FERRAUS PILBARA PROJECT

FLORA AND VEGETATION SURVEY

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EXECUTIVE SUMMARY

G&G Environmental Pty Ltd was commissioned by FerrAus Limited to conduct a Level 2 flora and vegetation survey for the FerrAus Pilbara Project (FPP) located approximately 80 km east of the township of Newman in Western Australia. The main objectives of the survey included compiling an inventory of plant taxa and vegetation types present, producing a map of the vegetation types, undertaking targeted searches for conservation significant flora species, Threatened Ecological Communities (TEC's), Priority Ecological Communities (PEC's), locally or regionally significant vegetation types, Declared Plants (under the *Agricultural and Related resources Protection Act 1976)* and other weed species, assessing the condition of the vegetation, and determining the potential impact on the vegetation types selected for clearing.

FerrAus Ltd had previously commissioned flora and vegetation surveys at the FPP (Ecologia 2007 and 2009). The results of these surveys were combined with the current survey by G&G Environmental to provide a level 2 flora and vegetation assessment of the broader FPP area.

During the initial survey, vegetation sampling sites were chosen on the basis of topography, previously mapped vegetation types, field observations of vegetation structure, floristics and changes in the vegetation identified during the on ground survey. Sites were also selected for ground-truthing in the field based on visible differences in vegetation apparent from Google Earth images of the unmapped survey areas. For the consecutive visits, many vegetation sites were revisited and new sites added in accordance with government guidelines requirement for replication of surveys in the vegetation types present, and verification of vegetation boundaries.

The vegetation was characterised within 50 m x 50 m quadrats utilising the structural formation and height classes of the National Vegetation Inventory System (NVIS 2003). The projected foliage cover of all plant taxa present was recorded and searches for TEC's, PEC's, T flora, priority flora and weeds were conducted within each quadrat. The condition of vegetation was assessed according to the scale of Keighery (1994). Targeted searches for T and priority flora were also conducted where landform and vegetation resembled the habitat description for the species and at locations within the survey area where priority flora were previously recorded by Ecologia (2007) or identified from the search of DEC databases.

Vegetation types were defined by UPGMA statistical similarity grouping utilising species composition and cover, observations recorded in the field and data from the prior surveys of Ecologia 2007 and 2009. The vegetation types were named, where possible, in accordance with those defined by the Ecologia 2007 and mapped utilising boundaries visible on Google Earth, contour lines and changes in the vegetation recorded on GPS during the survey.

A total of nineteen vegetation types (sub-formations) were described in the current survey comprised of 236 perennial and 107 annual species from 49 families and 145 genera. The most prominent families were the Fabaceae, Poaceae, Asteraceae and Malvaceae. The most prominent genera were *Acacia*,

Senna, *Eremophila* and *Ptilotus*. These families and genera were also prominent in flora surveys conducted in the Pilbara bioregion indicating that vegetation at the FPP is largely comprised of common and widespread species.

Eight of the sub-formations did not closely resemble those recorded in the survey areas of Ecologia (2007, 2009) and were regarded as previously undescribed vegetation in the expanded FPP survey area.

The vegetation sub-formations defined for the survey area were compared with the descriptions of the major vegetation groups of NLWRA (2003), the mapped vegetation of Beard (1975) and regional site types recorded for the landsystems of Van Vreeswyk *et al.* (2004) to provide an indication of the potential local and regional conservation significance of the vegetation in the survey areas. Comparison to the site types of Van Vreeswyk *et al* (2004) provided an indication of whether the vegetation sub-formation resembled a broadly distributed or restricted site type, and whether the site types were represented in conservation reserves or unallocated crown land (UCL).

The majority of the vegetation sub-formations defined for the FPP fit the broad descriptions of two of the nationally recognised major vegetation groups; *Acacia* shrublands and hummock grasslands both of which cover extensive areas of the Gascoyne bioregion. Regionally, each of the sub-formations resembled the vegetation communities mapped by Beard (1975) and the regional site types defined by Van Vreeswyk *et al.* (2004). The semblance of each of the sub-formations to the site types of Van Vreeswyk *et al* (2004) indicates that the vegetation recorded at the FPP may potentially occur elsewhere in the broader landscape and resembles vegetation either previously recorded in UCL and/or in conservation reserves including Karijini, Millstream-Chichester and other National Parks.

FerrAus Ltd provided GIS files of the proposed disturbance footprint at the FPP. The area (km^2) of each of the land systems of Van Vreeswyk *et al* (2004) that occur within the FPP footprint was determined utilising MapInfo 8.5. This value was then used to ascertain the proportion of each of the land system that may be disturbed by mining processes at the FPP. In a similar fashion, the proportion of each of the vegetation types defined for the FPP that may be impacted by the footprint was determined.

With the exception of Sylvania, areas that may potentially be disturbed at the FPP account for less than 1% of the land systems present. The FPP survey area is therefore considered to represent low conservation value for these systems. Conversely, a considerable proportion of the Sylvania land system occurs at the FPP, of which approximately half occurs within the disturbance footprint. It is recommended that where possible disturbance to this land system be minimised and all areas outside of the disturbance footprint be protected to minimise impacts to this system.

Eight of the vegetation sub-formations occupied an area of less than $2km^2$ and together cover just 7.92% of the area surveyed. In accordance with government guidelines these sub-formations may be considered potentially locally significant as they are scarce within the survey area.

Large proportions of the sub-formations 5 and 1f (more than 95%), 4b and 8 (more than 70%), 1a, 1d, 1e and 4a (in excess of 50%) occur within the disturbance footprint. Each of these vegetation types are composed of common species, were considered to resemble site types of Van Vreeswyk *et al* (2004) and are represented in a conservation estate. It is considered that these sub-formations may potentially occur in the surrounding landscape.

Vegetation at the FPP was typically in pristine (78.3%) or excellent (18.6%) condition. Small proportion of vegetation was considered to be in good (2.5%) or very good (0.6%) condition. Disturbance from over-grazing, vehicle tracks and exploration activities were the primary causes of vegetation attaining lower condition rating. High density weed infestations reduced condition to very good and good in a few patches of riparian vegetation.

A total of 484 taxa comprising 323 perennial taxa and 161 annual species have been recorded at FPP by Ecologia (2007, 2009) and G&G Environmental representing 49 families and 166 genera. The most prominent families (Fabaceae, Poaceae, Malvaceae and Asteraceae) were also dominant in flora surveys conducted in the adjacent Pilbara bioregion. *Acacia aneura* varieties were the most widespread trees with *A. pruinocarpa* and *Hakea lorea* subsp. *lorea* also common. Mid to tall shrubs included *Acacia ancistrocarpa*, *A. dictyophleba*, *A. tenuissima*, *A. tetragonophylla*, *Eremophila forrestii* subsp. *forrestii*, *E. fraseri*, *E. jucunda*, *Psydrax latifolia*, *Senna artemisioides* subsp. *helmsii* and *S. glaucifolia*. Common low shrubs included *Bonamia rosea*, *Halgania solanacea*, *Hibiscus burtonii*, *Keraudrenia velutina*, *Ptilotus obovatus*, *Scaevola parvifolia* subsp. *Pilbarae*, *Sida fibulifera*, *Sida platycalyx*, *Solanum centrale* and *Solanum lasiophyllum*. The most widely distributed perennial grasses included spinifex (*Triodia basedowii* and *Triodia schinzii*) and tussock grasses including *Aristida inaequiglumis*, *Cymbopogon obtectus*, *Eulalia aurea* and *Paraneurachne muelleri*. The annual grasses *Aristida contorta*, *Perotis rara* and *Yakirra australiensis* were widespread following seasonal rainfall. Common annual herbs included *Boerhavia coccinea*, *Bulbostylis barbata*, *Cleome viscosa*, *Dysphania kalpari*, *Evolvulus alsinoides* var. *villosicalyx*, *Fimbristylis dichotoma*, *Gomphrena kanisii*, *Goodenia triodiophila*, *Polycarpaea corymbosa*, *Ptilotus polystachyus* and *Tribulus astrocarpus*. Apparent range extensions for were identified for 12 species, including *Commelina ensifolia, Eremophila spuria, Eremophila georgei, Euphorbia schultzii, Halgania gustafsenii* var. Mid West (G. Perry 370), *Sida* sp. articulation below, *Sida* sp. B Kimberley Flora (A.A. Mitchell 2745), *Sida* sp. Pilbara (A.A. Mitchell PRP 1543), *Stemodia lathraia*, *Vittadinia pustulata* **P2**, *Wahlenbergia caryophylloides*, and *Yakirra australiensis* var. *australiensis*.

No threatened (T) flora, no TEC of national or state significance and no PEC were found at the FPP. Each of vegetation units defined resembled common widespread communities. Two priority flora have been recorded in the survey areas, a priority 1 taxa *Brachyscome* sp. Wanna Munna Flats and a priority 2 species *Vittadinia pustulata*. The vegetation in which each of the priority species was recorded resemble widespread communities that are typical of the Pilbara and Gascoyne regions and are generally well represented in the surrounding area. This indicates that suitable habitat for each of the species occurs not only within the survey area but also in the broader landscape. *Brachyscome* sp.

Wanna Munna Flats was recorded at five locations, none of which occur in the disturbance footprint. *Vittadinia pustulata* was recorded at a single location and represents the only record for the species in the Gascoyne bioregion. It may therefore be considered potentially regionally significant. The population occurs approximately 50 m outside of the disturbance footprint. It is recommended that the population be protected.

Eight introduced species were recorded in the combined surveys including Bidens bipinnata, Cenchrus ciliaris, Chloris virgata, Malvastrum americanum, Portulaca oleracea, Citrullus lanatus, Cucumis melo and Tribulus terrestris with Portulaca oleracea the most widespread in various vegetation assemblages and habitats. Each of the introduced species have previously been recorded in the Gascoyne bioregion and all have wide distributions across Western Australia. None of the species is a Declared Plant under the Agriculture and Related Resources Protection Act 1976

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1.0 INTRODUCTION

1.1 PROJECT OUTLINE

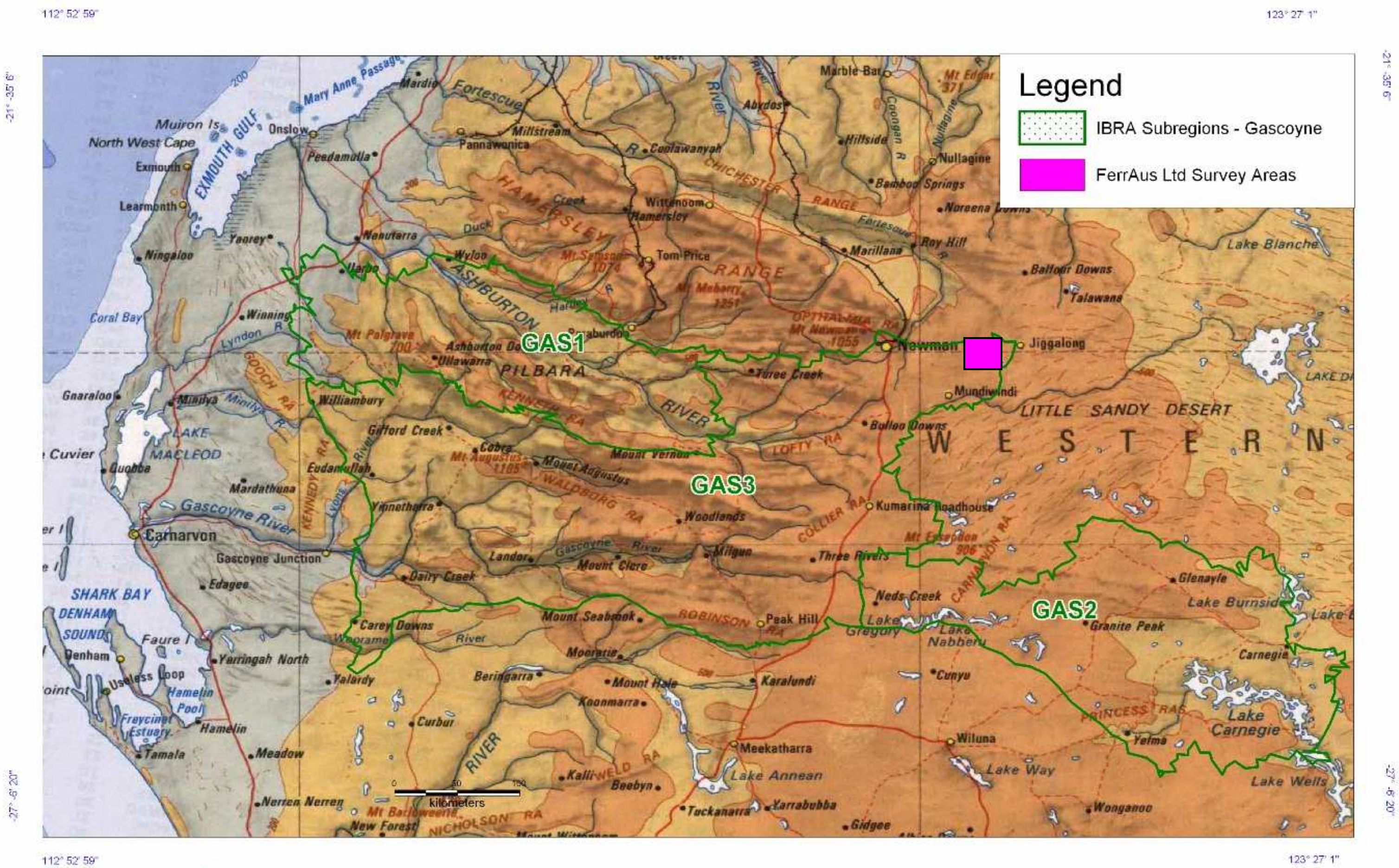
G&G Environmental Pty Ltd (G&G Environmental) was commissioned by FerrAus Limited to conduct a flora and vegetation field survey for the FerrAus Pilbara Project (FPP) located in the Gascoyne bioregion (see section 1.2.2) approximately 80 km east of the township of Newman in Western Australia (**Figure 1**). The survey was required for the purposes of environmental impact assessment and was thereby conducted in accordance with guidelines issued by the Environmental Protection Authority of Western Australia (EPA), including Guidance Statement No. 51 "Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia" (EPA 2004) and Position Statement No. 3 "Terrestrial Biological Surveys as an Element of Biodiversity Protection" (EPA 2002). The flora and vegetation survey utilised desktop information followed by reconnaissance and detailed field surveys of the FPP area over at least two seasons. This approach and intensity is consistent with a Level 2 survey (EPA 2004) and congruent with surveys conducted previously for environmental impact assessments in the Pilbara (e.g. Biota 2004, Environ 2004, Outback Ecology 2006, G&G Environmental 2006, 2007a and 2007b, Ecologia 2007, 2009).

The objectives of the Level 2 survey were to:

- identify the vascular plant species present in the survey areas;
- search for and describe populations of plants of conservation significance, including Declared Rare Flora (DRF), priority flora, geographically restricted taxa, endemic taxa, taxa at limits of recorded range, extensions to the recorded range of taxa;
- search for and describe populations of exotic plant species (weeds) particularly Declared Plants;
- define and map vegetation types present;
- review the local and regional significance of the vegetation types defined;
- record the condition of vegetation in the survey area, and
- assess impact of the infrastructure footprint on the vegetation types and previously described land systems present in the vegetation survey areas.

