetation Description	Associated Species Frequently Found In Lower Numbers	Habitat	Quadrats Surveyed	Photograph
3: *Acacia ancistrocarpa* tall-shrubland.				
Acacia tetragonophylla and *Hakea chordophylla* isolated tall shrubs, over *Acacia ancistrocarpa* mid-shrubland, over *Triodia melvillei* sparse mid-hummock grassland.	*Keraudrenia velutina* subsp. *elliptica*	In drainage areas between hills	**Phase 1** 25 **Phase 2** R25	
4: *Eucalyptus gamophylla* open mallee woodland, over *Triodia basedowii* mid-hummock grassland.				
Eucalyptus gamophylla open mallee woodland, with isolated trees of *Hakea lorea* subsp. *lorea*, over *Acacia ligulata*, *Acacia dictyophleba*, *Santalum lanceolatum* and *Eremophila forestii* var. *forestii* isolated mid-shrubs, over *Paraneurachne muelleri* and *Aristida holathera* var. *holathera* sparse low-tussock grassland, with *Triodia basedowii* and *Triodia schinzii* hummock grassland.	*Cymbopogon obtectus* *Scaevola parvifolia* subsp. *pilbarae* *Dicrastylis cordifolia* *Goodenia triodiophila*	Sandy plains	**Phase 1** 3, 4, 8, 11 17, 19, 20, 21 **Phase 2** B13, B16, B24, B25, R4, R21	

Vegetation Description	Associated Species Frequently Found In Lower Numbers	Habitat	Quadrats Surveyed	Photograph
5: *Hakea* spp. scattered low trees, over open low shrubland and open mid-hummock grassland.				
Hakea lorea subsp. *lorea* and *Hakea chordophylla* isolated low trees, over *Rulingia loxophylla* and *Keraudrenia velutina* subsp. *elliptica* open low-shrubland, over *Triodia basedowii* and *Triodia schinzii* open mid-hummock grassland	*Leptosema chambersii* *Scaevola parvifolia* subsp. *pilbarae* *Acacia dictyophleba* *Cymbopogon obtectus*	Sandy plains	**Phase 1** 5, 7, 9 **Phase 2** B26, B27, B31, R7	
6: *Hakea* spp. isolated low trees, over *Acacia dictyophleba* mid-shrubland, over open mid-hummock grassland.				
Hakea lorea subsp. *lorea* and *Hakea chordophylla* isolated low trees, over *Acacia dictyophleba* and *Acacia ancistrocarpa* open mid-shrubland, over *Triodia basedowii* and *Triodia schinzii* mid-hummock grassland, with *Aristida holathera* var. *holathera* and *Cymbopogon obtectus* sparse low-tussock grassland.	*Scaevola parvifolia* subsp. *pilbarae* *Dicrastylis cordifolia* *Bonamia rosea* *Leptosema chambersii* *Eriachne aristidea* *Triodia melvillei*	Sandy plains	**Phase 1** 13, 16, 18, 30, 31, 33, 34 **Phase 2** B5, B6, B7, B8, B9, B28, R18, R34	

Vegetation Description	Associated Species Frequently Found In Lower Numbers	Habitat	Quadrats Surveyed	Photograph
7a: Low regrowth shrubland.				
Hakea lorea subsp. *lorea* and *Hakea chordophylla* isolated low trees, with scattered *Eucalyptus gamophylla* isolated low mallee trees, over *Dicrastylis cordifolia*, *Bonamia rosea*, *Leptosema chambersii* and *Petalostylis cassioides* open low-shrubland, over *Aristida holathera* subsp. *holathera* and *Eragrostis eriopoda* sparse low-tussock grassland and *Triodia basedowii* and *Triodia schinzii* open low-regrowth hummock grassland.	*Scaevola parvifolia* subsp. *pilbarae* *Goodenia triodiophila* *Acacia dictyophleba* *Rulingia loxophylla*	Recently burnt sandy plains	**Phase 1** 1, 2, 6, 10, 14, 15 **Phase 2** B1, B15, B17, B22, B23, B33, R6, R10	
7b: Recent re-growth shrubland.				
Acacia pruinocarpa and *Codonocarpus cotinifolius* sparse mid-shrubland, over *Sida arenicola, Scaevola spinescens* (narrow form) and *Halgania solanacea* var. Mt Doreen (G.M. Chippendale 4206) low-shrubland, over *Paraneurachne muelleri* and *Eragrostis eriopoda* low-tussock grassland.	*Dicrastylis georgei* *Dampiera candicans* *Aristida holathera* var. *holathera*	Recently burnt footslopes	**Phase 1** 38	

Vegetation Description	Associated Species Frequently Found In Lower Numbers	Habitat	Quadrats Surveyed	Photograph
8: *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) and *Triodia basedowii* low-hummock grassland.				
Acacia trudgenii isolated low trees, over *Acacia maitlandii* and *Acacia spondylophylla* sparse mid-shrubland, over *Gompholobium polyzygum* sparse low-shrubland, over *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) and *Triodia basedowii* hummock grassland.	*Calytrix carinata* *Goodenia triodiophila* *Mirbelia viminalis* *Eremophila latrobei* subsp. *filiformis* *Eremophila exilifolia* *Grevillea wickhamii* subsp. *hispidula*	Rocky hill slopes and ridgetops	**Phase 1** 27, 28, 40 **Phase 2** B12, B14	
9: *Acacia aneura* open low-woodland.				
Acacia aneura var. *aneura* sparse to open low-woodland, over *Eremophila latrobei* subsp. *filiformis* open mid-shrubland, over *Eremophila exilifolia* sparse low-shrubland, over *Eragrostis eriopoda* and *Cymbopogon obtectus* sparse low-tussock grassland and *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) open hummock grassland.	*Solanum lasiophyllum* *Anthobolus leptomerioides* *Tribulus suberosus* *Eremophila forrestii* subsp. *forrestii*	Drainage areas on rocky midslopes, and drainage areas at the base of hill slopes	**Phase 1** 12, 29, 26, 39 **Phase 2** B4, B10, B11, R39,	

3.2.3 Vegetation Condition

Vegetation condition is noted in the field using the disturbance levels indicated below (Table 3.3). Factors taken into consideration when determining these levels of disturbance are the presence of weeds, tracks and litter and any evidence of grazing and general ground disturbance. These levels are based on the vegetation scales in column three of Table 12 of Bush Forever Volume 2 (Bush Forever, 2000).

Table 3.3 – Vegetation condition assessment

Vegetation Condition	Level of Disturbance	Percentage of Quadrats
Pristine	None	36%
Excellent	Minimal	55%
Good	Moderate	8%
Poor	Significant	1%
Degraded	Very high	0%

The condition of the vegetation surveyed at Robertson Range was classified as excellent; one weed species was recorded, grazing was not evident, few tracks cross the tenement and ground disturbance over the larger part of the tenement is minimal.

In the north-western section of the tenement, a significant amount of ground disturbance and vegetation clearing has occurred as a result of exploration drilling that has occurred in those areas.

3.2.4 Burn History

A large proportion (approximately 50%) of the survey area had been burnt from 1-5 years before the first phase. No fires had occurred between the first and second phases.

The burnt areas grouped together statistically and have been mapped (Figure 3.4) and described as vegetation unit 7 (Table 3.2).

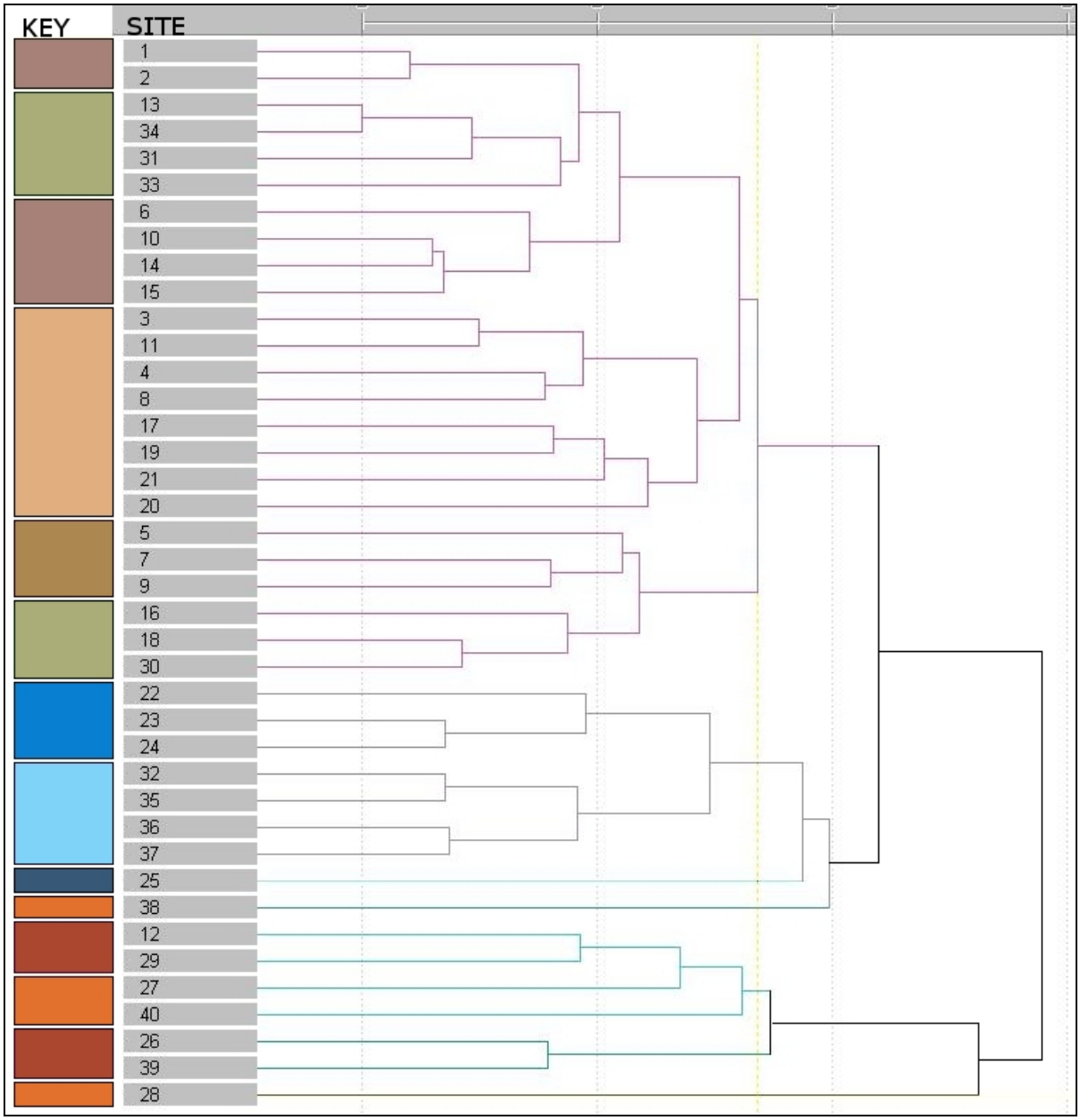

Figure 3.3 – Dendrogram produced by PATN™ analysis.

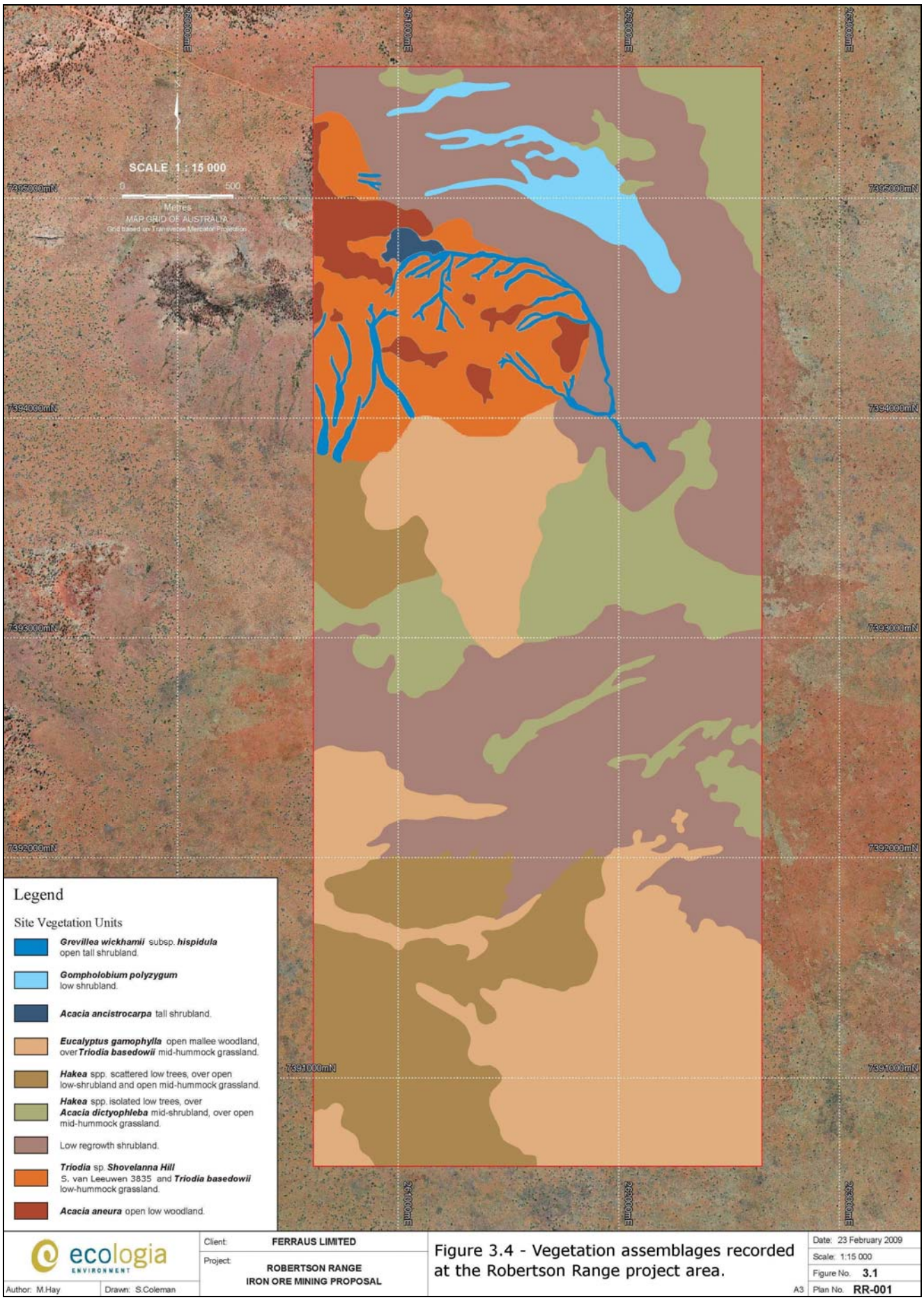

Figure 3.4 – Vegetation assemblages recorded at the Robertson Range project area.