FerrAus Ltd had previously commissioned flora and vegetation surveys for areas of the FPP including a desktop review and reconnaissance survey (Level 1) of a proposed 200 km^2 transport/services corridor north-west of M52/1034 mining lease (Ecologia 2007) and a Level 2 survey of a prospective mining area within M52/1034 (Ecologia 2009). The results of Ecologia 2007 and Ecologia 2009 were

combined with those of G&G Environmental (this survey) to provide a Level 2 flora and vegetation description across broader FPP area (**Figure 2**).



Location Map

FerrAus Ltd

Figure 1

Scale 1 : 4 000 000

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Produced by G. Wells on 6/06/2010 Projection : GDA 94, MGA Zone 51

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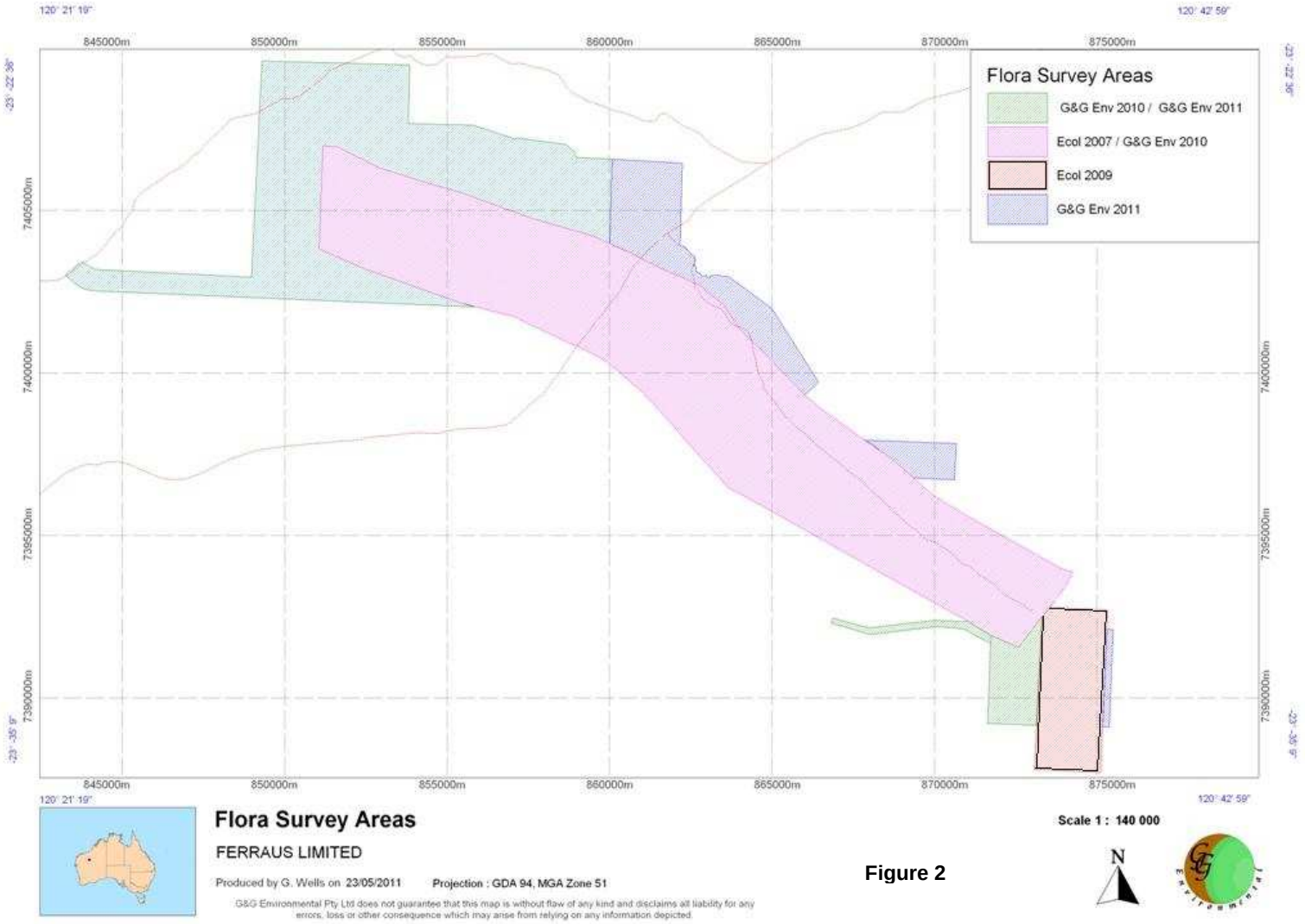
120° 21' 19"
120° 42' 59"
845000m
850000m
855000m
860000m
865000m
870000m
875000m
-23° 22' 36"
-23° 35' 9"
7405000m
7400000m
7395000m
7390000m
Flora Survey Areas
G&G Env 2010 / G&G Env 2011
Ecol 2007 / G&G Env 2010
Ecol 2009
G&G Env 2011
Flora Survey Areas
FERRAUS LIMITED
Produced by G. Wells on 23/05/2011
Projection : GDA 94, MGA Zone 51
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Figure 2

1.2 PHYSICAL ENVIRONMENT

1.2.1 Climate

The local climate is arid with patchy rainfall of spatially averaged annual median 202 mm. The closest Bureau of Meteorology (BoM, www.bom.gov.au) weather recording station is located at Newman airport where a long term average daily maximum temperature is 31.4°C and a long term average daily minimum temperatures is 17.4°C. Average daily maximum temperatures range from 22.3°C (July) to 39°C (January) (**Table 1**).

The long term average annual rainfall total is 311.5mm, approximately 63% of which occurs during the summer wet season (December to March). Rainfall prior to the April 2010 survey was well below average. Rainfall in the months preceding the surveys conducted in October 2010 and March 2011 was well above average (**Figure 3**).

Table 1: Long term temperature and rainfall averages recorded at the Newman BoM weather station. Temperature averages are from records taken over a 31 year period, 1965-1997, rainfall for a 34 year period 1965-1997.

NEWMAN												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean max °C	39	37.2	35.8	31.6	26	22.4	22.3	24.8	29.2	33.6	36.6	38.3
Mean min °C	25.3	24.4	22.4	18.4	13	9.6	8.1	10.1	13.7	17.9	21.4	23.9
Mean rain mm	51.4	80.1	38.6	25.3	23.2	25	12.6	10.5	4.1	3.9	9.8	27

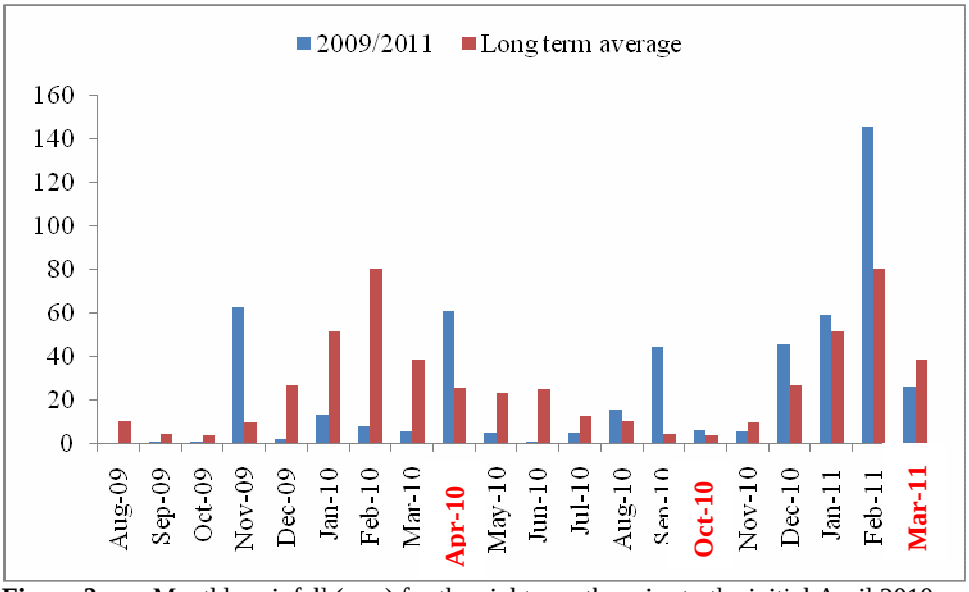


Figure 3: Monthly rainfall (mm) for the eight months prior to the initial April 2010 survey and for the entire survey period (blue) in comparison with the long term monthly averages (red) recorded at the Newman weather station (BoM 2011). Field surveys were conducted during the months highlighted by red print.

1.2.2 IBRA (Version 6.1) Bioregion and Land Systems

The FPP is situated in the Gascoyne bioregion (**Figure 1**) which covers an area of 180, 750 km^2 and comprises low, rugged ranges and broad, flat valleys. The bioregion is divided into three subregions; the Ashburton (GAS1), Carnegie (GAS2) and Augustus (GAS3).

The survey area falls within the largest subregion, Augustus, which has an area of 10,687,739 ha and is characterised by rugged, low, Proterozoic sedimentary and granite ranges that support Mulga (*Acacia aneura*) woodlands and *Triodia* and mulga parklands (Desmond *et al*. 2003). Broad flat valleys divide the ranges. About 10.3% of the bioregion lies within conservation estate. Extensive sheep and cattle grazing is the main land use on pastoral leasehold in the bioregion. Mining is important for the bioregion's economy.

The survey area intercepts nine land systems mapped by Van Vreeswyk *et al* (2004), *Cadgie*, *Divide*, *Newman*, *Prairie*, *River*, *Robertson*, *Sylvania* and *Washplain* (**Figure 4**). The land systems were based on areas "with a recurring pattern of topography, soils and vegetation" (Christian and Stewart 1953 in Van Vreeswyk *et al* 2004). The recurring patterns are visible from aerial photography and other remotely sensed images (Van Vreeswyk *et al* 2004). Descriptions by Van Vreeswyk *et al* (2004) of each of the land systems present at the FPP, including general landform features, geology, geomorphology and vegetation, are summarised in **Table 2.**

1.2.3 Previous Botanical Surveys

On a national scale, the Australian Native Vegetation Assessment, conducted as a component of the National Land and Water Resources Audit (NLWRA 2001), defined 23 major vegetation groups for Australia, ten of which occur within the Gascoyne bioregion (**Table 3**) and are dominated by three major groups; *Acacia* forests and woodlands, *Acacia* shrublands, and hummock grasslands with other shrublands. Chenopod shrublands are also common. Eucalypt woodlands, tussock grasslands and other grasslands comprised minor components of the bioregion's vegetation.

A substantial proportion of three of the major vegetation groups present in the Gascoyne bioregion are believed to have been altered since European settlement (**Table 4**) with the majority of these changes confined to the agricultural areas. Disturbance to the other vegetation groups present in the Gascoyne bioregion has been comparatively low with the majority of the vegetation represented in protected areas.

On a regional scale the vegetation communities of the area were mapped by Beard (1975) and include:

- a1Li - low continuous mulga woodland;
- a_1Lp - mulga trees in groves or patches;
- a_nSr.tHi - scattered shrubs over spinifex; and

- $e_{25}Srt_2Hi$ - *Eucalyptus gamophylla* over spinifex.

For the nine land systems that occur within the FPP survey area, Van Vreeswyk *et al* (2004) defined a total of 27 'site types' (**Table 5**) which are described according to their land surface, dominant plant species and vegetation formation**..**

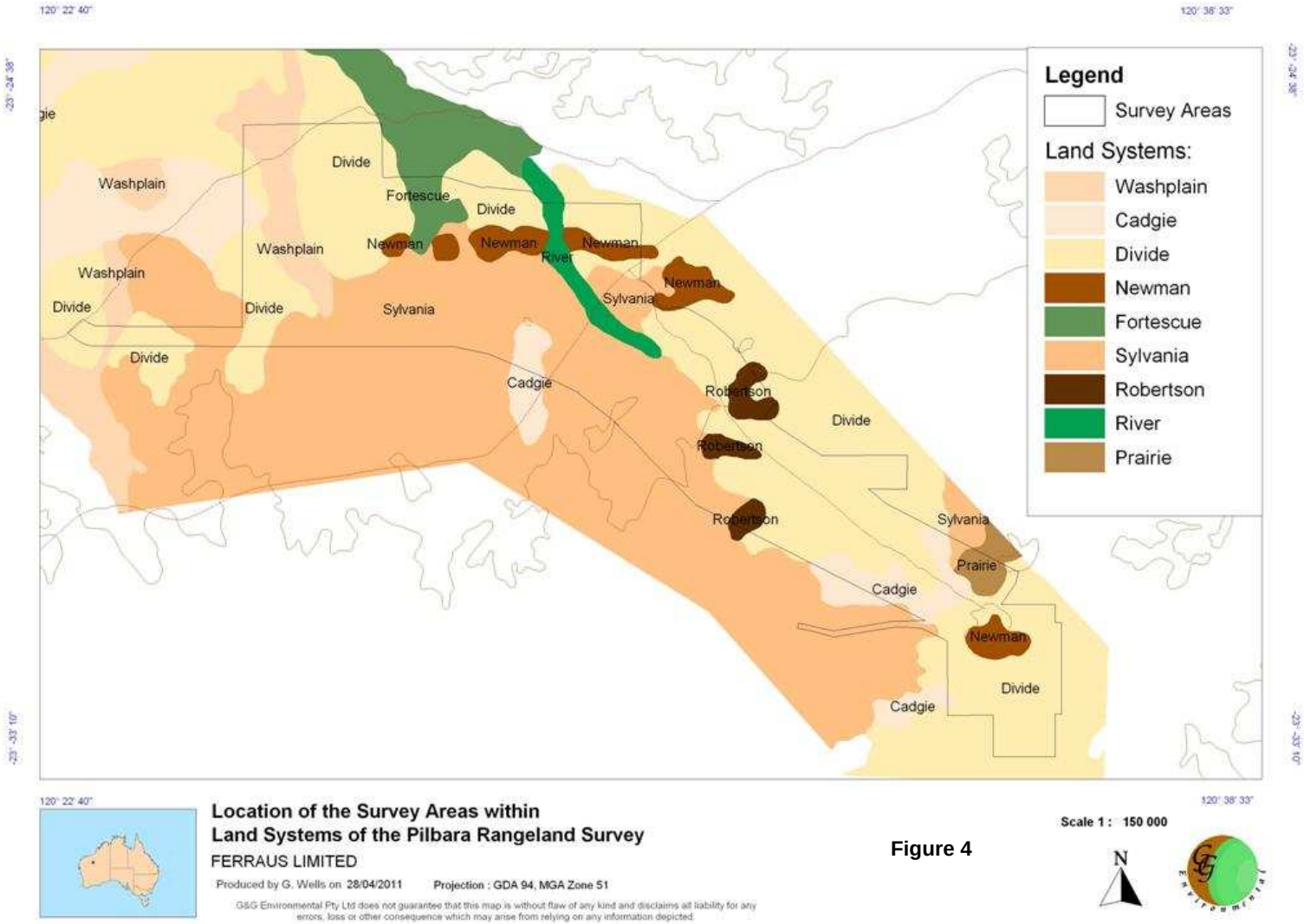

120° 22' 40"
120° 38' 33"
-23° 24' 38"
-23° 33' 10"
Legend
Survey Areas
Land Systems:
Washplain
Cadgie
Divide
Newman
Fortescue
Sylvania
Robertson
River
Prairie
Divide
Washplain
Fortescue
Divide
Newman
Newman
Newman
River
Washplain
Washplain
Divide
Divide
Sylvania
Newman
Sylvania
Divide
Cadgie
Robertson
Divide
Robertson
Robertson
Sylvania
Prairie
Cadgie
Newman
Divide
Cadgie
Location of the Survey Areas within
Land Systems of the Pilbara Rangeland Survey
FERRAUS LIMITED
Produced by G. Wells on 28/04/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
Scale 1 : 150 000
N

Figure 4

Table 2: Description of the land systems within the survey areas (Van Vreeswyk *et al* 2004).