3.3 ECOLOGICAL COMMUNITIES

3.3.1 State and Nationally Recognised Threatened and Priority Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat. At a national level, flora and threatened ecological communities (TECs) are protected under the EPBC Act. TECs are listed as Critically Endangered, Endangered or Vulnerable (Appendix A.3). No federally listed TECs occur in the vicinity of the survey area.

The DEC maintains a list of TECs that are Presumed Totally Destroyed, Critically Endangered, Endangered or Vulnerable; no state listed TECs occur in the vicinity of the survey area.

Potential TECs that do not meet survey criteria, or that are not adequately defined, are added by the DEC to a list of priority ecological communities (PECs; see Appendix A.3 for definition). Communities are placed in this category while consideration can be given to their declaration as a TEC. No state listed PECs occur in the vicinity of the survey area.

3.4 FLORA

3.4.1 Results from Current Survey

A total of 196 flora taxa, comprising 36 families and 89 genera, was recorded at the Robertson Range project area. During the first phase of the survey 151 taxa were recorded, while 139 taxa were recorded during the second phase survey. Ninety-four taxa were recorded during both phases of the survey, while 57 were recorded in the first phase only and 46 in the second phase.

Five plant specimens could not be identified beyond genus level and one specimen beyond family level because flowering and/or fruiting material was not available.

The most species rich families were Poaceae (30 taxa), Mimosaceae (24 taxa), Malvaceae (17 taxa), Caesalpiniaceae (15 taxa), Amaranthaceae (9 taxa), Chenopodiaceae (9 taxa) and Papilionaceae (9 taxa).

The most species rich genera were *Acacia* (24 taxa), *Senna* (14 taxa) *Ptilotus* (8 taxa), *Sida* (8 taxa) and *Senna* (7 taxa).

Twelve families and 56 genera were represented by a single taxon.

A complete list of the flora recorded during the survey is included in Appendix A.4.

3.4.2 Comparison with Other Surveys in the vicinity of the Robertson Range Project Area

The number of families, genera and taxa recorded during this survey can be compared with information recorded during other surveys in the vicinity of the Robertson Range project area. This comparative information is provided in Table 3.4 below.

Table 3.4 – Flora records from previous surveys.

Location	Time of year of survey	Area surveyed (ha)	Number of Species Recorded	Average # Species per hectare	Reference
Robertson Range Phase 1	April, 2007	10	151	15	Current Survey
Robertson Range Phase 2	June, 2008	9.25	140	15	
Jimblebar to Wheelarra Hill	Feb, 2004	11	180	16	*ecologia* 2005a
Chichester Deviation Phase 1	Oct, 2007	10.25	204	20	*ecologia,* 2008
Chichester Deviation Phase 2	May, 2008	10.75	261	24	

Note: Area surveyed has been calculated using the number of 50 × 50 meter quadrats surveyed at each area.

While these other survey areas do not occur in the same land systems and botanical regions as the Robertson Range project area, they enable broad comparisons to be made on botanical diversity.

A slightly lower than average floristic diversity was recorded at Robertson Range. This is worked out using an average number of species per hectare and comparing it to other areas surveyed in the Pilbara. This probably reflects the sandy plains vegetation that comprises the greater part of the tenement.

3.4.3 Sampling Adequacy

Species accumulation curves provide a theoretical basis for understanding the relationship between sampling effort and the accumulation of species and provide a means of estimating species richness and assessing survey adequacy. As sampling effort increases with a corresponding increase in survey area and time, the rate at which new species are recorded is reduced and the total record levels out (i.e. becomes asymptotic). At this point, where there is a diminishing return with regards to increases in species richness with sampling effort, the survey size is deemed sufficient.

Flora sampling adequacy was estimated using species accumulation curve analysis (Colwell, 2006) (Figure 3.5) and extrapolation of the curve to the asymptote using Michaelis-Menten modelling. The incidence-based coverage estimator of species richness was determined by ICE Mean (222.51) and Chao 2 Mean (219.88). As a result it was estimated that a maximum of 223 species could potentially be found in the project area.

One hundred and eighty-one taxa were recorded from the quadrats assessed during the two phases of the survey. Therefore, approximately 82% of the flora species potentially present within the study area were recorded from the quadrats surveyed. This figure does not include opportunistic collections of species made while traversing from site to site. Fifteen species were recorded opportunistically during the surveys. Therefore 196 taxa were recorded from the project area indicating that approximately 88% of the flora species potentially present within the study area were recorded.

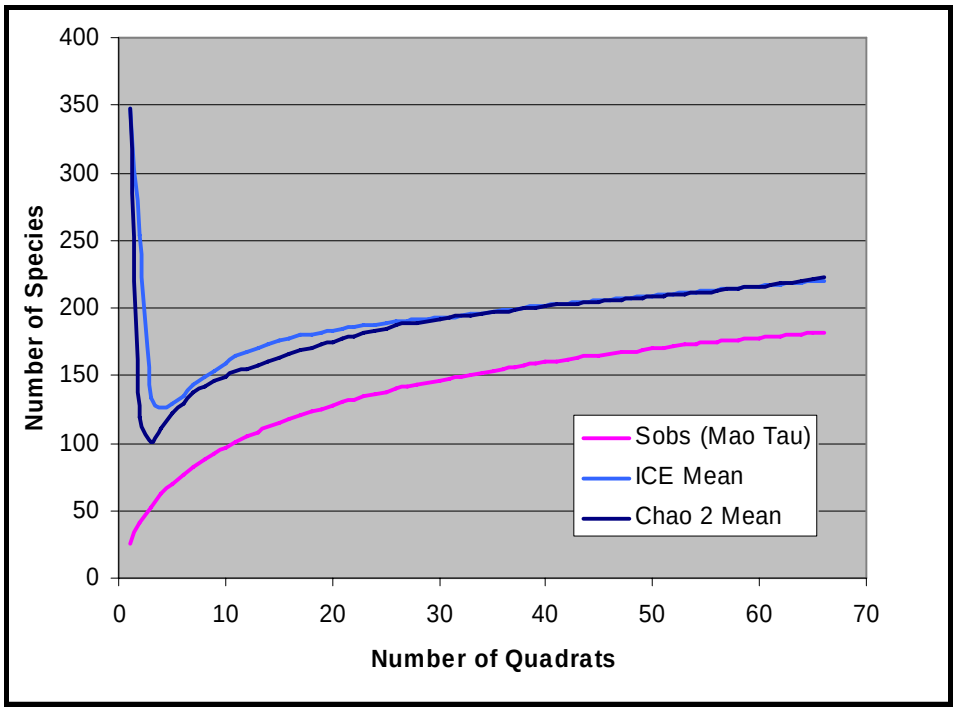

Figure 3.5 – Average randomised species accumulation curve for flora at the Robertson Range project area.

3.4.4 Taxonomy of two commonly occurring acacias

Acacia dictyophleba was recorded as a dominant species in the project area from the specimens identified following the first phase survey. *Acacia melleodora* was not identified from collections made during this first phase of the survey but was identified as a dominant species from the specimens collected during the second phase of the survey.

Acacia dictyophleba and *A. melleodora* are very similar. They grow in similar habitats and their growth habit and many of their taxonomic features are similar also. These include plant shape, and phyllode characteristics (shape, nerve number, absence of hairs and texture). The number of flowers occurring per flowering head is one distinguishing characteristic; *A. dictyophleba* is described as having 40-60 flowers per head and *A. melleodora* 20-40.

Acacia dictyophleba is generally a more commonly occurring species than *A. melleodora* but both are widespread and have a similar range. Because of their similarity *A. melleodora* may be placed as an infraspecific taxon of *A. dictyophleba* in the future (Maslin, 2001).

Because *A. melleodora* was not identified from the specimens collected during the first phase survey, but was from the second phase survey, the specimens of *A. dictyophleba* and *A. melleodora* collected during both phases of the survey were re-examined. While the specimens had features characteristic of both *A. dictyophleba* and *A. melleodora* the number of individual flowers per flower head indicates that the specimens are *A. dictyophleba*.

For the purpose of this report, *A. dictyophleba* has been accepted as the dominant species occurring in the Robertson Range project area. Neither of these species are conservation significant flora.

3.5 FLORA OF CONSERVATION SIGNIFICANCE

3.5.1 Statutory Framework

Flora species are protected at a national level under the Commonwealth EPBC Act. The Act contains a list of species that are considered Critically Endangered, Endangered, Vulnerable, Conservation Dependent, Extinct or Extinct in the Wild (for definitions of categories, see Appendix A.3). Two flora taxa occurring in the Pilbara region are protected by this Act – *Lepidium catapycnon* and *Thryptomene wittweri* - and both are listed as Vulnerable.

Flora of conservation significance within Western Australia are protected under the WC Act and termed Declared Rare Flora (DRF). The current DRF list is published in the *Western Australian Wildlife Conservation (Rare Flora) Notice 2008(2)*. DRF taxa are defined as "taxa which have been adequately searched for and deemed to be either rare, in danger of extinction, or otherwise in need of special protection in the wild". Two DRF taxa occurring in the Pilbara region are protected by this Act - *Lepidium catapycnon* and *Thryptomene wittweri.*

The Department of Environment and Conservation maintains a list of Priority Flora taxa, which are considered poorly known, uncommon, or under threat, but for which there is insufficient justification based on known distribution and population sizes for inclusion on the DRF schedule. Priority Flora taxa are assigned to one of four priority categories – Priority 1 to Priority 4 (Atkins, 2008) (for a full definition of categories see Appendix A.3).

One hundred and thirty nine Declared Rare and Priority Flora species are recorded as occurring in the Pilbara botanical region, and 69 in the Gascoyne botanical region (Western Australian Herbarium FloraBase, 2009).

3.5.2 Database Searches

Searches of the DEC Threatened (Declared Rare) Flora database, the Threatened Ecological Communities (TEC) database and the Western Australian Herbarium database were requested before carrying out any surveys at the Robertson Range project area. The search coordinates used encompassed the actual project area and surrounds. The search coordinates used were: 23°S, 120°E (NW corner) and 24°S, 121°E (SE corner)).

No TECs or flora species of conservation significance were recorded on these databases as occurring in the project area or immediate surrounds.

A search of the Department of the Environment and Water Resources database for flora species protected under the Commonwealth EPBC Act listed one threatened flora species as possibly occurring within a 50 km buffer of the project area - *Pityrodia augustensis* (Mt Augustus Foxglove) - which is listed as vulnerable.

Pityrodia augustensis (Mt Augustus Foxglove; Plate 3.1) is a bushy shrub of the Lamiaceae family. It grows to 1 m in height and produces purple to red flowers from August to September. This species grows most commonly amongst rocks on slopes or in drainage lines.

Plate 3.1 – *Pityrodia augustensis*.

Photography by, S. Armstrong, S.D. Hopper & S.J. Patrick. Image used with the permission of the Western Australian Herbarium, Department of Environment and Conservation (http://florabase.calm.wa.gov.au/help/copyright). Accessed on 25th February 2009.

3.5.3 Declared Rare or Priority Flora Previously Recorded in the Vicinity of the Project Area

ecologia has not carried out any other flora surveys within the Robertson Range project area.

FerrAus has tenements at Davidson Creek (approximately 18 km from the Robertson Range project area), and during a Rare and Priority Flora survey carried out by *ecologia* along proposed drill lines and tracks in that area one Priority 3 plant was located – *Goodenia nuda*.

In the wider area, within 100 km of the Robertson Range project area, seven Priority Flora species have been recorded during surveys previously carried out by *ecologia* Environment. These are: *Isotropis winneckei* (Priority 1) at both the Eastern Ophthalmia Range Orebody and Orebody 24; *Goodenia hartiana* (Priority 2) at Wheelarra Hill and Hashimoto; *Goodenia nuda* (Priority 3) at Hashimoto; *Rhodanthe frenchii* (Priority 2) at Orebody 18; *Triumfetta leptacantha* (Priority 3 at that time but not currently listed) at both Orebody 24 and Orebody 25; *Tephrosia* sp. Cathedral Gorge (F.H. Mollemans 2420) (Priority 3) at Orebody 24; and *Eremophila magnifica* subsp. *magnifica* (Priority 4) at Orebody 25.

3.5.4 Conservation Significant Flora Species that Could Occur in the Robertson Range Project Area

Using the results of the Rare and Priority Flora survey of the DEC's database and taking into consideration habitat preferences and distribution ranges from FloraBase, it is considered that one DRF and 13 Priority taxa could potentially occur in the survey area (Table 3.5). The table excludes some species provided by the DEC's database search, because of the habitats present in the survey area.

Table 3.5 – Rare and Priority Flora with potential to occur in the project area.

Conservation Status	Species	Area Found (Nearest Named location)	Habitat	Potential to Occur in the Survey Area	DEC
Rare	*Lepidium catapycnon*	Wittenoom, Weeli Wolli Creek, Newman.	Skeletal soils on stony hill slopes.	Unlikely	*
Priority 1	*Acacia levata*	Marble bar road, Woodstock, Great Northern Hwy, Spear Hill	Sand or sandy loam over granite. Hill slopes.	Unlikely	
	Eremophila pilosa	Roy Hill, Jigalong Community.	Sand plain, loamy soils.	Unlikely	*
	Goodenia lyrata	Hamersley Ranges, Newman, Marandoo.	Red, sandy loam, near clay pan.	Unlikely	*
	Isotropis winneckei	Eastern Ophthalmia Range, Orebody 24.	Skeletal soils. Sandstone ranges, rocky rises.	Unlikely	
Priority 2	*Gonocarpus ephemerus*	Mt Augustus, Jigalong, Newman.	Sand, along drainage lines, granite.	Possible	*
	Goodenia hartiana	Wheelarra Hill, Hashimoto.	Sand, sand dune swales and sand hills.	Possible	
	Olearia fluvialis	Hamersley Range, Karijini N.P. West Angelas, Newman.	Iron rich alluvium, pebbly sand, stony creeks.	Unlikely	*
	Rhodanthe frenchii	Orebody 18.	Stoney hills, rocky river banks and outcrops.	Unlikely	
	Spartothamnella puberula	Rocky loam, sandy or skeletal soils, clay. Sandplains, hills	Tom Price, West Angeles, Karijini, Mount Bruce.	Unlikely	
Priority 3	*Goodenia nuda*	Hashimoto, Davidson Creek.	Plain, dry, red sand, bare river sand in dry scoured river bed.	Possible	
	Gymnanthera cunninghamii	Cloudbreak mine, FMG Stage A Rail Corridor, Port Hedland, Kennedy Range	Sandy soils	Possible	
	Tephrosia sp. Cathedral Gorge (FH Mollemans 2420)	Fortescue Valley, Hamersley Range, Newman, Orebody 24.	Stony hill slope, ridge crest, skeletal loam, gentle drainage depression.	Unlikely	*
Priority 4	*Eremophila magnifica* subsp. *magnifica*	Hamersley Range, Newman, Marandoo, Orebody 25.	Skeletal soils over ironstone, rocky scree.	Possible	*

3.5.5 Declared Rare or Priority Flora Recorded within the Robertson Range Project Area

No Declared Rare or Priority Flora taxa were collected during the vegetation and flora survey carried out at the Robertson Range project area.