Land System	Landform	Geology	Vegetation
Cadgie	Hardpan plains with thin sand cover and sandy banks.	Tertiary cemented colluvium and alluvium.	Mulga shrublands with soft and hard spinifex. Vegetation on the sandy plains and banks comprise three types HPMS, PMSS and SBAS. HPMS also occurs on the hardpan plains and drainage tracts with GMUW on the drainage foci.
Divide	Sandplains and occasional dunes.	Quaternary eolian sand.	Shrubby hard Spinifex grasslands. Vegetation recorded was PMSS, SHSG and SSSG.
Fortescue	Alluvial plains and flood plains	Quaternary alluvium	Patchy grassy woodlands and shrublands and tussock grasslands. Vegetation on floodplains and alluvial plains include ARPG, PMGS and DEGW. DEGW and GMEW on river channels and levees, GMGW in groves and ARPG and HPMS on gilgai and hard plains.
Newman	Rugged jaspilite plateaux, ridges and mountains.	Lower Proterozoic jaspilite, chert, siltstone, shale, dolomite and minor acid volcanic.	Hard spinifex grasslands. Vegetation on the plateaux's, mountains and hills includes HESG and HSPG. HESG and PHSG occur on the lower slopes with PHSG and PSSG on the stony plains. Vegetation of the drainage floors is more diverse with ASSG, DEGW, DAHW and DESG present.
Prairie	Gently undulating stony plains and granite hills.	Archaean granitoid rocks, metagranite to meta granodiorite with amphibolites and metadolerite intrusions.	*Acacia-Eremophila-Senna* shrublands and minor soft spinifex grasslands. SAES and HSPG vegetation occur on the hills and lower footslopes. SAES and PAGS occur on the stony plains, PAGS, PHSG and PMSS on the gritty plains, PXHS on the saline plains. PAGS dominates the dolerite ridges with DAHW, PMCS and DEGW on the sandy drainage floors, creek lines and channels.
River	Active floodplains and major rivers.	Quaternary alluvium.	Grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands. Vegetation is diverse with APBG, ASSG, AHSG, AEBG, DEGW, DESG and DAHW recorded for the floodplains and lower terraces. GMEW and AEBG occur in the channels, ASSG and PSSG on the sandy levees and sheets, PSSG, PHSG and DEGW on the stony plains and PHSG and PSSG on the upper terraces.
Robertson	Hills and ranges	Proterozoic shale, siltstone, sandstone, dolomite and minor conglomerate.	Hard spinifex grasslands. Vegetation on the hill crests, plateaux's, upper and lower hillslopes is uniform HSPG. PAGS and PHSG occur on the stony plains and low rises and DEGW and DAHW occur on the drainage floors and creek lines.
Sylvania	Gritty surface plains and low rises on granite	Archaean granitoid rocks, metagranite to metagranodiorite, Quaternary colluvium and alluvium	*Acacia-Eremophila-Senna* shrublands. The gritty surface plains and low rises and tors support PAGS and SAES vegetation. PMSS and PAGS occur on the sandy plains, HPMS and GMUW on the hardpan plains, PXHS on the stony saline plains and DEGW along the drainage tracts.
Washplain	Hardpan plains	Quaternary partly cemented alluvium.	Groved mulga shrublands. Vegetation on hardpan plains comprises HPMS and LHAS with SAES and PMGS on stony plains, SSSG and SHSG on sandplains, GMGW in groves and DEAW and DEGW along the drainage tracts.

Table 3: Major vegetation groups and the area they occupy in the Gascoyne bioregion (Source NLWRA 2001).

Major Vegetation Group Names	Code	Area (Ha)
Eucalypt woodlands	MVG5	4,584
Acacia forests and woodlands	MVG6	9,255,076
Acacia open woodlands	MVG13	74,400
Acacia shrublands	MVG16	5,752,440
Other shrublands	MVG17	666,940
Tussock grasslands	MVG19	1,264
Hummock grasslands	MVG20	1,262,828
Grassland group	MVG21	12,560
Chenopod group	MVG22	794,620
Mangrove group	MVG23	250,616

Table 4: Summary of the major vegetation groups present in the FPP and the status of each of the groups (Data Source NLWRA 2001).

Major Vegetation Group Code	Estimated area pre 1750 (km^2)	Present area (km^2)	% altered since 1750	Area protected (km^2)	% protected	Major disturbances and threats
MVG 5	1 362 263	892 920	~34.5%	72 589	~8%	Removed particularly in the agricultural zones of eastern and south-western Australia, altered fire regimes and impacts from invasive introduced plant species.
MVG 6	495 059	408 632	~17.5%	36 064	~8.8%	Extensively cleared for grazing and agriculture and modified by the grazing of cattle/sheep and feral animals, and increased macropod populations supported by water bores.
MVG 13	320 981	314 040	~2%	23 815	~7.6%	Clearing for pastoral activities, change in local drainage systems, increased grazing pressure by providing stock watering and the introduction and spread of feral animals and changes to fire regimes.
MVG 16	865 845	851 274	~1.7%	85 444	~10%	Clearing for pastoral activities, altered fire regimes and combined grazing of domestic stock feral and native animals.
MVG 17	157 530	123 464	~21.6%	23 136	~18.7%	Extensively cleared in the agricultural regions and in coastal areas adjoining major cities. In the arid zone, little of this group has been cleared but many areas have been subject to modification by grazing by domestic stock and feral herbivores.
MVG 19	559 850	525 888	~6%	15 795	~3%	Extensively grazed and altered fire regimes.
MVG 20	1 368 861	1 367 973	~0.06%	135 637	~10%	Some grazing by domestic stock but primarily from feral herbivores, altered fire regimes.
MVG21	67 977	64 810	~4.7%	11 112	~17.1%	Different hydrological conditions, changes to fire regimes, impacts from feral animals and localised tourism.
MVG 22	447 239	436 801	~2.3%	55 143	~12.6%	Generally these communities have remained intact since European settlement. In some cases the communities have increased in extent because of increased salinity and waterlogging. Foremost among threats for coastal occurrences are infilling for urban areas, changes to tidal regimes and isolation from the estuary by roads and infrastructure.
MVG 23	9 664	9 325	~3.5%	3 08	~33.1%	Widespread clearing or infilling of mangroves and tidal mudflats has occurred in coastal areas near urban major centers for industrial uses or urban developments.

Table 5: Description of the site types of Van Vreeswyk *et al* 2004.

Site Type	Description
AEBG – Alluvial plain buffel grass grassland with eucalypt overstorey	Occurs on level floodplains, alluvial plains, levees and drainage tracts. A *Cenchrus ciliaris* tussock grassland with an overstorey of eucalypt trees, also a tall shrub layer and less frequently mid and low shrub layers. Dominant trees are *Eucalyptus camaldulensis* and *E. victrix* with *Atalaya hemiglauca*, *Hakea suberea* and *Bauhinia cunninghamii* common. Tall shrubs include *Acacia inaequilatera, A. sclerosperma* and *A. trachycarpa*. Common mid shrubs are *Carissa lanceolata*, *Rhagodia eremaea*, *Tephrosia rosea* and *Vachellia farnesiana*. Low shrubs are *Aerva javanica*, *Atriplex bunburyana*, *Cucumis maderaspatanus* and *Senna artemisioides* subsp. *oligophylla*. Perennial grasses are dominated by *Cenchrus ciliaris* with *Bothriochloa bladhii* subsp. *bladhii*, *Cenchrus setiger*, *Chrysopogon fallax*, *Eriachne benthamii* and *Triodia pungens* common.
AHSG - Alluvial plain hardpan spinifex grassland	Occurs widely on alluvial plains and drainage tracts usually with non-cracking, weakly saline, sand duplex and clay soils. A hummock grassland with up to 60% foliage cover, occasionally an *Acacia* mid and/or tall shrub layer. Tall shrubs include *Acacia ancistrocarpa*, *A. arida* and *A. inaequilatera*, mid and low shrubs are *Acacia bivenosa*, *A. stellaticeps*, *Corchorus walcotii*, *Hibiscus sturtii*, *Mollugo molluginea*, *Pluchea tetranthera* and *Sida rohlenae*. Perennial grasses *Triodia lanigera*, *T. longiceps*, *T. secunda* are dominant and *Aristida holathera* var. *holathera*, *Cenchrus ciliaris*, *Chrysopogon fallax* and *Triodia pungens* are common.
APBG - Alluvial plain buffel grass grassland	Occurs on level alluvial plains, flood plains, levees and drainage tracts. Occurs as Cenchrus *ciliaris* tussock grassland with a few shrubs and trees. Common trees are *Atalaya hemiglauca* and *Hakea lorea* subsp. *suberea*. Tall and mid shrubs include *Acacia inaequilatera, A. sclerosperma, A. victoriae, Carissa lanceolata* and *Vachellia farnesiana*. Common low shrubs are *Senna artemisioides* subsp. *oligophylla*, *Sida fibulifera*, *Solanum esuriale* and *Trianthema turgidifolia*. Perennial grasses are dominated by *Cenchrus ciliaris* with *Cenchrus setiger, Chrysopogon fallax, Eragrostis eriopoda, E. xerophila, Panicum decompositum* and *Triodia pungens* common.
ARPG – Alluvial plain Roebourne Plains grass grassland	Common on level plains with gilgai microrelief in cracking and/or saline clays. An *Eragrostis xerophila* tussock grassland usually with other minor grass species and occasionally with a poorly developed lower shrub stratum, larger shrubs and trees if present are typically isolated. *Acacia victoriae* is a common tall shrub; lower shrubs include *Indigofera trita, Neptunia dimorphantha, Senna artemisioides* subsp. *helmsii, Senna artemisioides* subsp. *oligophylla, S. hamersleyensis, Sida fibulifera, Solanum lasiophyllum, Tephrosia clementii*. The dominant perennial grass is *Eragrostis xerophila*, *Cenchrus ciliaris*, *Chrysopogon fallax*, *Eragrostis setifolia, Eriachne benthamii, Triodia pungens* are common.
ASSG - Alluvial plain soft spinifex grassland	Occurs widely on alluvial plains and drainage floors in sandy soils. A hummock grassland of *Triodia pungens* with mostly isolated to scattered shrubs and trees. Dominant trees are *Corymbia hamersleyana* and *Hakea lorea* subsp. *suberea*. Dominant tall and mid shrubs are *Acacia ancistrocarpa*, *A. inaequilatera* and *A. victoriae*. Low shrubs include *Acacia stellaticeps*, *Corchorus sidoides*, *Hibiscus sturtii*, *Indigofera monophylla*, *Mollugo molluginea*, *Pluchea tetranthera*, *Senna artemisioides* subsp. *oligophylla* and *Sida fibulifera*. Grasses are dominated by *Triodia pungens*; *Cenchrus ciliaris*, *Chrysopogon fallax* and *Eragrostis xerophila* are common.
DAHW - Drainage acacia hummock grass	Occurs on narrow drainage floors and occasionally on groves on wash plains.

shrubland/woodland	An *Acacia* woodland or shrubland with hummock grass layer. Occasionally the hummock grassland is dominant with an overstorey of *Acacia* tall shrubs or trees. Dominant trees include *Acacia aneura*, and *Corymbia hamersleyana*. Common tall shrubs are *Acacia ancistrocarpa*, *A. citrinoviridus*, *A. holosericea*, *A. trachycarpa*, *A. tumida* and *Hakea lorea* subsp. *suberea*. Mid shrubs include *Acacia acradenia, A. atkinsiana, A bivenosa*, *Grevillea pyrifolia, G. wickhamii* and *Senna glutinosa* subsp. *glutinosa*. Low shrubs are *Corchorus sidoides, Evolvulus alsinoides, Goodenia stobbsiana, Hybanthus aurantiacus, Indigofera monophylla, Mollugo molluginea, Senna artemisioides* subsp.'s, *Sida fibulifera* and *Solanum lasiophyllum*. *Triodia pungens* is the dominant perennial grass with *Cenchrus ciliaris, Chrysopogon fallax, Paraneurachne muelleri* and *Triodia wiseana* common.
DEAW – Drainage eucalypt and acacia woodland/shrubland	Occurs on near level drainage tracts and floors, channelled or unchannelled up to 500m wide, occasionally wider. A eucalypt and/or *Acacia* woodland or tall shrubland with a low shrub layer but no perennial grass layer. Dominant trees are *Eucalyptus victrix* and *Acacia aneura, Hakea suberea* is common. Tall shrubs include *Acacia ancistrocarpa, A. sclerosperma* and *A. tumida*. Mid and low shrubs are *Muehlenbeckia florulenta, Chenopodium auricomum, Eremophila lanceolata, Indigofera monophylla, Cucumis maderaspatanus, Maireana villosa, Sida* spp., *Solanum lasiophyllum* and *Tephrosia bidwillii*. The perennial grass *Chrysopogon fallax* may also be present
DEGW - Drainage eucalypt and acacia grassy woodland/shrubland	Occurs mainly on narrow drainage floors but also wider drainage floors, floodplains, levees and on drainage foci such as claypans and swamps. An *Acacia* and/or eucalypt tall shrubland or woodland with a tussock grass layer. There is generally a mid and low shrub layer. Dominant trees are *Acacia aneura, A. coriacea, Corymbia aspera, C. flavescens, C. hamersleyana, Eucalyptus camaldulensis, E. victrix* with *Hakea suberea* also common. Tall and mid shrubs include *Acacia citrinoviridus, A. distans, A. inaequilatera, A. pyrifolia, A. trachycarpa, A. tetragonophylla, A. tumida, A. victoriae, Carissa lanceolata, Rhagodia eremaea* and *Vachellia farnesiana*. Low shrubs include *Eremophila forrestii, Indigofera monophylla, Maireana planifolia, M. villosa, Ptilotus obovatus, Senna artemisioides* subsp.'s, *Sida fibulifera, Solanum lasiophyllum* and *Tephrosia rosea*. Dominant perennial grasses are *Cenchrus ciliaris, Chrysopogon fallax* and *Eriachne benthamii* with *Eragrostis xerophila, Eulalia aurea, Themeda triandra* and *Triodia pungens* common.
DESG – Drainage spinifex grassland with eucalypt overstorey	Occurs on drainage tracts and floors. A hummock grassland with an overstorey of eucalypt trees typically with tall, mid and low shrub strata. Dominant trees are *Corymbia flavescens, C. hamersleyana, Eucalyptus camaldulensis, E. victrix* and *Hakea lorea* subsp. *suberea*. Common tall shrubs include *Acacia inaequilatera, A. pyrifolia* and *A. tumida*; mid shrubs are *Gossypium australe, G. robinsonii, Petalostylis labicheoides* and *Rhagodia eremaea*. Common low shrubs are *Corchorus* spp., *Bonamia erecta, Euphorbia australis, Indigofera monophylla* and *Ptilotus australasicus*. Perennial grasses are dominated by *Triodia* spp., particularly *T. pungens* with *Cenchrus ciliaris* and *Chrysopogon fallax* common.
GMEW – Gallery (riverbank and channel) melaleuca eucalypt woodland	Occurs along banks and channels of major rivers. A *Melaleuca argentea* or *Eucalyptus camaldulensis* woodland often with a tall shrub layer, infrequently mid or low shrub layers and a patchy layer of sedges or perennial grasses. Dominant trees are *Melaleuca argentea* or *Eucalyptus camaldulensis* with *Acacia coriacea, Atalaya hemiglauca, Ficus platypoda* and *Sesbania formosa* common. Tall shrubs include *Acacia holosericea, A.*

	pyrifolia, *A. trachycarpa*, *Melaleuca glomerata* and *M. linophylla*. Mid shrubs are *Capparis lasiantha*, *C. spinosa* and *Petalostylis labicheoides*. *Jasminum didymum* subsp. *lineare* is a common low shrub and common perennial grasses and sedges include *Cenchrus ciliaris*, *Cymbopogon procerus*, *Cyperus vaginatus*, *Eulalia aurea*, *Themeda triandra* and *Triodia pungens*.
GMGW - Grove mulga grassy woodland/shrubland	Occur as arcuate clumps of notably denser mulga shrubs and trees than surrounding vegetation with the long axes along the contour of slightly inclined wash plains and also as diffuse foci on drainage tracts. A moderately close to closed *Acacia* woodland with a tussock grass ground layer. Dominant trees include *Acacia aneura* and *A. catenulata*. *Hakea suberea* is a common tall shrub, mid and low shrubs include *Eremophila clarkei*, *E. forrestii*, *E. latrobei*, *E. lanceolata*, *Enchylaena tomentosa*, *Evolvulus alsinoides*, *Hibiscus sturtii*, *Maireana planifolia*, *M. villosa*, *Psydrax latifolia*, *Ptilotus obovatus*, *Sida fibulifera*, *Solanum ferocissimum* and *S. lasiophyllum*. Perennial grasses include *Chrysopogon fallax*, *Themeda triandra*, *Aristida latifolia*, *Digitaria ammophila*, *Eragrostis setifolia*, *E. xerophila*, *Eriachne benthamii* and *E. obtusa*.
GMUW - Grove mulga woodland/shrubland	Occurs on hardpan wash plains subject to sheet water flow as bands of dense vegetation separated by inter-grove plains supporting much sparser vegetation. Moderately close to closed *Acacia* woodland or tall shrubland. Dominant tree is most commonly *A. aneura* other trees include *A. pruinocarpa* and *Hakea lorea* subsp. *suburea*. Tall and mid shrubs *Acacia catenulata*, *Eremophila forrestii*, *E. latrobei*, *Psydrax latifolia*, *Rhagodia eremaea*, *Sida calyxhymenia* and *Stylobasium spathulatum*. Low shrubs include *Enchylaena tomentosa*, *Evolvulus alsinoides*, *Hibiscus burtonii*, *Maireana planifolia*, *M. villosa*, *Ptilotus obovatus*, *Senna artemisioides* subsp. x *sturtii*, *Sida fibulifera* and *Solanum lasiophyllum*. Perennial grasses include *Chrysopogon fallax* and *Monachather paradoxa*.
HESG - Hill eucalypt spinifex grassland	Occurs on hillslopes, footslopes and low rises. A hummock grassland of *Triodia* species with an overstorey of isolated to scattered eucalypts and isolated to scattered shrubs. Dominant trees include *Eucalyptus leucophloia*, *Corymbia hamersleyana* and *Acacia pruinocarpa*. Dominant tall shrubs *Grevillea wickhamii*, *Hakea lorea* subsp. *suberea*, *Acacia adoxa*, *A. tetragonophylla* and *A. maitlandii*. Dominant mid and low shrubs *Acacia atkinsiana*, *A. bivenosa*, *A. monticola*, *Senna glutinosa* and subsp.'s, *Acacia hilliana*, *Goodenia stobbsiana*, *Indigofera monophylla*, *Ptilotus calostachyus*, *P. obovatus*, *P. rotundifolius*, *Senna artemisioides* subsp. *oligophylla* and *Solanum lasiophyllum*. Dominant grasses *Triodia angusta*, *T. biflora*, *T. brizoides*, *T. concinna*, *T. plurinervata*, *T. pungens* and *T. wiseana*. *Themeda triandra* is also common.
HPMS - Hardpan plain mulga shrubland	Widely distributed, occurs on extensively broad plains overlying hardpan between erosional uplands and salt lake or river systems. A very scattered to scattered tall shrubland of mulga with well developed mid and low shrub layers, occasionally only a low shrub layer. Dominant trees include *Acacia aneura*, *A. pruinocarpa* and *Hakea lorea*; tall and mid-shrubs *Acacia tetragonophylla*, *A. wanyu*, *Eremophila fraseri*, *E. latrobei*, *Senna glutinosa* subsp.x *luerssenii*, *Psydrax latifolia*, *Rhagodia eremaea* and *Sida calyxhymenia*. Common low shrubs *Eremophila forrestii*, *E. margarethe*, *Hibiscus burtonii*, *Maireana tomentosa*, *M. villosa*, *Ptilotus obovatus*, *P. schwartzii*, *Senna artemisioides* subsp.'s, and *Solanum lasiophyllum* and common perennial grasses *Eriachne obtuse* and *Monachather paradoxa*.
HSPG - hill Spinifex grassland	Occurs on hillslopes, hill crests, footslopes, plateaux, ridges and low rises. A hummock grassland of *Triodia* species with isolated to scattered trees

	and shrubs. Common trees include *Corymbia hamersleyana* and *Eucalyptus leucophloia*. Dominant tall shrubs include *Acacia orthocarpa, Acacia inaequilatera, Grevillea wickhamii* and *Hakea lorea* subsp. *suberea*. Common mid-low shrubs are *Acacia bivenosa, Senna glutinosa* and subsp.'s, *Abutilon lepidum, Corchorus* spp., *Goodenia stobbsiana, Indigofera monophylla, Mollugo molluginea, Ptilotus calostachyus* and *Senna artemisioides* subsp *oligophylla, Tribulus platypterus* and *T. suberosus*. The most common perennial grasses include *Triodia pungens* and *T. wiseana* also *T. brizoides, T. lanigera, T. plurinervata, Cymbopogon ambiguous* and *Eriachne mucronata*.
LHAS - Lateritic hardpan plain acacia shrubland	Occurs on plains on hardpan with ironstone gravel or pebbles. An isolated to scattered tall acacia shrubland, commonly *Acacia aneura*, with well developed mid and low shrub layers. Dominant tall shrubs include *Acacia aneura, A. synchronicia* and *Hakea lorea* subsp. *suberea*. Mid and low shrubs include *Acacia wanyu, Senna glutinosa* subsp. x *luerssenii, Eremophila exilifolia, E. lanceolata, E. pensilis, Maireana planifolia, M. villosa, Ptilotus schwartzii* and *Senna* spp. Common perennial grasses are *Aristida holathera* var. *holathera* and *Triodia pungens*.
PAGS - Plain acacia cassia grassy shrubland	Occurs on gritty and stony plains and low rises typically in granitic terrain but also dolerite, sedimentary rocks and colluvium. A very scattered mixed shrubland with low, mid and tall shrub strata of *Acacia* , *Eremophila* and *Senna* species and a conspicuous understorey of *Aristida contorta* and/or *Enneapogon* spp. Annual grasses with *Aristida holathera* var. *holathera* a common perennial grass. Dominant tall shrubs include *Acacia aneura, A. tetragonophylla, A victoriae* and *Hakea lorea* subsp. *suberea*. Common mid and low shrubs are *Eremophila fraseri, E. latrobei, E. forrestii, E. margarethe, E. pensilis, Rhagodia eremaea, Senna* spp., *Evolvulus alsinoides, Indigofera monophylla, Maireana planifolia, M. villosa, Ptilotus obovatus, Sida echinocarpa, S. fibulifera, Solanum lasiophyllum* and *Tephrosia supina*. Perennial grasses include *Aristida holathera* var. *holathera, Chrysopogon fallax, Eragrostis eriopoda* and *Monachather paradoxa*.
PHSG - Plain hard Spinifex grassland	Occurs extensively on plains including stony, loamy, gravelly and gritty plains, also on footslopes and low rises. A hummock grassland of *Triodia* spp. with isolated to scattered to trees and shrubs. Common trees include *Corymbia hamersleyana, Eucalyptus leucophloia* and *Hakea lorea* subsp. *suberea*. Common tall shrubs include *Acacia ancistrocarpa, A. inaequilatera A. victoriae* and *Grevillea wickhamii*. Common mid and low shrubs include *Acacia bivenosa, A. stellaticeps, Senna glutinosa* and subsp.'s, *Corchorus* spp., *Mollugo molluginea, Solanum lasiophyllum* and *Ptilotus astrolasius, P. calostachyus, Indigofera monophylla, Senna artemisioides* subsp. *helmsii, Senna artemisioides* subsp. *oligophylla, Senna symonii* and *Sida echinocarpa.* Perennial grass cover frequently dominated by *Triodia wiseana* with *T. lanigera, T. longiceps, T. plurinervata, T. pungens, Paneurachne muelleri* and *Cenchrus ciliaris* also common.
PMCS - Plain mulga shrubland with chenopod low shrubs	Uncommon and occurs on plains including hardpan and saline plains and drainage tracts. A scattered tall *Acacia aneura* shrubland with a few mid shrubs and a low shrub layer dominated by chenopod shrubs. Tall shrubs are dominated by *Acacia aneura* with *A. tetragonophylla, A. victoriae* and *A. xiphophylla* common. *Senna glutinosa* subsp. x *luerssenii* is the dominant mid shrub with *Eremophila latrobei* and *Rhagodia eremaea* common. Low shrubs include *Enchylaena tomentosa, Eremophila forrestii, Maireana georgei, M. melanocoma, M. pyramidata, M. tomentosa, M. triptera, Ptilotus obovatus, Senna artemisioides* subsp.'s and *Solanum lasiophyllum.*
PMGS - Plain mosaic grassy shrubland	Uncommon and occurs on alluvial and stony plains that have a mosaic of gilgai and non-gilgai surfaces where typically the non-gilgai surface

	dominates but not always. A variably dense low shrubland of *Senna* and *Eremophila* species with a prominent but patchy ground layer of perennial grasses. *Acacia tetragonophylla* is a common tall shrub, mid shrubs include *Eremophila forrestii* and *Senna glutinosa* subsp. x *luerssenii*; low shrubs are *Eremophila cuneifolia, E. lanceolata, E. pantonii, Maireana planifolia, Sclerolaena deserticola, Senna* spp. And *Solanum lasiophyllum*. Perennial grasses include *Chrysopogon fallax* and *Eragrostis eriopoda.*
PMSS - Plain mulga Spinifex shrubland/grassland	Occurs on stony, loamy, gravelly and hardpan plains. A moderately closed *Acacia aneura* shrubland with a prominent to patchy ground layer of spinifex, or hummock grassland with a scattered overstorey of mulga and other shrubs. Common trees are *Acacia aneura, A.* pruinocarpa *and* Corymbia hamersleyana. Tall shrubs include *Acacia inaequilatera* and *Hakea suberea* with mid shrubs *Acacia ancistrocarpa, A. bivenosa, Eremophila forrestii, E. latrobei, Rhagodia eremaea* and *Senna* spp. Low shrubs include *Hibiscus burtonii, Maireana planifolia, M. villosa, Ptilotus obovatus, Solanum lasiophyllum* and *Tribulus platypterus* with dominant grasses *Triodia pungens* and *Chrysopogon fallax.*
PSSG - Plain soft Spinifex grassland	Occurs extensively on stony, loamy and gritty plains. A hummock grassland of resinous *Triodia* grasses with isolated to moderately close trees and shrubs which may forma strata and are often *Acacia*. Common trees and include *Corymbia hamersleyana, Eucalyptus leucophloia, Acacia pruinocarpa, Grevillea wickhamii* and *Hakea lorea* subsp. *suberea*. Tall and mid shrubs include *Acacia ancistrocarpa, A. atkinsiana, A. inaequilatera, Senna glutinosa* and subsp.'s, *Bonamia rosea, Corchorus sidoides, C. walcotii, Euphorbia australis, Indigofera monophylla, Mollugo molluginea , Ptilotus australasicus, P. calostachyus, Solanum lasiophyllum, Tephrosia uniovulata* and *Senna artemisioides* subsp. *oligophylla*. Perennial grasses include *Triodia pungens, T. epactia, A. latifolia, Cenchrus ciliaris, Chrysopogon fallax, Eragrostis eriopoda* and *Paraneurachne muelleri*.
PXHS – Plain mixed halophyte shrubland	Occurs on level plains and drainage floors with abundant mantles of gravel or pebbles, typically in saline soils. A scattered to very scattered low shrubland of saltbush and bluebush with sparse perennial grasses. Common tall shrubs are *Acacia aneura, A victoriae* and *Hakea preisii*. Mid and low shrubs include *Atriplex bunburyana, Enchylaena tomentosa, Eremophila cuneifolia, E. maculate, Frankenia* spp., *Maireana carnosa , M. glomerifolia, M. planifolia, M. pyramidata, Senna artemisioides* subsp. *helmsii, Senna* sp. Meekatharra, *Solanum lasiophyllum* and *Streptoglossa cylindriceps.* Common grasses are *Enteropogon ramosus, Eragrostis eriopoda* and *E. xerophila*.
SAES - Stony plan acacia-eremophila-cassia shrubland	Common on stony plains and low rises and also occurs on stony hardpan plains, gravelly plains and occasionally hillslopes. A very scattered to scattered *Senna* and *Eremophila* low or mid-height shrubland with prominent tall *Acacia* shrubs seldom with trees or a perennial grass cover. Common tall shrubs include *Acacia pruinocarpa, A. aneura, A. tetragonophylla, A. victoriae* and *A. wanyu*. Mid and low shrubs include *Eremophila exilifolia, E. fraseri, E. cuneata, E. latrobei , Rhagodia eremaea, Senna glutinosa* subsp. x *luerssenii, Senna artemisioides* subsp.'s, *Sida calyxhymenia, Maireana georgei, M. tomentosa, M. triptera , Ptilotus obovatus, P. roei, P. schwartzii* and *Solanum lasiophyllum*. Perennial grasses are sparse but include *Eragrostis eriopoda, Triodia lanigera* and *T. wiseana*.
SBAS - Sandy bank acacia Spinifex shrubland	Occurs on deep sands on sand banks. A scattered to moderately closed *Acacia* shrubland with a hummock grass layer.

	Tall shrubs are dominated by *acacia aneura* with *A. pruinocarpa* and *A sclerosperma* common. Mid shrubs include *Eremophila latrobei* and *Rhagodia eremaea*; low shrubs are *Abutilon otocarpum, Eremophila pensilis, Hibiscus burtonii, H. Sturtii, Maireana planifolia, M. villosa* and *Senna artemisioides* subsp. *helmsii*. Perennial grasses dominated by *Triodia basedowii, T. lanigera* and *T. pungens* with *Digitaria brownii* and *Eragrostis eriopoda* common.
SHSG - Sandplain hard spinifex grassland	Common on sandplains gravelly sandplains and dunes. Triodia hummock grassland with variable shrub layers. Common trees include *Allocasuarina decaisneana, Corymbia chippendalei, Eucalyptus gamophylla* and *Hakea lorea* subsp. *suberea*. Tall shrubs include *Acacia ancistrocarpa, A. inaequilatera* and *Grevillea eriostachya*. Mid and low shrubs include *Acacia stellaticeps, A. tumida, Bonamia rosea, Corchorus* spp., *Halgania* spp., *Indigofera monophylla, Ptilotus aphyllus, Scaevola parvifolia* subsp. *parvifolia* and *Sida cardiophylla*. Dominant grasses are *Triodia lanigera* and *T. pungens* with *Aristida holathera* var. *holathera, Eragrostis eriopoda* and *Paraneurachne muelleri* common.
SSSG - Sandplain soft spinifex grassland	Widespread on the deep sands of sandplains and dunes. Hummock grassland of *Triodia pungens, T. epactia* or *T. schinzii* with variable shrubs and occasional trees. Common trees include *Corymbia zygophylla*, *Bauhinia cunninghamii, Owenia reticulata, Acacia coriacea* and *Hakea lorea* subsp. *suberea*. Tall shrubs include *Acacia ancistrocarpa, A. holosericea, A. tumida, Grevillea pyramidalis* and *G. wickhamii*; mid shrubs are *Acacia inaequilatera, Carissa lanceolata* and *Sida pilbarensis*. *Acacia stellaticeps* is the dominant low shrub with *Bonamia eremaea, Corchorus walcotii, Dicrastylis* spp., *Evolvulus alsinoides, Indigofera monophylla, Mollugo molluginea, Ptilotus astrolasius, Scaevola parvifolia* subsp. *parvifolia* and *Solanum diversiflorum*. Perennial grasses include *Triodia pungens¸ T. epactia*, *T. schinzii*, *Aristida holathera* var. *holathera*, *Chrysopogon fallax*, *Eragrostis eriopoda*, *Eriachne obtuse* and *Paraneurachne muelleri*.