3.6 INTRODUCED FLORA

Weeds that are, or have the potential to become, pests to agriculture can be declared formally under the *Agriculture and Related Resources Protection Act, 1976* (ARRP Act). Declared weeds listed under the ARRP Act are given a coded definition of the requirements for their control. Five priority groupings are used, and more than one priority may be placed on a weed species.

A search was conducted of the declared weeds list for any declared weed species that potentially could be found within the Robertson Range project area. The search identified two declared weeds that could potentially occur in the Pilbara: **Parkinsonia aculeata* and **Salvinia molesta*. A search of the WA Herbarium database for weeds occurring in the East Pilbara region confirmed that these taxa have been recorded in the area (FloraBase, 2009).

No Declared Weeds were recorded within the Robertson Range project area.

In addition, 80 general weed species are currently known to occur in the East Pilbara Region (Department of Agriculture and Food, 2009). One general/environmental weed, **Portulaca oleracea* (Purslane), was located during the first phase survey while no weed species were located during the second phase survey. **Portulaca oleracea* was recorded at isolated densities at two sites. Its locations are listed and mapped in Appendix A.5. A description of this weed species follows.

**Portulaca oleracea* is a succulent, prostrate to decumbent annual herb growing to 0.2 m high (Plate 3.2). Its shiny leaves are spoon-shaped and the yellow flowers occur in their axils from April to May. Under water stress the whole plant becomes reddish. The species favours clay loams and sands, is often found on disturbed sites and is widely distributed in Western Australia. **Portulaca oleracea* is a common and widespread weed of horticulture, paddocks and gardens. It is considered a native in most of Western Australia but is probably introduced to the south-west (Hussey *et al*, 2007).

Plate 3.2 – **Portulaca oleracea*.

Five other weed species were recorded during a survey of the Davidson Creek exploration area approximately 18 km from the Robertson Range project area; **Bidens bipinnata, *Cenchrus ciliaris, *Cucumis sp., *Malvastrum americanum* and **Sonchus oleraceus.*

4 CONSERVATION SIGNIFICANCE

The significance of the flora of the project area has been assessed at four spatial scales; international/national, state, regional and local.

4.1 INTERNATIONAL / NATIONAL SIGNIFICANCE

National significance refers to those features of the environment which are recognised under legislation as being of importance to the Australian community. Flora species and TECs listed under the *Commonwealth EPBC Act* are regarded as nationally significant.

No flora species or TECs of national significance were recorded during the vegetation and flora survey at the Robertson Range project area.

4.2 STATE SIGNIFICANCE

State significance refers to those features of the environment that are recognised under state legislation as being of importance to the Western Australian community; in particular, species scheduled/listed under the *Wildlife Conservation Act 1950*.

No TECs or DRF of state significance were recorded at the Robertson Range project area.

4.3 REGIONAL SIGNIFICANCE

Regional significance addresses the representation of species and habitats at a biogeographic regional level. Species or habitat types that are endemic to the Pilbara bioregion or the Robertson Range area and whose distributions are limited or unknown are considered regionally significant.

4.3.1 Vegetation

The conservation significance of the vegetation of the region has been assessed based upon two sources of information: the land systems of the survey area and Beard's vegetation mapping of the survey area.

Land Systems Assessment

The Robertson Range project area spans two land systems – the Divide and Newman Land Systems. Based on the 957.4 ha tenement area an estimated percentage impact to these land systems has been calculated. These are overestimates of the actual impact to the land systems, as the whole of the tenement will not be cleared for the proposed project.

Approximately 95% of the tenement occurs on the **Divide Land System.** This land system of medium size (529,266 ha) and is mapped as occurring in a north-west / south-east trending multiple unit block mostly occurring north-east of Newman. The Robertson Range project area occurs in the more southerly units of this land system. Approximately 0.17% of this land system would be impacted if the whole tenement was to be cleared. The vegetation of this land system occurring within the Robertson Range project area was mapped as six units: *Grevillea wickhamii* subsp. *hispidula* open tall-shrubland (Unit 1), *Gompholobium polyzygum* low-shrubland (Unit 2), *Eucalyptus gamophylla* open mallee woodland, over *Triodia basedowii* mid-hummock grassland (Unit 4), *Hakea* spp. scattered low trees, over open low-shrubland and open mid-hummock grassland (Unit 5), *Hakea* spp. isolated low trees, over *Acacia dictyophleba* mid-shrubland, over open mid-hummock grassland (Unit 6), and low regrowth shrubland (Unit 7).

Given the moderately large are of this land system mapped in the East Pilbara, and the relatively common vegetation units occurring in it, it is rated as having low regional conservation significance.

The **Newman Land System** is the second largest in the Pilbara region (1,457,984 ha) and a small discrete unit is mapped as occurring within the Robertson Range project area. Based on approximately 5% of the tenement spanning this land system the estimated impact to it is 0.06%.

Four vegetation units were mapped in this land system: *Grevillea wickhamii* subsp. *hispidula* open tall-shrubland (Unit 1), *Acacia ancistrocarpa* tall-shrubland (Unit 3), *Triodia* sp. Shovelanna Hill (S. van Leeuwen 3835) and *Triodia basedowii* low-hummock grassland (Unit 8), and *Acacia aneura* open low-woodland (Unit 9).

While the Newman Land System is large and relatively common vegetation units are mapped as occurring in it, the unit occurring in the Robertson Range project area is the most southerly mapped discrete block of this land system, and because of this could be viewed as having moderate regional conservation significance.

Beard Mapping Assessment

The project area lies in the Kumarina Hills subdivision of Beard's Ashburton Botanical District. This area is mapped as shrub steppe on sandplains, and more specifically as *Eucalyptus gamophylla* sparse shrubland, over *Triodia basedowii* open hummock grassland ($e_{25}Srt_2Hi$).

Nine distinct vegetation units were mapped by *ecologia* in the project area, and only one of these units was mapped as *Eucalyptus gamophylla* open mallee woodland, over *Triodia basedowii* mid-hummock grassland. This can be expected given the coarse scale of Beard's mapping of the area compared with the finer scale mapping exercise undertaken over the Robertson Range project area.

Many areas of this vegetation unit were mapped by Beard as occurring in the Pilbara – and a relatively large area was mapped on Ethel Creek and Balfour Downs stations to the north of Jigalong. While none of the areas at Jigalong are as large as those on Ethel Creek or Balfour Downs, there are a number of discrete patches that include the unit within which the Robertson Range project area lies. The shrub steppe on sandplains unit mapped by Beard is not as large or as widely distributed as other vegetation units mapped by Beard, and because of this it could be considered to be of moderate regional conservation significance.

The remaining units mapped by *ecologia* in the Robertson Range project area are all relatively common for that area and those habitats of the Pilbara, and are not considered to be regionally conservation significant.

4.3.2 Flora

No Priority Flora species of regional significance were recorded at the Robertson Range project area.

4.4 LOCAL SIGNIFICANCE

Species are of local significance when their presence is confined to a specialised habitat type that is not common within the local area and whose disturbance or removal may lead to local extinction.

4.4.1 Vegetation and Flora

Based on the information presented in Section 4.3.1 above, the vegetation units occurring in the project area are not locally conservation significant, as they would occur on the sandplains and hills of the surrounding areas.

No Declared Rare or Priority Flora species were recorded during the survey, and none of the flora recorded in the Robertson Range project area tended to be restricted to a specialised habitat.