Ecologia (2009) defined and mapped the following nine broad vegetation types (including one split into two sub-groups) in a 10 km^2 area at the FPP (**Figure 2**):

- A tall *Grevillea* shrubland along drainage channels of flat plains;
- A low *Gompholobium* shrubland on sandy plains;
- A tall *Acacia* shrubland along drainage tracts between hills;
- A *Eucalyptus* mallee woodland over spinifex grassland on sandy plains;
- Scattered *Hakea* trees over mid and low shrublands in a spinifex grassland on sandy plains;
- Low regrowth shrublands on recently burnt sandplain;
- Sparse mid-shrubland over low shrubland in tussock grassland on recently burnt hill footslopes;

- Low spinifex hummock grasslands on rocky hillslopes and ridges; and
- Low open mulga woodland in drainage areas of hill slopes.

Ecologia (2007) defined and mapped the following eight broad vegetation types along a 60 km corridor (covering 200 km^2), a section of which forms part of the FPP survey area (**Figure 2**):

- Scattered trees and shrubs over spinifex hummock grassland on sandy plains;
- Scattered trees and low open shrubland over spinifex hummock grassland on rocky plains;
- Open low woodland over dense tussock grasses along river and creek banks;
- Low open trees over mixed mid shrubland in dense tussock and hummock grassland on floodplains;
- Open low *Acacia* woodland over mixed *Acacia* shrubland in dense mixed tussock and spinifex hummock grassland in minor depressions;
- Spinifex hummock grassland on rocky hill footslopes;
- Sparse trees over spinifex hummock grassland on hill mid-slopes; and
- Open mid-shrubland over tussock and hummock grasses on hill tops.

Ecologia (2009) recorded 196 taxa comprising 36 families and 89 genera at M52/1034 at the FPP[1]. The most species rich families were Poaceae (30 taxa), Fabaceae (48 taxa), Malvaceae (17 taxa), Amaranthaceae (9 taxa), and Chenopodiaceae (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. One taxon was identified to family level only and five to genus level.

Ecologia (2007) recorded 289 flora taxa within the 200 km^2 corridor comprised of 44 families[2] and 115 genera. The most species rich plant families were Fabaceae (69 taxa) and Poaceae (33 taxa), while the most species rich genera were *Acacia* (34 taxa) and *Senna* (17 taxa); 16 families and 66 genera were represented by a single taxon. Two taxa were identified to family level only and another four to genus level.

[1] The Western Australian Herbarium has adopted a new plant family arrangement with reassignment of plant families and genera. Revision of the currency of the species names of the taxon recorded identified several changes. Adopting these changes for the Ecologia (2009) species list, there were 196 taxa recorded from 32 families and 89 genera.

[2] The Western Australian Herbarium has adopted a new plant family arrangement with reassignment of plant families and genera. Revision of the currency of the species names of the taxon recorded identified several changes. Adopting these changes for the Ecologia (2007) species list the recorded 289 taxa now comprise 37 families and 115 genera.

1.2.4 Threatened and Priority Flora, Threatened and Priority Ecological Communities, and Potentially Significant Taxon and Communities

The Department of Environment and Conservation define conservation codes for Western Australia (http://florabase.calm.wa.gov.au/conservationtaxa). Threatened Flora, Declared Rare Flora – Extant (T) are defined as taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1) under the Wildlife Conservation Act 1950 (**Appendix A**).

Priority flora are taxa under consideration for declaration as Threatened but require further surveys or monitoring (**Appendix A**). Priorities 1, 2 or 3 are taxa not adequately surveyed to be listed under Schedule 1 or 2 and are ranked in order of priority for survey and evaluation of conservation status. Priority 4 are taxa that are adequately known, are rare but not threatened, or meet criteria for Near Threatened, or that have been recently removed from the threatened list for other than taxonomic reasons. Conservation Dependent species are Priority 5.

At the time of compiling this report Florabase (2011) listed a combined 61 T and priority flora for the Gascoyne bioregion. The list contains two T; *Pityrodia augustensis* (Lamiaceae) and *Thryptomene wittweri* (Myrtaceae) (**Appendix B**). The remaining species comprise sixteen P1, six P2, thirty three P3 and four P4 species.

Pityrodia augustensis has been listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The species has been recorded in the Ashburton sub-region (ANRA 2010). Naturemap (2011) lists 24 records for the species the closest of which lies several hundred kilometres from the FPP survey area

Thryptomene wittweri is also listed as vulnerable but has not been recorded for the Ashburton sub-region. Naturemap (2011) lists 14 records for the species the closest of which lies approximately 150 km from the FPP.

Van Vreeswyk *et al* (2004) recorded seven priority flora in site types that may potentially occur in the survey areas (**Table 6**)

Table 6: Priority species recorded by Van Vreeswyk *et al* (2004) in vegetation communities that may occur in the survey areas.

Species	Priority Code	Site type
Acacia aphanoclada	P1	HSPG
Bulbostylis burbidgeae	P4	HSPG, PHSG, PSSG, SHSG, SSSG, AHSG, DAHW
Eremophila pilosa	P1	PSSG
Eremophila spongiocarpa	P1	PXHS
Josephinia sp Marandoo	P1	PAGS
Sida sp Barlee Range	P3	HSPG
Tephrosia bidwillii	P3	DEAW

Guidance Statement 51 (EPA 2004) states that for environmental impact assessments significant flora should be considered at all scales with advice sought on significant flora in the study area and appropriate region. A comprehensive listing of all taxa should be provided.

Searches of the Department of Environment and Conservation (DEC) databases including Threatened (DRF), Threatened Ecological Communities (TEC) and the Western Australian Herbarium identified a single T (*Lepidium catapycnon*), four P1 flora (*Acacia levata*, *Eremophila pilosa*, *Goodenia lyrata*, *Isotropis winneckei*), five P2 flora (*Gonocarpus ephemerus*, *Goodenia hartiana*, *Olearia fluvialis*, *Rhodanthe frenchii*, *Spartothamnella puberula*), three P3 flora (*Goodenia nuda*, *Gymnanthera cunninghamii*, *Tephrosia* sp. Cathedral Gorge) and one P4 flora (*Eremophila magnifica* subsp. *magnifica*) that could potentially occur in the survey areas (Ecologia 2009). Database searches by Ecologia (2007) indicate a further two P3 species (*Eremophila magnifica* subsp. *velutina* and *Goodenia* sp. East Pilbara) may also be present.

Surveys by Ecologia (2009) recorded no T or priority flora at the FPP. Ecologia (2007) recorded three priority flora; *Brachyscome* sp. Wanna Munna Flats (P1), *Gompholobium karijini* (P2) and *Vittadinia pustulata* (P2). *Brachyscome* sp. Wanna Munna Flats was recorded in riparian vegetation, unit 3a (Ecologia 2007). *Vittadinia pustulata* was recorded on a red sand plain, vegetation unit 1b. *Gompholobium karijini* was included in the species list for the Ecologia (2007) survey but there was no record of the species in the quadrat data, the species was presumably observed outside of the quadrat surveys and hence no location for the species was provided. The survey area of Ecologia (2007) extended beyond the present FPP area. It is possible that *Gompholobium karijini* was observed in this extended area and does not occur within the present FPP survey area.

Selected plant communities are listed as "Threatened Ecological Communities" (TECs) under the EPBC Act and are classed as critically endangered, endangered and vulnerable. No plant communities from the Gascoyne bioregion are listed under the EPBC act as a TEC.

In Western Australia, the DEC describes four categories of TECs (**Appendix A**). None of the DEC listed TECs occur in the Gascoyne bioregion (ANRA 2010).

In Western Australia, the DEC also describes five categories of Priority Ecological Communities (PEC's) that are possible threatened ecological communities (**Appendix A**). No flora PEC from the most recent listings available from the DEC website (dated 6th December 2010) occurs within the close proximity of the FPP.

Plant taxon may be considered locally or regionally significant for numerous reasons (EPA 2004) including:

- a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;
- relic status;
- being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range;

- the presence of restricted subspecies, varieties or naturally occurring hybrids;
- local endemism/a restricted distribution; and
- being poorly reserved.

Plant communities or assemblages may also be considered locally or regionally significant for numerous reasons (EPA 2004) including:

- scarcity;
- unusual species;
- novel combinations of species;
- a role as a refuge;
- a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;
- being representative of the range of a unit (particularly, a good local and/or regional example of a unit in "prime" habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range; and
- a restricted distribution.

Ecologia (2007, 2009) did not identify any TECs, or consider any of the vegetation communities within their study areas at FPP to be potentially regionally or locally significant.

1.2.5 Weeds and Declared Plant Species

Florabase (2011) listed 40 weed species recorded in the Gascoyne bioregion (**Appendix C**). None of the species are a Declared Plant for the Shire of East Pilbara under the *Agriculture and Related Resources Protection Act 1976*. Five species; *Argemone ochroleuca*, *Argemone ochroleuca* subsp. *ochroleuca*, *Datura leichhardtii*, *Emex australis* and *Heliotropium europaeum* are Declared Plants for other regions of Western Australia.

Ecologia (2009) recorded one weed species at the FPP *Portulaca oleracea*. The species is not a Declared Plant and has a broad distribution across Western Australia including the Gascoyne bioregion (NatureMap 2011).

Ecologia (2007) recorded four weed species, *Bidens bipinnata*, *Cenchrus ciliaris*, *Chloris virgata* and *Malvastrum americanum.* None of the species are a Declared Plant and all have broad distributions across the Gascoyne and Pilbara bioregions (NatureMap 2011).

2.0 METHODS

2.1 BACKGROUND RESEARCH

Two reports documenting previous vegetation surveys at FPP (Ecologia 2007 and 2009) were reviewed along with other flora surveys from the Pilbara bioregion (e.g. Van Vreeswyk *et al.*2004) to provide background information on the existing vegetation assemblages within FPP.

Searches of the Department of Environment and Conservation (DEC) databases including Threatened (DRF), Threatened Ecological Communities (TEC's), Priority Ecological Communities (PEC's) and the Western Australian Herbarium were conducted to identify potential significant flora and communities and determine the local and regional significance of vegetation communities identified in the current survey. The EPBC search tool was also used to determine national scale TEC listed under the EPBC Act.

The conservation status, brief description, habitat preference, flowering season and images (where available) of T and Priority Flora, either recorded at the FPP in previous surveys, or identified as potentially occurring within the FPP from database searches were compiled utilising FloraBase (2011). A hard copy of the information was printed as a 'field guide' for T and Priority flora.

2.2 RECONNAISSANCE

A detailed survey that involved multiple site visits in differing seasons (including one in the main flowering season), replication of survey plots in vegetation types and greater coverage and displacement of plots over the target area was conducted. Field surveys were conducted by Dr Grace Wells and Dr Grant Wells from G&G Environmental (**Table 7**).

Table 7: Field survey schedule.

Number of Field Days	Dates
6	6-11th April 2010
8	1st-8th October 2010
8	11th-18th March 2011

Quadrat-based sampling of vegetation was undertaken in areas selected in accordance with the methods applied previously to map flora and vegetation in the Pilbara bioregion (Biota 2004, Outback Ecology 2006, Ecologia 2007, 2009, G&G Environmental 2006, 2007a, b, 2008, 2009a, b). During the initial survey sites were chosen on the basis of topography, interpretation and ground truthing of Google Earth images, previously mapped vegetation types, and field observations of vegetation structure, floristics and condition. The sites chosen for the consecutive surveys were based on the vegetation mapping carried out following the first phase of the survey. In addition, surveys were conducted where changes in the vegetation were identified during the on ground survey.

Sampling of the vegetation was conducted in 50 m x 50 m quadrats that included cover values of all present species, description of topography, vegetation based on NVIS (2003) and condition scale of

Keighery (1994) (**Table 8)**. In accordance with EPA (2004), where possible, quadrat surveys were conducted in at least two different locations within each of the vegetation types.

Table 8: Data recorded in quadrat surveys.

Data	Details
Location	The coordinates of the quadrat were recorded in GDA 94 projection utilising a hand-held Garmin GPS.
Vegetation Description	A broad description utilising the structural formation and height classes based on NVIS (2003) (**Appendix D**). The vegetation was described to association level (**Appendix E**) with the dominant growth form, height and cover of species from the traditional three strata, upper, mid and ground, recorded. The vegetation was also compared to the descriptions of Ecologia 2007, 2009). When the dominant species in each stratum matched a description the vegetation code from the prior survey was recorded in the data set.
Landform	A brief description of landform, eg. creek, undulating plain, hill slope.
Soil Type	A broad description of surface soil type and rocks, eg. red sand with ironstone.
Disturbance History	A brief description of any observed disturbance including a visual estimate of time since last fire, weed invasions, soil disturbance and animal grazing.
Vegetation Condition	A condition rating for the vegetation was assigned utilising the condition scale of Keighery (1994).
Species List	The name of every species present in the quadrat. Where species were located that were unknown to the staff conducting the survey, a specimen was collected and pressed for later identification. All such specimens were later identified utilising Florabase (2011), and by comparison to specimens at the WA state reference herbarium. Plants were named according to the nomenclature of Florabase (2011), DEC (http://florabase.calm.wa.gov.au).
Foliage Cover	A visual estimate of the canopy cover of each species present was recorded as was the total vegetation cover, cover of shrubs and trees >2m tall, cover of shrubs <2m, total grass cover and total herb cover
Photograph	A digital colour photograph of the vegetation within each quadrat

Targeted searches for T and priority flora were conducted in and around quadrat survey locations, where landform and vegetation resembled the brief habitat description for the species in the compiled field guide and at locations within the survey area where they were recorded either by Ecologia (2007) or identified from the search of the various databases.

2.3 VEGETATION TYPE DEFINITION, MAPPING AND FLORA ASSESSMENT

To aid definition of vegetation type, statistical ordination tests were conducted using UPGMA Cluster Analysis (PATN™). The quadrats were grouped by topographical feature, including sandy plains, rocky plains, undulating plains, groves, depressions and creeks (by giving a constant value to each of the topographical features within the PATN™ tests). Vegetation types were further defined from the clusters of quadrats on a dendogram based on species composition and cover values.

The resulting grouping of survey quadrats in the dendogram generated by PATN for the current survey did not always validate the visual descriptions of sites noted during the reconnaissance. Ecologia (2009) incurred a similar situation where grouping in the dendogram conflicted with field notes.

Often one or two dominant species can influence the visual interpretation of an area. Thus, not all vegetation communities visible at ground level and and/or grouped by the multivariate analysis could be reliably discriminated. Where ordination tests deviated from field descriptions, the final assignment of units was based on field observations of the experienced botanists (in excess of 15 years), Dr Grant Wells and Dr Grace Wells largely influenced by structure and species composition of the dominant strata. This is in accordance to the approach of the earlier survey (Ecologia 2009).

To further define vegetation at the FPP, the description, species composition, individual species cover values and photographs of each of the types defined in the current survey were compared to the descriptions, species composition, individual species cover values and photographs of vegetation types of the initial surveys conducted at the FPP (Ecologia 2007, 2009). Where the dominant species (highest cover values for each of the canopy levels) of vegetation types defined for the current survey and Ecologia (2009) were congruent with those of Ecologia (2007), and numerous other species were also common to both, the vegetation was named in accordance with the initial survey. This was conducted to facilitate a consolidated vegetation map for the entire FPP area. However, the consolidation of the vegetation associations recorded in the three separate surveys resulted in a broadening of the overall description to that of the sub-formation hierarchy of NVIS (refer **Appendix E**)

The defined vegetation sub-formations were mapped utilising Map Info Professional version 8.5 by plotting boundaries visible on aerial photos, contour lines and changes in the vegetation recorded on GPS during the survey.

The broad description of the vegetation sub-formations defined for FPP were compared to the description of the major vegetation groups of NLWRA (2001), the mapped vegetation of Beard (1975) and regional site types recorded for the landsystems of the area of Van Vreeswyk *et al.* (2004) to provide an indication of the potential local and regional conservation significance of the vegetation in the survey areas. Where landform and the broad vegetation description were congruent and numerous of the species recorded were common a sub-formationof the current survey was considered to resemble the broader site type of Van Vreeswyk *et al* (2004). The conservation status of the site type was then ascertained from Van Vreeswyk *et al* (2004) to provide an indication of whether the sub-formation defined for the current survey resembled a broadly distributed or restricted site type and whether the site type is represented in conservation reserves or unallocated crown land (UCL).

A species list for the current survey was compiled from the survey quadrat data and opportunistic collections while traversing the area (to target species that occur within the survey area but outside the quadrats surveyed). This list was combined with previous surveys at FPP (Ecologia 2007, 2009) to provide a comprehensive species list for the project area.

The current conservation status of each of the species in the combined list was determined from Florabase (2011). The mapped range of each species was consulted on NatureMap (2011) and Florabase (2011) to determine whether the survey areas represented a range extension for any of the recorded species.

2.4 DISTURBANCE IMPACT ASSESSMENT

FerrAus Ltd provided GIS files of the proposed disturbance footprint at the FPP. The area (km^2) of each of the land systems of Van Vreeswyk *et al* (2004) that occurr within the FPP footprint was determined utilising MapInfo 8.5. This value was then used to ascertain the proportion of each of the land system that may be disturbed by mining processes at the FPP. In a similar fashion, the proportion of each of the vegetation types defined for the FPP that may be impacted by the footprint was determined.

The occurrence of flora and vegetation of either listed conservation significance (EPBC or DEC listed) or potentially locally or regionally significant taxa or vegetation within the disturbance footprint was also examined.

2.5 LIMITATIONS OF THE SURVEY

EPA (2004) includes a list of potential limitations of terrestrial flora and vegetation surveys, each of which is addressed for the current survey (**Table 9**).

Table 9: 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	The land systems and vegetation of the survey area have been mapped by Van Vreeswyk *et al*.(2004) and two prior flora and vegetation surveys undertaken for the FerrAus Pilbara Project were available (Ecologia 2007, 2009).
The scope (i.e. what life forms, etc., were sampled)	No	The scope of the survey was prepared in accordance to EPA (2004) and to that of previous surveys conducted for public environmental reviews and environmental impact assessments in the Pilbara (Biota 2004, Outback Ecology 2006, Ecologia 2007, 2009, G&G Environmental 2006, 2007a, b, 2008, 2009a, b).
Proportion of flora collected and identified (based on sampling, timing and intensity)	No	The combined surveys for the FPP have identified at total of 484 taxa from 48 families and 166 genera from 151 quadrat surveys in an area of ~160 km^2. These figures compare favourably with other surveys conducted in the Pilbara bioregion. Of the taxa recorded 161 (`33.3%) were annual species indicating surveys were conducted at appropriate times.
Completeness and further work which might be needed (e.g. was the relevant area fully surveyed)	No	Survey areas were carefully selected utilising existing vegetation maps and aerial photo's to ensure all apparent different vegetation types were sampled. It is considered that the combined Ecologia (2007, 2009) quadrats and quadrats of the current survey have adequately sampled the vegetation at FPP.
Mapping reliability	No	As with all surveys of this nature the map of vegetation was extrapolated utilising aerial photos and some inaccuracies in the depiction of the vegetation boundaries may be expected to occur. However, given the intensity of the ground survey, marking of vegetation boundaries by GPS and the effort expended outlining vegetation boundaries visible from aerial photo's it is considered that the vegetation maps have been prepared to a satisfactory level of accuracy.
Timing, weather, season, cycle	No	Rainfall prior to the initial survey in April 2010 was well below average and as a consequence few annual species were recorded. However, rainfall prior to the final two surveys in October 2010 and March 2011 were well above average and over this period a high number of annual species (161) were recorded. In March 2011 quadrat surveys were conducted at the majority of sites surveyed in 2010 to record annual species and confirm the

		identity of perennial grasses which had abundant inflorescences.
Disturbances (fire, flood, accidental human intervention etc.)	No	The survey area occurs on an active pastoral lease and some areas have been impacted (e.g. access tracks, fence lines, wells). However, the majority of the survey area appeared in excellent to pristine condition. The majority of the survey area had not been burnt for an estimated 5-10 years. A few areas had been burnt more recently, estimated 1-2 years, and diversity in these areas due to a flush of ephemeral species was frequently higher than more mature stands of the same vegetation type. It is considered that disturbance in the survey area did not limit the survey; on the contrary, it assisted in identifying the plant diversity of the area.
Intensity (in retrospect, was the intensity adequate)	No	A total of six surveys over six different seasons have been conducted at the FPP. A total of 151 quadrats were surveyed for an area of ~160 Km^2, this sampling intensity is high in comparison to previous flora surveys in the Pilbara bioregion.
Resources	No	It is considered that the resources for the current survey were satisfactory given the quality and amount of background material available, intensive use of botanical databases and the period and intensity of the field survey by highly qualified and experienced personnel.
Access problems	No	The survey areas were large and, as such, the entirety of the areas was not traversed. While vehicle access to some sections was unavailable this was overcome by undertaking long treks by foot.
Experience levels (e.g. degree of expertise in plant identification to taxon)	No	All work, including background, reconnaissance, data analysis and report preparation has been conducted by Dr Grace Wells and Dr Grant Wells of G&G Environmental Pty Ltd. These personnel share in excess of 25 years experience undertaking botanical surveys and research of the Western Australia flora. Where plant taxa are unknown specimens are collected for identification utilising the combined resources of the Florabase and NatureMap databases, taxonomical texts and through comparison to specimens at the state herbarium. Any taxa not identified by this process are lodged with the herbarium Collections Manager to be identified by taxonomic specialists.

3.0 RESULTS

3.1 VEGETATION

3.1.1 Overview

In total 151 quadrat surveys were conducted at the FPP: Eighteen quadrats were established by Ecologia in 2007; an additional 40 in its 2009 study and a further 93 quadrats were established by G & G Environmental over three field surveys. During April 2010 G&G Environmental surveyed 41 quadrats. A further 40 quadrats were surveyed in October 2010 and repeat observations (restricted to recording the presence of annual species and, where required, the collection of reproducing specimens to confirm prior species identification) were conducted at 17 quadrats. In March 2011, 80 quadrats were surveyed with repeat observations conducted at 41 quadrats to record annuals species present following above average rainfall and to collect flowering grass specimens to finalise identification of the species.

From the current survey, vegetation at the FPP was classified into 19 sub-formations that occur on six broad landforms (**Figure 5**, **Table 10)**. Eight of these sub-formations did not closely resemble those recorded in the survey areas of Ecologia (2007, 2009) and were regarded as previously undescribed vegetation in the expanded FPP survey area. Vegetation sub-formation 7 (**Table 10**) defined and mapped by Ecologia (2007) occurred at only one location at the FPP (**Figure 5**) and was absent from the expanded area of the current survey. The remaining ten sub-formations defined by the current study were regarded similar to previously defined vegetation (Ecologia 2007) and were thereby assigned the same vegetation code.

3.1.2 Comparison with previous botanical studies

The majority of the vegetation sub-formations defined for the FPP fit the broad descriptions of two of the nationally recognised major vegetation groups, *Acacia* shrublands and hummock grasslands both of which cover extensive areas of the Gascoyne bioregion. Another major vegetation group, *Acacia* open woodlands resemble the vegetation found in groves and drainage areas at the FPP. In addition, another major vegetation group, Eucalyptus *camaldulensis* woodland is present at the FPP as riparian vegetation of large creeks. *Eucalyptus camaldulensis* woodlands are the most geographically widespread of all the woodlands as they occur along the majority of inland waterways in Australia (NLWRA 2001).

Regionally the vegetation sub-formations at the FPP resemble three of the vegetation communities mapped by Beard (1975), namely, a_1Lp - mulga trees in groves or patches; a_nSr.tHi - scattered shrubs over spinifex; and $e_{25}Srt_2$Hi - *Eucalyptus gamophylla* over spinifex. Large areas of the mulga community occur throughout the Gascoyne bioregion and extend up through the Fortescue valley in the Pilbara bioregion. Similarly, large areas of the *Eucalyptus gamophylla* community extend through the

Fortescue valley and the eastern Gascoyne. The scattered shrubs over spinifex are restricted to the north-east of the Gascoyne bioregion but cover an extensive area of the Little Sandy Desert.

Each of the vegetation sub-formations defined for the FPP (**Table 11**) also resembled the regional site types defined by Van Vreeswyk *et al.* (2004) even though some of the vegetation sub-formations did not closely resemble units defined by Ecologia (2007. 2009) The vegetation sub-formation 1f of the current survey that occurred on flat loamy plains resemble the PMSS site type described as widespread on stony plains, loamy plains and hardpan plains and is well represented in conservation reserves including Karijini National Park and also occurs on Unallocated Crown Land (UCL). Vegetation sub-formation 5a of the current survey recorded on flat loamy plains was similar to the widespread DEAW site type of Van Vreeswyk *et al.* (2004). DEAW was recorded in loamy soils on large flat drainage tracts, is represented in national parks and is common on UCL.

Similarly, the vegetation sub-formations 2a and 2b recorded in the current survey on rocky plains differed to the units previously described by Ecologia (2007, 2009) but did resemble the HSPG site type of Van Vreeswyk *et al.* (2004). HSPG was recorded on hills, ridges and footslopes and is represented in conservation reserves including Karijin National Park and Meentheena pastoral lease and occurs extensively on UCL. Vegetation sub-formation 4a was most closely aligned with sub-formation 4 of Ecologia (2007) but with a notably denser tree canopy. The vegetation is similar to the widespread DAHW site type of van Vreeswyk *et al* (2004) that occurs on narrow drainage floors and occasionally as groves on washplains and is well represented in conservation reserves including Karijini National Park and Meentheena pastoral lease and is common on UCL. Vegetation sub-formation 4b recorded in groves resemble the GMUW site type of Van Vreeswyk *et al.* (2004) recorded on hardpan washplains as bands of dense vegetation separated by inter-grove plains supporting much sparser vegetation. GMUW is represented at Karijini National Park and was recorded at a few locations on UCL. Van Vreeswyk *et al* (2004) note that this site type is important habitat for both native animals and is favoured by domestic stock and will degrade if overland sheet flow to the grove is disrupted.

Vegetation sub-formation 8 of the current survey recorded in a red loam soil on an undulating plain was similar to the PMSS site type of Van Vreeswyk *et al.* (2004) recorded on stony, loamy, gravelly and hardpan plains and is well represented in conservation reserves including Karijini National Park and also occurs on UCL.

Vegetation sub-formation 7 was only recorded by Ecologia (2007) on the mid-slope of a rocky hill and resembles the HSPG site type of Van Vreeswyk *et al.* (2004) that is widely distributed on hillslopes, ridges and plateaux's throughout the Pilbara. HSPG occurs at the Karijini and Millstream-Chichester National Parks and extensively on UCL.

The majority of vegetation sub-formations (**Table 11**) were recorded by the current survey (G&G Environmental) and Ecologia (2007, 2009). The 1a vegetation sub-formation was recorded on red sandplain and resembles the SSSG and SHSG site types of Van Vreeswyk *et al.* (2004) both of which

were described as common and widespread on red sandplain and are important habitat for a wide range of fauna dependent on *Triodia* grasses for food or shelter. SHSG occurs at the Rudall River National Park and extensively on UCL. SSSG occurs at the Cane River Nature Reserve and has been recorded on UCL. Large patches of the 1a sub-formation had been burnt in recent years and at the time of monitoring numerous short-lived; fire ephemeral shrubs formed a low regrowth shrubland Over the course of a few seasons (in the absence of further fire) these areas are expected to mature to resemble the 1a sub-formation. Vegetation sub-formation 1b was recorded by G&G Environmental and Ecologia (2007) on red sandplain and resembled the widespread PSSG site type of Van Vreeswyk *et al*. (2004). PSSG occurs extensively on stony, loamy and gritty plains is common on UCL and occurs in nature reserves including Karijini and Millstream-Chichester National Parks, Cane River Nature Reserve and Meentheena pastoral lease.

Vegetation sub-formation 1c was recorded by G&G Environmental and Ecologia (2007, 2009) on red sand plain and is synonymous with the $e_{25}Srt_2Hi$ - *Eucalyptus gamophylla* over spinifex community mapped by Beard (1975) and the SHSG site type (Van Vreeswyk *et al.* 2004) that is common on sandplain, gravelly sandplain and dunes and occurs at Rudall River National Park and extensively on UCL.

Vegetation sub-formation 1e was recorded by G&G Environmental and Ecologia (2007) in groves and along creeklines and was similar to the widespread GMGW site type of Van Vreeswyk *et al.* (2004) recorded on wash plains and drainage tracts. GMGW is favoured by domestic stock and is important habitat for native fauna; it has been recorded at Karijini National Park and occurs on UCL.

Vegetation sub-formation 2 was recorded by G&G Environmental and Ecologia (2009) on rocky plains and resembles the PAGS and SAES site types of Van Vreeswyk *et al*. (2004) which were common on stony plains, low rises, hardpan plains, gravelly plains and occasionally hillslopes. The PAGS site type is not represented in conservation reserves and poorly in UCL. SAES is poorly represented in nature reserves of the Pilbara but is widespread in the Eremaea zone and is represented in the Wanjarri Nature Reserve.

Vegetation sub-formation 3a was riparian vegetation recorded on the banks of large creeks at FPP by G&G Environmental and Ecologia (2007) and closely resembles the GMEW site type of Van Vreeswyk *et al.* (2004) recorded on the banks of rivers. GMEW is well represented on UCL and occurs at the Karijini and Millstream-Chichester National Parks.