4.5 BIODIVERSITY

Australia has an international obligation to maintain biodiversity. The Commonwealth Government has initiated the National Strategy for the Conservation of Biological Diversity, which incorporates elements of the National Strategy for Ecologically Sustainable Development (NSESD). Biological diversity (biodiversity) relates to the richness of the biota at a local, regional, state, national or even global level, and includes all components of the environment, from bacteria to insects, plants, and vertebrate fauna. Biodiversity can be thought of as existing at several levels, including genetic, population and species (or taxon) diversity. This study examines biodiversity at the species and population level, and places it within a local, regional and national context.

A major consideration from a biodiversity perspective is whether individual species would be restricted to the particular habitat of the project area.

As indicated above, the habitats within the project area are generally well represented both regionally and in the surrounding areas and loss or modification of the habitat within the project area is unlikely to significantly reduce regional biodiversity.

5 ENVIRONMENTAL IMPACTS

The vegetation associations, habitats and landforms found in the project area (and within the proposed disturbance footprint) are not considered to be of national, state, regional or local conservation significance and are well represented within the Pilbara biogeographic region. This implies that at a regional scale loss of vegetation associations, habitat types and landforms found in the project area will not constitute a significant loss to biodiversity.

However, potential impacts from the proposed mining activities on vegetation and flora of the Robertson Range project area include:

- impact to general vegetation and flora through clearing;
- indirect loss of vegetation and flora from ongoing practices; and
- increase in numbers of invasive weeds in the project area from ongoing practices.

Clearing: Direct loss of vegetation and flora

The most substantial environmental impact arising from the proposed project would be the clearing of native vegetation, and the consequent loss of flora and loss of habitat.

Within the proposed disturbance footprint many of the flora species are expected to be lost. However, the habitats proposed to be disturbed, and the flora of the hills, creeks and sandplains are generally well represented in the surrounding areas.

Indirect loss of flora habitat

Flora habitats can be impacted indirectly by increased activity in an area leading to increased dust, fire, and the introduction and / or spread of weeds.

No declared weeds listed under the *Agriculture and Related Resources Protection Act,* 1976 were recorded in the project area. One general environmental weed species, **Portulaca oleracea*, was recorded in the area.

A number of weeds occur in the region and implementation of the project has the potential to introduce new weed species or spread existing weed species unless precautionary measures are taken. Environmental weed species such as Buffel grass (**Cenchrus ciliaris*), Ruby dock (**Acetosa vesicaria*) and Bipinnate beggartick (**Bidens bipinnata*) have been recorded near the Robertson Range project area and their spread should be minimised. Many environmental weeds (including those mentioned above) are highly invasive and lead to the displacement of native vegetation and the loss of habitat for fauna species.

Dust degradation of native vegetation may occur with increased vehicular traffic and will need to be managed appropriately.

The potential for fires in the area may increase with increased activity and this will need to be managed appropriately, especially as spinifex grows over a large area of the tenement.

6 MANAGEMENT RECOMMENDATIONS

Detailed recommendations are listed in two categories where appropriate; design level and management level. Recommendations at the design level present strategies which will mitigate impacts to the environment inherent in the design of proposed developments. Management level recommendations aim to reduce the ongoing impacts to the biological environment following construction and to preserve existing conservation values. In order to reduce impacts to vegetation and flora from proposed mining activities within the Robertson Range project area, FerrAus needs to implement the following:

DESIGN LEVEL

RECOMMENDATION 1

Limit vegetation clearing to within the tenement boundaries surveyed by *ecologia*. This will ensure that any significant vegetation units or species occurring outside the study area will not be impacted.

RECOMMENDATION 2

Minimise vegetation clearing to that which is absolutely necessary.

RECOMMENDATION 3

The whole tenement was not surveyed by *ecologia*. Areas designated for infrastructure should be surveyed before clearing takes place to determine whether any conservation significant flora taxa occur in those areas.

RECOMMENDATION 4

In areas allocated for temporary clearing and rehabilitation, minimise the amount of topsoil removed when clearing vegetation. Minimal topsoil disturbance will encourage natural regeneration due to retention of the seed store and microbiological activity, which is largely confined to the topsoil. Achieving minimum disturbance will also discourage weeds and other species which proliferate following disturbance.

RECOMMENDATION 5

Minimise the height of stockpiles of soil and cleared vegetation. Multiple smaller stockpiles, dispersed at regular intervals along the length of the edges of cleared areas, are preferable to a single stockpile. Lower stockpiles allow greater retention of biological activity within the soil (bacteria, fungi and lichen), which improves seed germination rates once the soil is reused.

RECOMMENDATION 6

Rehabilitate any areas that have been impacted by earthworks but are not needed for long-term infrastructure as soon as practicable after completion of works. This will promote soil stabilisation by plant roots and help to discourage weed proliferation in these areas.

RECOMMENDATION 7

Avoid or minimise disturbance to vegetation associated with drainage lines whenever possible. Removing vegetation associated with drainage lines can lead to the accelerated erosion of soil or the alteration of surface water flow.

RECOMMENDATION 8

Avoid disturbance to significant fauna habitat. This includes living and dead standing trees, fallen logs and rock material.

RECOMMENDATION 9

Avoid or minimise disturbance to vegetation associated with drainage lines whenever possible. Removing vegetation associated with drainage lines can lead to the accelerated erosion of soil or the alteration of surface water flow.

MANAGEMENT LEVEL

RECOMMENDATION 10

Implement existing environmental procedures for staff and contractors. These include managing the risk of fire, the introduction and spread of weeds (particularly Buffel grass, Ruby dock and Bipinnate beggartick) and encouraging general environmental impact awareness.

7 STUDY TEAM

The Robertson Range vegetation and flora survey described in this document was planned, coordinated and executed by:

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Project Staff		
Christina Cox	PhD	Project Manager, Manager Botany
Melissa Hay	BSc. (Hons)	Botanist
Carmel Winton	BSc	Botanist
Malcolm Trudgen	BSc.	Plant Taxonomist – Phase 1
Sharnya Thompson	BSc.	Plant Taxonomist – Phase 2

Licences - "Licence to take flora for scientific purposes"		
This survey was conducted under the authorisation of the following licences issued by Department of Environment and Conservation to:		
Botanist	**Permit Number**	**Valid Until**
Christina Cox	SL007794	30th April 2008
Melissa Hay	SL007712/SL008037	30th April 2008/30th April 2009
Carmel Winton	SL008099	30th April 2009

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A.1 SITE INFORMATION (TO BE INCLUDED ELECTRONICALLY)

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A.2 VEGETATION STRUCTURAL CLASSES

Height classes used for vegetation classification.

Height Class	Height Range (m)	TREE	SHRUB	MALLEE	GRASS
8	>30	tall	NA	NA	NA
7	10-30	mid	NA	tall	NA
6	<10	low	NA	mid	NA
5	<3	NA	NA	low	NA
4	>2	NA	tall	NA	tall
3	1-2	NA	mid	NA	tall
2	0.5-1	NA	low	NA	mid
1	<0.5	NA	low	NA	low

Structural Formation Classes (NVIS, 2003).