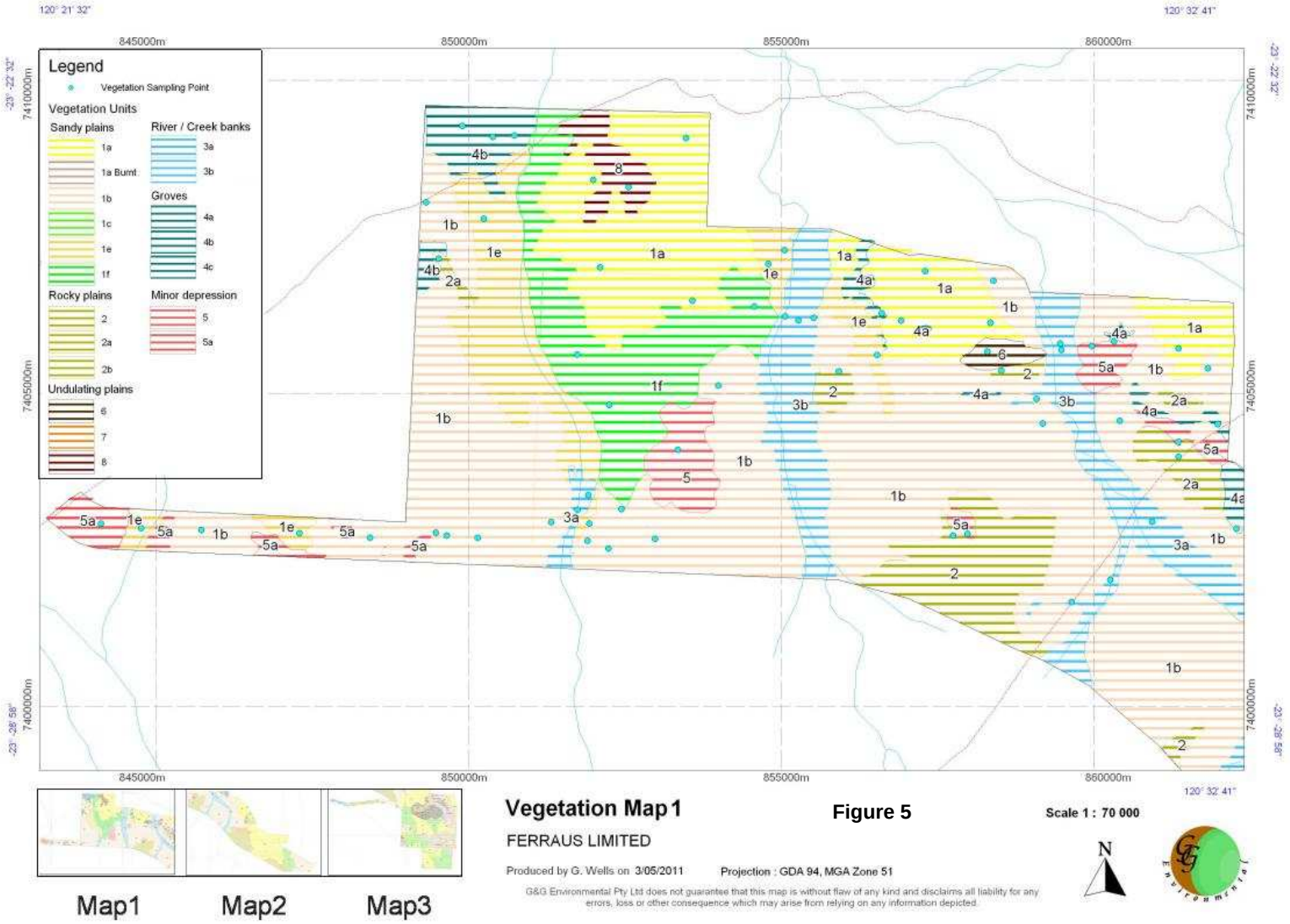
Vegetation sub-formation 3b recorded by G&G Environmental and Ecologia 2007 in riparian vegetation of large creeks also resembled the GMEW site type of Van Vreeswyk *et al.* (2004).

Vegetation sub-formation 4c recorded by G&G Environmental and Ecologia (2009) along drainage lines in foothills resembles vegetation PHSG of Van Vreeswyk *et al.* (2004) recorded on rocky plains, footslopes and low stony rises. PHSG was the most common site type in the Van Vreeswyk *et al.* (2004) survey area and occurs extensively on UCL and is well represented in conservation reserves

including Karijini and Millstream-Chichester National Parks, Cane River Nature Reserve and the Meentheena pastoral lease.

Vegetation sub-formation 5 recorded by G&G Environmental and Ecologia (2007) in minor depressions in flat plains resembled the AHSG site type of Van Vreeswyk *et al.* (2004) recorded over a wide area on alluvial plains and is represented on UCL, the Cane River Nature Reserve and Meentheena pastoral lease.

Vegetation sub-formation 6 recorded by G&G Environmental and Ecologia (2007) on hillslopes and undulating plains resembles the HESG site type of Van Vreeswyk *et al*. (2004) common on hillslopes, footslopes and low rises. HESG occurs at the Karijini and Millstream-Chichester National Parks and is common on UCL.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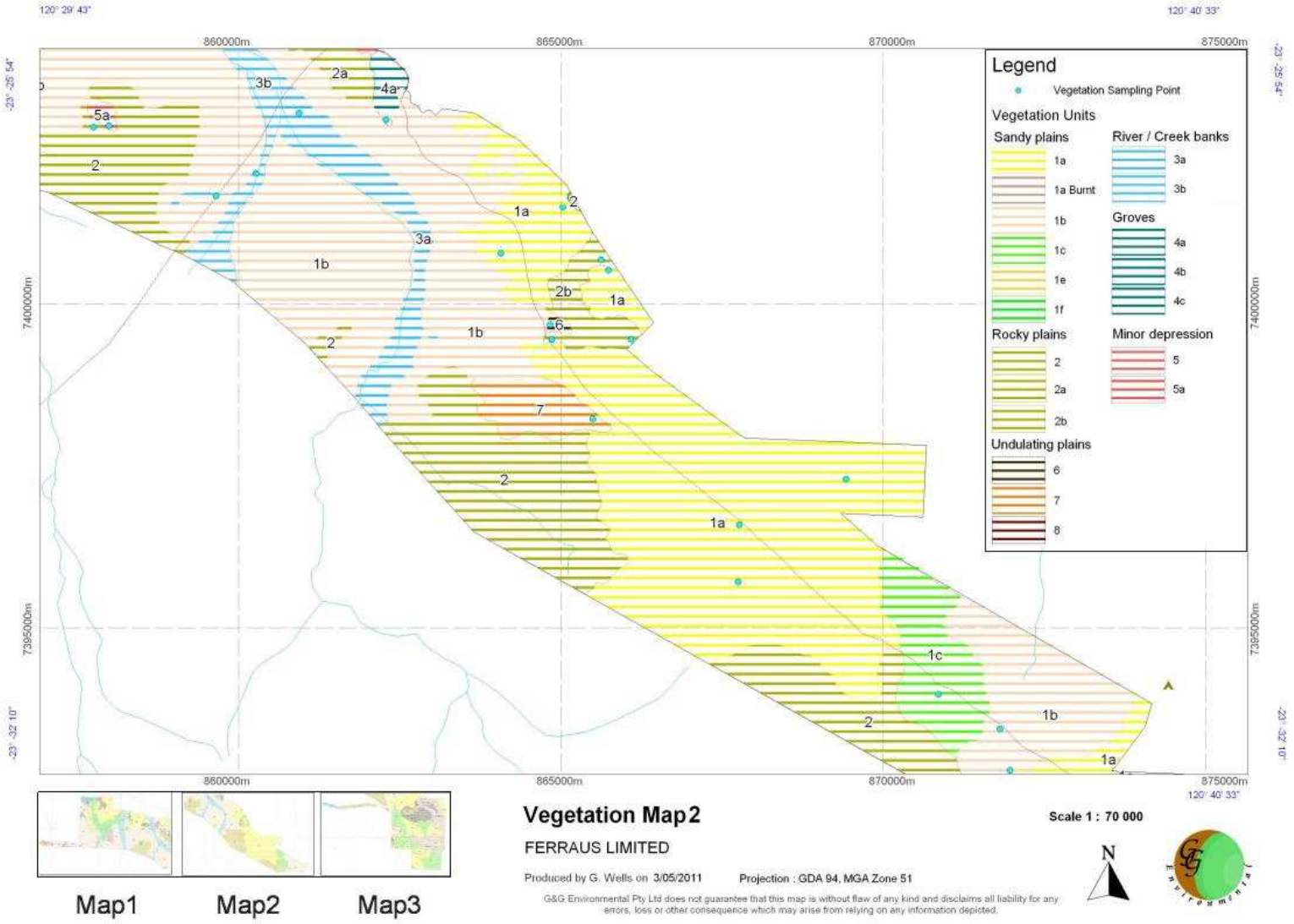
850000m
855000m
860000m
7410000m
7405000m
7400000m
-23° 22' 32"
-23° 28' 58"
Legend
Vegetation Sampling Point
Vegetation Units
Sandy plains
1a
1a Burnt
1b
1c
1e
1f
River / Creek banks
3a
3b
Groves
4a
4b
4c
Rocky plains
2
2a
2b
Minor depression
5
5a
Undulating plains
6
7
8
Map1
Map2
Map3
Vegetation Map 1
FERRAUS LIMITED
Produced by G. Wells on 3/05/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
Scale 1 : 70 000
N

Figure 5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120° 40' 33"
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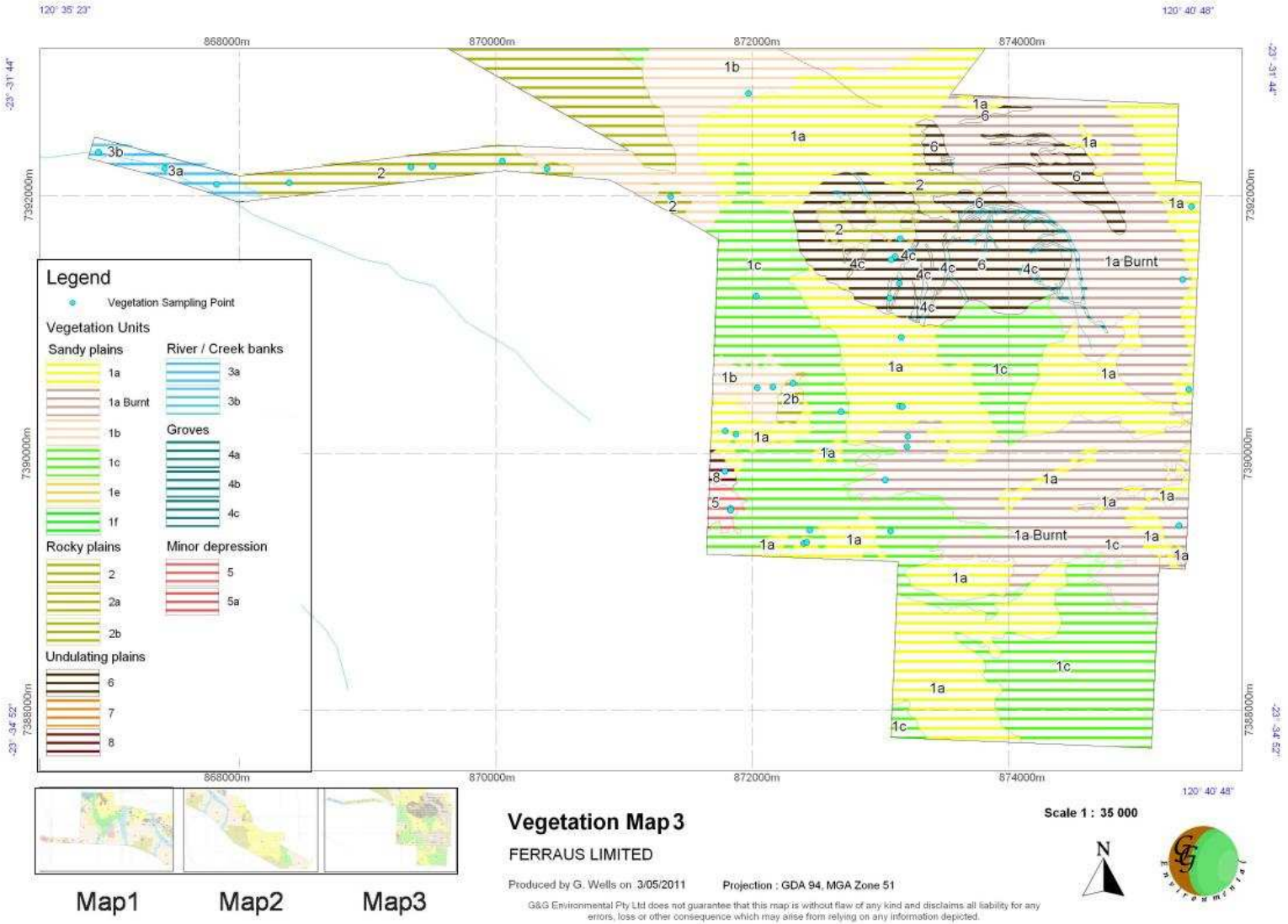
870000m
875000m
7400000m
7395000m
-23° -25' 54"
-23° -32' 10"
Legend
Vegetation Sampling Point
Vegetation Units
Sandy plains
1a
1a Burnt
1b
1c
1e
1f
River / Creek banks
3a
3b
Groves
4a
4b
4c
Rocky plains
2
2a
2b
Minor depression
5
5a
Undulating plains
6
7
8
Map1
Map2
Map3
Vegetation Map2
FERRAUS LIMITED
Scale 1 : 70 000
Produced by G. Wells on 3/05/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
N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120° 40' 48"
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870000m
872000m
874000m
-23° 31' 44"
-23° 34' 52"
7392000m
7390000m
7388000m
Legend
Vegetation Sampling Point
Vegetation Units
Sandy plains
1a
1a Burnt
1b
1c
1e
1f
River / Creek banks
3a
3b
Groves
4a
4b
4c
Rocky plains
2
2a
2b
Minor depression
5
5a
Undulating plains
6
7
8
1a Burnt
Map1
Map2
Map3
Vegetation Map 3
FERRAUS LIMITED
Produced by G. Wells on 3/05/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
Scale 1 : 35 000
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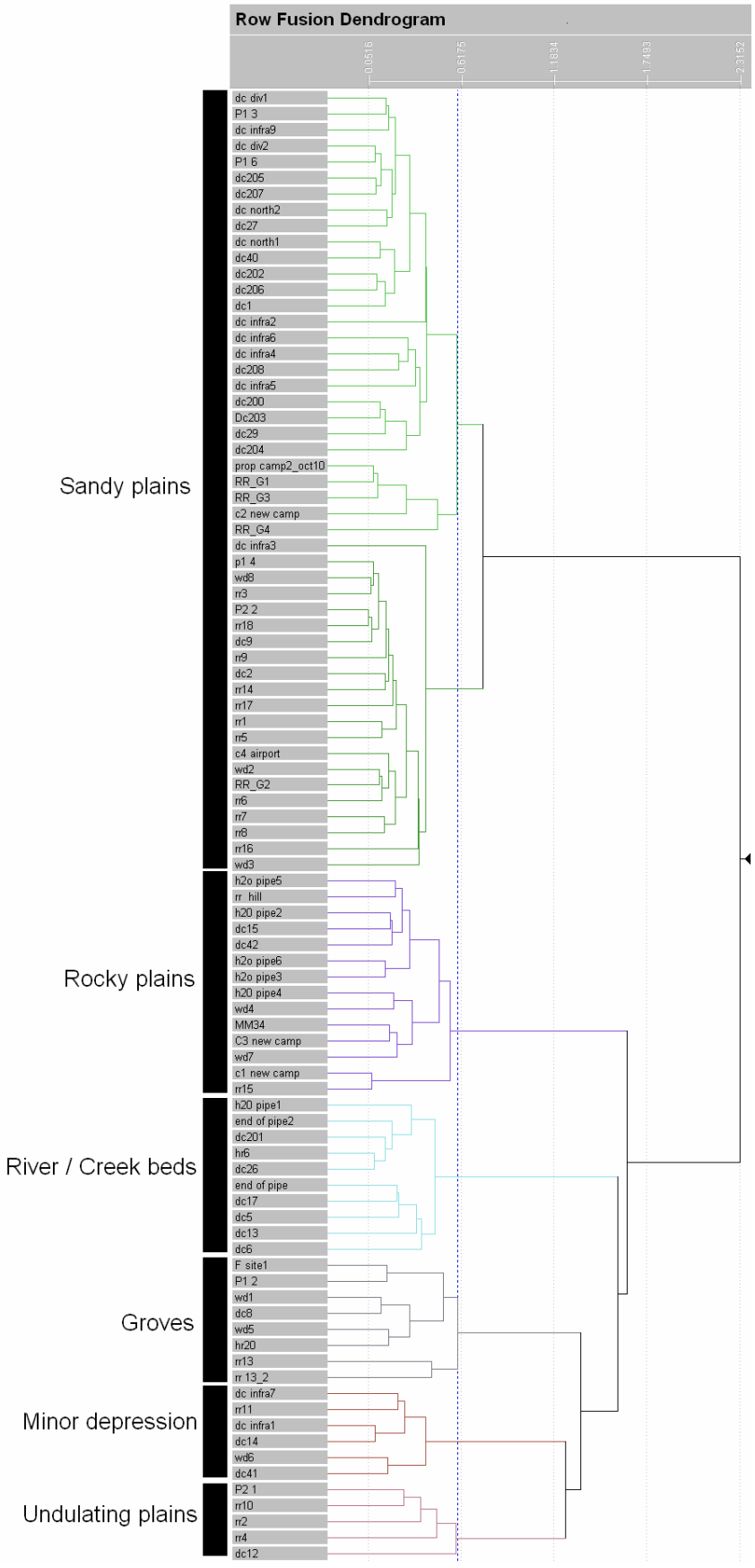