Growth Form	Height (m)	Structural Formation Classes					
Foliage cover% (Cover #)		70-100% (5)	30-70% (4)	10-30% (3)	<10% (2)	0-5% (1)	≈0% (N)
TREE	<10,10-30, >30	closed forest	open forest	woodland	isolated clumps of trees	isolated trees	isolated clumps of trees
TREE MALLEE	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	isolated clumps of mallee trees	isolated mallee trees	isolated clumps of mallee trees
SHRUB	<1,1-2,>2	closed shrubland	shrubland	open shrubland	isolated clumps of shrubs	isolated shrubs	isolated clumps of shrubs
MALLEE SHRUB	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	isolated clumps of mallee shrubs	isolated mallee shrubs	isolated clumps of mallee shrubs
HEATH SHRUB	<1,1-2,>2	closed heathland	heathland	open heathland	isolated clumps of heath shrubs	isolated heath shrubs	isolated clumps of heath shrubs
CHENOPOD SHRUB	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	isolated clumps of chenopod shrubs	isolated chenopod shrubs	isolated clumps of chenopod shrubs
SAMPHIRE SHRUB	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	isolated clumps of samphire shrubs	isolated samphire shrubs	isolated clumps of samphire shrubs
HUMMOCK GRASS	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	isolated clumps of hummock grasses	isolated hummock grasses	isolated clumps of hummock grasses
TUSSOCK GRASS	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	isolated clumps of tussock grasses	isolated tussock grasses	isolated clumps of tussock grasses
SEDGE	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	isolated clumps of sedges	isolated sedges	isolated clumps of sedges
RUSH	<0.5,>0.5	closed rushland	rushland	open rushland	isolated clumps of rushes	isolated rushes	isolated clumps of rushes

A.3 DEFINITIONS OF DECLARED RARE, PRIORITY, AND DECLARED WEED FLORA SPECIES AND THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

NATIVE FLORA

Commonwealth EPBC Act

Schedule 1 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* contains a list of species that are considered Critically Endangered, Endangered, Vulnerable, Extinct, Extinct in the wild and Conservation Dependent.

Explanation of Codes for Flora protected under the Commonwealth EPBC Act.

Conservation Category	Definition
Extinct	A species is extinct if there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	A species is categorised as extinct in the wild if it is only known to survive in cultivation, in captivity or as a naturalised population well outside its past range; or if it has not been recorded in its known/expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered	The species is facing an extremely high risk of extinction in the wild in the immediate future.
Endangered	The species is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction.
Vulnerable	Within the next 25 years, the species is likely to become endangered unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate.
Conservation Dependent	The species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of five years.

Definition of Declared Rare and Priority Flora categories.

Code	Definition
DRF	Declared Rare Flora-Extant Taxa. Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such.
P1: Priority One	Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2: Priority Two	Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P3: Priority Three	Poorly Known Taxa. Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.
P4: Priority Four	Rare Taxa. Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

(From Atkins, K.J., Declared Rare and Priority Flora List, Oct. 2008, DEC)

INTRODUCED FLORA

Explanation of codes for Declared Weeds in Western Australia.

Priority	Requirements
P1 Prohibits movement	The movement of plants or their seeds is prohibited within the State. This prohibits the movement of contaminated machinery and produce, including livestock and fodder.
P2 Aim is to eradicate infestation	Treat all plants to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.
P3 Aims to control infestation by reducing area and/or density of infestation	The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property, on or in livestock, fodder, grain, vehicles and/or machinery. Treat to destroy and prevent seed set for all plants: • within 100 metres inside of the boundaries of the infestation. • within 50 metres of roads and high-water marks on waterways. • within 50 metres of sheds, stock yards and houses. Treatment must be done prior to seed set each year. Of the remaining infested area: • Where plant density is 1-10 per hectare, treat 100% of infestation. • Where plant density is 11-100 per hectare, treat 50% of infestation. • Where plant density is 101-1000 per hectare, treat 10% of infestation. Properties with less than two hectares of infestation must treat the entire infestation. Additional areas may be ordered to be treated.
P4 Aims to prevent infestation spreading beyond existing boundaries of infestation	The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property, on or in livestock, fodder, grain, vehicles and/or machinery. Treat to destroy and prevent seed set for all plants: • within 100 metres inside of the boundaries of the infested property. • within 50 metres of roads and high-water marks on waterways. • within 50 metres of sheds, stock yards and houses. Treatment must be done prior to seed set each year. Properties with less than two hectares of infestation must treat the entire infestation. Additional areas may be ordered to be treated. Special considerations: In the case of P4 infestations where they continue across property boundaries, there is no requirement to treat the relevant part of the property boundaries as long as the boundaries of the infestation as a whole are treated. There must be agreement between neighbours in relation to the treatment of these areas.
P5	Infestations on public lands must be controlled.

TEC and PEC codes

Explanation of codes for Threatened Ecological Communities (TEC)

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

Explanation of codes for Priority Ecological Communities (PEC)

Code	Definition
P1: Priority One	Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2: Priority Two	Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3: Priority Three	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences

Code	Definition
	may occur, much of it not under imminent threat, or; (iii) Communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4: Priority Four	Ecological communities that are adequately known, *Rare* but not threatened or meet criteria for *Near Threatened*, or that have been recently removed from the threatened list. These communities require regular monitoring. (a) *Rare*. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (b) *Near Threatened*. Ecological communities that are considered to have been adequately surveyed and that do not qualify for *Conservation Dependent*, but that are close to qualifying for *Vulnerable*. (c) Ecological communities that have been removed from the list of threatened communities during the past five years.
P5: Priority Five	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

A.4 FLORA SPECIES RECORDED FROM THE ROBERTSON RANGE PROJECT AREA

Flora recorded from the Robertson Range project area.

FAMILY	Species	Phase 1	Phase 2
ADIANTACEAE	*Cheilanthes sieberi* subsp. *sieberi*	x	x
AIZOACEAE	*Trianthema glossostigma*	x	
AMARANTHACEAE	*Gomphrena kanisii*	x	x
	Ptilotus calostachyus var. *calostachyus*	x	x
	Ptilotus exaltatus var. *exaltatus*	x	
	Ptilotus obovatus var. *obovatus*	x	x
	Ptilotus polystachyus var. *polystachyus*	x	
	Ptilotus roei	x	
	Ptilotus rotundifolius		x
	Ptilotus schwartzii		x
	Ptilotus schwartzii var. *schwartzii*	x	
APIACEAE	*Trachymene oleracea*	x	
ASCLEPIADACEAE	*Rhyncharrhena linearis*	x	x
	Sarcostemma viminale subsp. *australe*	x	x
ASTERACEAE	*Chrysocephalum pterochaetum*	x	
	Pluchea dentex	x	
	Podolepis capillaris	x	x
	Pterocaulon sphacelatum		x
	Pterocaulon sphaeranthoides		x
	Streptoglossa decurrens		x
	Streptoglossa macrocephala	x	
BORAGINACEAE	*Halgania gustafsenii* var. Mid West (G. Perry 370)	x	
	Halgania solanacea		x
	Halgania solanacea var. Mt Doreen (G.M. Chippendale 4206)	x	
	Halgania solanacea var. *solanacea*		x
	Heliotropium chrysocarpum	x	
	Heliotropium pachyphyllum		x
CAESALPINIACEAE	*Petalostylis cassioides*	x	x
	Senna artemisioides subsp. *filifolia*		x
	Senna artemisioides subsp. *glaucifolia*	x	
	Senna artemisioides subsp. *helmsii*	x	x
	Senna artemisioides subsp. *oligophylla*	x	
	Senna artemisioides subsp. *sturtii*	x	
	Senna curvistyla	x	x
	Senna glaucifolia		x
	Senna glutinosa subsp. *glutinosa*	x	x
	Senna glutinosa subsp. *luerssenii*	x	x
	Senna glutinosa subsp. *pruinosa*		x
	Senna notabilis	x	x
	Senna sericea		x
	Senna stricta	x	x
	Senna symonii		x
CARYOPHYLLACEAE	*Polycarpaea corymbosa* var. *corymbosa*	x	
CELASTRACEAE	*Maytenus* sp. Mt Windell (S. van Leeuwen 846)	x	x
CHENOPODIACEAE	*Dysphania kalpari*	x	
	Enchylaena tomentosa var. *tomentosa*	x	x
	Maireana georgei	x	
	Maireana melanocoma		x
	Maireana triptera	x	x
	Maireana villosa	x	

FAMILY	Species	Phase 1	Phase 2
	Rhagodia eremaea		x
	Sclerolaena cornishiana	x	
	Sclerolaena eriacantha	x	
CHLOANTHACEAE	*Dicrastylis cordifolia*	x	x
	Newcastelia hexarrhena	x	x
CONVOLVULACEAE	*Bonamia rosea*	x	x
	Bonamia sp.	x	
	Duperreya commixta	x	x
	Evolvulus alsinoides var. *decumbens*		x
	Evolvulus alsinoides var. *villosicalyx*	x	
CYPERACEAE	*Bulbostylis barbata*	x	
	Fimbristylis dichotoma	x	
	Fimbristylis rara		x
EUPHORBIACEAE	*Euphorbia tannensis* subsp. *eremophila*	x	
GOODENIACEAE	*Dampiera candicans*	x	x
	Goodenia triodiophila	x	x
	Scaevola parvifolia		x
	Scaevola parvifolia subsp. *pilbarae*	x	
	Scaevola spinescens	x	x
GYROSTEMONACEAE	*Codonocarpus cotinifolius*	x	x
LAURACEAE	*Cassytha capillaris*	x	x
MALVACEAE	*Abutilon cryptopetalum*		x
	Abutilon leucopetalum	x	x
	Alyogyne pinoniana	x	
	Hibiscus aff. *coatesii*	x	
	Hibiscus brachychlaenus	x	
	Hibiscus burtonii	x	
	Hibiscus leptocladus		x
	Hibiscus sturtii var. *campylochlamys*		x
	Hibiscus sturtii var. *truncatus*	x	x
	Sida arenicola	x	x
	Sida atrovirens	x	
	Sida billbarkeri	x	
	Sida cardiophylla	x	x
	Sida ectogama		x
	Sida fibulifera	x	x
	Sida sp. B Kimberley Flora (A.A. Mitchell 2745)		x
	Sida sp. dark green fruit (S. van Leeuwen 2260)		x
MIMOSACEAE	*Acacia adsurgens*	x	x
	Acacia aff. *catenulata*	x	
	Acacia ancistrocarpa	x	x
	Acacia aneura	x	
	Acacia aneura var. *aneura*	x	x
	Acacia aneura var. *microcarpa*		x
	Acacia citrinoviridis		x
	Acacia coriacea subsp. *pendens*	x	x
	Acacia dictyophleba	x	x
	Acacia kempeana	x	x
	Acacia ligulata	x	x
	Acacia maitlandii	x	x
	Acacia marramamba		x
	Acacia pruinocarpa	x	x

FAMILY	Species	Phase 1	Phase 2
	Acacia rhodophloia	x	
	Acacia sericophylla	x	x
	Acacia sibirica		x
	Acacia sp. Hamersley Range hilltops (S. van Leeuwen 3552)		x
	Acacia spondylophylla	x	x
	Acacia stowardii	x	
	Acacia synchronicia	x	
	Acacia tenuissima	x	x
	Acacia tetragonophylla	x	x
	Acacia trudgeniana	x	x
MYOPORACEAE	*Eremophila exilifolia*	x	x
	Eremophila forrestii		x
	Eremophila forrestii subsp. *forrestii*	x	x
	Eremophila jucunda subsp. *pulcherrima*	x	x
	Eremophila latrobei subsp. *filiformis*	x	
	Eremophila latrobei subsp. *latrobei*		x
	Eremophila longifolia		x
MYRTACEAE	*Calytrix carinata*	x	x
	Corymbia aspera		x
	Corymbia candida subsp. *dipsodes*	x	
	Corymbia deserticola subsp. *deserticola*	x	x
	Corymbia hamersleyana	x	x
	Eucalyptus gamophylla	x	x
	Lamarchea sulcata	x	x
OLEACEAE	*Jasminum didymum* subsp. *lineare*	x	x
PAPILIONACEAE	*Gompholobium polyzygum*	x	x
	Indigofera georgei	x	x
	Indigofera monophylla	x	x
	Isotropis atropurpurea	x	x
	Kennedia prorepens	x	x
	Leptosema chambersii	x	x
	Mirbelia viminalis	x	x
	Muelleranthus trifoliolatus	x	
	Tephrosia aff. *clementii*	x	
POACEAE	*Amphipogon sericeus*	x	x
	Aristida contorta	x	
	Aristida holathera var. *holathera*	x	x
	Aristida ingrata	x	
	Cymbopogon ambiguus		x
	Cymbopogon obtectus	x	x
	Cymbopogon sp.		x
	Digitaria brownii	x	
	Enneapogon intermedius	x	
	Enneapogon polyphyllus	x	
	Eragrostis cumingii		x
	Eragrostis eriopoda	x	x
	Eragrostis sp.		x
	Eriachne aristidea	x	x
	Eriachne helmsii	x	
	Eriachne mucronata	x	x
	Eriachne pulchella subsp. *pulchella*	x	

FAMILY	Species	Phase 1	Phase 2
	Eulalia aurea	x	x
	Panicum effusum		x
	Paraneurachne muelleri	x	x
	Paspalidium reflexum	x	
	Schizachyrium fragile	x	
	Triodia basedowii	x	x
	Triodia epactia		x
	Triodia lanigera		x
	Triodia melvillei	x	x
	Triodia schinzii	x	x
	Triodia sp. Shovelanna Hill (S. van Leeuwen 3835)	x	
	Triraphis mollis		x
	Yakirra australiensis var. *australiensis*	x	
POLYGALACEAE	*Polygala* aff. *isingii*	x	
PORTULACACEAE	*Calandrinia balonensis*	x	
	**Portulaca oleracea*	x	
PROTEACEAE	*Grevillea berryana*		x
	Grevillea eriostachya	x	x
	Grevillea wickhamii subsp. *hispidula*	x	x
	Hakea chordophylla	x	x
	Hakea lorea subsp. *lorea*	x	x
RUBIACEAE	*Psydrax latifolia*	x	x
	Psydrax rigidula	x	x
	Psydrax suaveolens	x	x
SANTALACEAE	*Anthobolus leptomerioides*	x	x
	Santalum lanceolatum	x	x
SAPINDACEAE	*Diplopeltis stuartii* var. *stuartii*	x	x
	Dodonaea coriacea	x	x
	Dodonaea petiolaris	x	x
SOLANACEAE	*Solanum centrale*	x	x
	Solanum lasiophyllum	x	x
	Solanum sturtianum	x	x
STERCULIACEAE	*Brachychiton gregorii*	x	x
	Hannafordia bissillii subsp. *bissillii*	x	x
	Keraudrenia velutina subsp. *elliptica*	x	x
	Melhania oblongifolia	x	x
	Rulingia loxophylla	x	x
	Rulingia luteiflora		x
TILIACEAE	*Corchorus sidoides*		x
	Corchorus sidoides subsp. *sidoides*	x	x
	Corchorus sp.		x
VIOLACEAE	*Hybanthus aurantiacus*	x	x
ZYGOPHYLLACEAE	*Tribulus suberosus*	x	x

Classification and nomenclature according to the Western Australian Herbarium.
* signifies weed species.

A.5 WEED SPECIES LOCATIONS

Locations of Introduced flora recorded during the survey.

Species	Phase	Quadrat	Easting (mE)	Northing (mN)
***Portulaca oleracea**	1	1	262088	7390885
		6	261261	7391204

Zone = 51K, datum = WGS84