Figure 6: Dendogram of quadrat survey sites for the current survey of the FPP.

Table 10: Vegetation sub-formations recorded during surveys and examples of sites where units were described.

Vegetation Description	Frequently Recorded Species	Photograph
Flat Sand Plains		
1a: Mixed *Acacia, Corymbia* and *Hakea* species scattered low trees or shrubs, over low to mid isolated shrubs to open shrubland over mid *Triodia basedowii* hummock grassland.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura*, *Corymbia hamersleyana*, *Hakea chordophylla* and *H. lorea* subsp. *lorea* Mid Shrubs – *Acacia ancistrocarpa*, *A. dictyophleba*, *A. ligulata*, *A. tenuissima*, *A. trudgeniana* Low Shrubs – *Bonamia rosea*, *Halgania solanacea*, *Kennedia prorepens*, *Keraudrenia velutina* and *Leptosema chambersii* Grasses – *Triodia basedowii*, *T. schinzii* and *Paraneurachne muelleri*	
1a burnt: Isolated tall *Acacia* and *Hakea* species shrubs over a low mixed species shrubland in open low *Triodia basedowii* hummock grassland.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura*, *Hakea chordophylla* and *H. lorea* subsp. *lorea* Mid Shrubs – *A. dictyophleba*, *A. trudgeniana* Low Shrubs –*Halgania solanacea*, *Keraudrenia velutina*, *Leptosema chambersii* and *Rulingia loxophylla* Grasses – *Triodia basedowii* and *T. schinzii.*	

1b: Isolated low trees to open low *Acacia aneura* woodland over isolated shrubs to open *Acacia, Eremophila* and *Senna* species low to mid shrubland over low to mid mixed grassland.	Trees/Tall Shrubs – *Acacia aneura* varieties, *A. distans, A. pruinocarpa, Hakea chordophylla* and *H. lorea* subsp. *lorea* Mid Shrubs – *Acacia sclerosperma, A. tenuissima, Eremophila fraseri, E. forrestii, Senna artemisioides* subsp. *helmsii* and *Senna glaucifolia* Low Shrubs –*Halgania solanacea, Solanum lasiophyllum* Grasses – *Aristida inaequiglumis, Cymbopogon obtectus, Eulalia aurea, Paraneurachne muelleri* and *Triodia basedowii.*	
1c - *Eucalyptus gamophylla* low open mallee woodland, over isolated mid to tall *Acacia* species and *Hakea chordophylla* shrubs in a *Triodia basedowii* mid-hummock grassland.	Trees– *Eucalyptus gamophylla, Acacia pruinocarpa* Mid/Tall Shrubs - *Acacia dictyophleba, A. ligulata, A. trudgeniana, Hakea chordophylla* Low Shrubs – *Scaevola parvifolia* Grasses – *Triodia basedowii*	
1e - *Acacia aneura* low open woodland to low woodland/tall shrubland, over isolated mid *Eremophila* and *Senna* species shrubs over isolated low *Sida* species shrubs over low mixed grassland.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura, A. pruinocarpa* and *A. sibirica* Mid Shrubs –*Eremophila forrestii, E. jucunda, Senna artemisioides* subsp. *helmsii, S. glaucifolia* and *Solanum phlomoides* Low Shrubs –*Sida fibulifera, Sida platycalyx* Grasses –*Eragrostis eriopoda Eulalia aurea* and *Triodia basedowii.*	

1f - Isolated *Acacia pruinocarpa* low trees and isolated tall mixed *Acacia* shrubs in an open low *Triodia basedowii* hummock grassland	Trees –*A. pruinocarpa* Tall Shrubs –*Acacia aneura* var. *aneura, A. kempeana* and *A. tenuissima* Grasses –*Triodia basedowii.*	
Rocky Hills		
2 – Isolated low trees to open low *Acacia aneura* var. *aneura* and *A. aneura* var. *pilbarana* woodland over isolated low to mid shrubs to low to mid open mixed shrubland in isolated low mixed tussock grasses and/or *Triodia wiseana* low open hummock grassland.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura, A. aneura* var. *pilbarana* Mid Shrubs – *Eremophila forrestii, E. latrobei* subsp. *latrobei, Ptilotus obovatus, Senna glutinosa* varieties. Low Shrubs – *Eremophila jucunda, Maireana triptera* Grasses – *Aristida contorta, Enteropogon ramosus, Tragus australianus* and *Triodia wiseana*	
2a - Isolated low mixed trees over isolated low to mid shrubs to open mixed shrubland in *Triodia wiseana* low hummock grassland.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura, Grevillea berryana* Mid Shrubs – *Acacia maitlandii, A. marramamba, Eremophila latrobei* subsp. *latrobei* and *Senna glutinosa* varieties. Low Shrubs – *Eremophila exilifolia, E. jucunda* and *Keraudrenia velutina* Grasses – *Eragrostis eriopoda, Eriachne mucronata* and *Triodia wiseana*	

2b – Isolated low mixed tall shrubs over isolated clumps of *Keraudrenia velutina* shrubs in *Triodia wiseana* low hummock grassland.	Tall Shrubs – *Acacia abrupta, Grevillea wickhamii* Low Shrubs – *Keraudrenia velutina* Grasses – *Triodia wiseana*	
River / Creek Banks		
3a – Open low *Acacia aneura* woodland to open low forest with *Corymbia candida* subsp. *dipsodes* low trees over mid to tall *Eremophila* shrubs over low isolated tussock grasses to low tussock grassland.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura, Corymbia candida* subsp. *dipsodes* Mid Shrubs – *Eremophila fraseri* and *E. forrestii* Grasses – *Aristida inaequiglumis, Chrysopogon fallax* and *Cymbopogon ambiguus*	

3b – Isolated *Corymbia* and *Eucalyptus* mid trees over low *Acacia aneura* woodland over mixed isolated mid shrubs to low mixed shrubland in a low to mid mixed tussock grassland and isolated sedges.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura*, *A. paraneura*, *Corymbia candida* subsp. *dipsodes*, *C. hamersleyana* and *Eucalyptus camaldulensis* Mid Shrubs – *Acacia sibirica*, *Eremophila fraseri*, *E. forrestii*, *Senna artemisioides* subsp. *helmsii* Grasses/Sedges – *Aristida inaequiglumis*, *Chrysopogon fallax*, *Cyperus iria*, *Themeda triandra*, *Urochloa holosericea*	
Grove/Inter Groves		
4a –Low open mixed *Acacia* species woodland over isolated mixed low to mid shrubs in open *Triodia basedowii* hummock grassland.	Trees/Tall Shrubs – *Acacia aneura* var. *aneura*, *A. distans* and *A. paraneura* Low/Mid Shrubs – *Eremophila forrestii*, *E. jucunda*, *Hibiscus burtonii*, *Psydrax latifolia* and *Sida fibulifera* Grasses – *Eragrostis eriopoda*, *Triodia basedowii*	
4b –Low *Acacia aneura* woodland over isolated clumps of low *Eremophila lanceolata* shrubs in low open mixed tussock grassland	Trees/Tall Shrubs – *Acacia aneura* var. *aneura* Low/Mid Shrubs – *Eremophila lanceolata*, *Senna artemisioides* subsp. *helmsii*, *S. glaucifolia*, *Sida platycalyx* Grasses – *Aristida inaequiglumis*, *Cymbopogon obtectus*, *Eulalia aurea* and *Monachather paradoxa*	

4c –Mid *Acacia ancistrocarpa* shrubland over a low *Halgania solanacea* and *Keraudrenia velutina* shrubland in *Triodia wiseana* hummock grassland.	Tall/ Mid Shrubs – *Acacia ancistrocarpa, A. trudgeniana, Hakea lorea* Low Shrubs - *Halgania solanacea* and *Keraudrenia velutina* Grasses – *Eriachne mucronata, Triodia melvillei, T. wiseana*	
Minor Depressions		
5 – Open *Acacia distans* low woodland, over isolated mid shrubs to mixed *Acacia* species mid shrubland, over mixed low tussock and *Triodia basedowii* hummock grassland.	Trees/Tall Shrubs –*A. aneura* var. *aneura* and *Acacia distans* Low/Mid Shrubs – *Acacia dictyophleba, A. sclerosperma, A. xiphophylla Eremophila fraseri, E. forrestii* and *Senna artemisioides* subsp. *oligophylla* Grasses – *Aristida inaequiglumis, Thyridolepis xerophila* and *Triodia basedowii*	

5a – Mid to tall *Acacia ancistrocarpa* shrubland over isolated low mixed shrubs over isolated mixed tussock hummock grasses to open mixed grassland.	Trees/Tall Shrubs – *Acacia ancistrocarpa*, *A. aneura* var. *conifera* and *Corymbia hamersleyana* Low/Mid Shrubs – *Bonamia rosea*, *Hybanthus aurantiacus*, *Scaevola parvifolia*, *Senna artemisioides* subsp. *helmsii* and *Solanum centrale* Grasses – *Aristida inaequiglumis*, *Cymbopogon obtectus*, *Eragrostis eriopoda* and *Triodia basedowii*	
Undulating Plains		
6 – Isolated low to tall shrubs in a *Triodia basedowii* and *T. wiseana* hummock grassland.	Tall Shrubs – *Acacia ancistrocarpa*, *A. trudgeniana*, *Grevillea wickhamii* Low/Mid Shrubs – *Calytrix carinata*, *Ptilotus obovatus* Grasses – *Triodia basedowii* and *T. wiseana*	
7 – Isolated low *Corymbia spp*. trees over isolated mixed shrubs in a mid *Triodia basedowii* hummock grass land.	Trees – *Corymbia hamersleyana* and *C. opaca* Shrubs – *Acacia ligulata*, *A. trudgeniana* and *Hakea chordophylla* Grasses – *Triodia basedowii*, and *T. schinzii*	

8 – Low open *Acacia aneura* woodland over open low *Eremophila jucunda* shrubland in open *Triodia basedowii* hummock grassland	Trees – *Acacia aneura* var. *aneura* and *A. pruinocarpa* Shrubs – *Eremophila cuneifolia*, *E. jucunda* and *Senna artemisioides* subsp. *helmsii* Grasses – *Aristida contorta*, *Eragrostis eriopoda* and *Triodia basedowii*	

3.13Vegetation Condition

Combining the results of all of the surveys, vegetation condition at the FPP was recorded as good (2.5%), very good (0.6%), excellent (18.6%) with the majority of the vegetation considered to be in pristine condition (78.3%)/

Disturbance from over grazing/trampling of vegetation by stock, vehicle access tracks and exploration drill pads and drill lines were the primary causes of vegetation attaining an excellent rather than pristine rating. High density weed infestations reduced condition to very good and good in a few patches of riparian vegetation.

3.2 FLORA

3.2.1 Overview

A total of 343 taxa were recorded in the quadrat surveys conducted by G&G Environmental (**Appendix F**) comprised of 236 perennial taxa and 107 annual species. The identity of five species could only be identified to genus level and cannot be definitively confirmed to species level due to a lack of reproductive structures. Each of the species identified to genus level closely resemble common unthreatened species.

The 343 taxa identified to at least genus level represent 49 families and 145 genera. The most prominent families were the Fabaceae (67 taxa), Poaceae (53), Asteraceae (26) and Malvaceae (23). The Chenopodiaceae (16), Goodeniaceae (14), Amaranthaceae (14), Scrophulariaceae (13) and Convolvulaceae (11) were also well represented. The most prominent genera included *Acacia* (30), *Senna* (16), *Eremophila* (13), *Ptilotus* (11), *Sida* (9) and *Goodenia* (9).

Combining the results of the current survey with those of Ecologia (2007, 2009) a total of 484 taxa comprising 323 perennial taxa and 161 annual species have been recorded at FPP. The 484 taxa represent 49 families and 166 genera. The most prominent families were the Fabaceae (95 taxa), Poaceae (70), Malvaceae (49) and Asteraceae (33). The Chenopodiaceae (23), Goodeniaceae (22), Scrophulariaceae (19), Amaranthaceae (18), Convolvulaceae (14), Boraginaceae (13) and Myrtaceae (13) were also well represented. The most prominent genera included *Acacia* (44), *Senna* (21), *Eremophila* (19), *Sida* (18), *Goodenia* (13), *Ptilotus* (12) and *Hibiscus* (11). The dominant families recorded at FPP were also dominant in flora surveys conducted in the adjacent Pilbara bioregion (**Table 11**).

The number of taxa recorded for the FPP (**Table 12**) compares favourably with other flora surveys in the adjacent Pilbara bioregion with the number of taxa recorded per km^2 of survey area higher than prior surveys. These results reflect the large number of seasonal surveys (6) and high number of quadrats surveys (151).

Acacia aneura varieties were the most widespread trees at FPP with *A. pruinocarpa* and *Hakea lorea* subsp. *lorea* also common. Widespread mid to tall shrubs included *Acacia ancistrocarpa, A.*

dictyophleba, *A. tenuissima*, *A. tetragonophylla*, *Eremophila forrestii* subsp. *forrestii*, *E. fraseri*, *E. jucunda*, *Psydrax latifolia*, *Senna artemisioides* subsp. *helmsii* and *S. glaucifolia*. Common low shrubs included *Bonamia rosea*, *Halgania solanacea*, *Hibiscus burtonii*, *Keraudrenia velutina*, *Ptilotus obovatus*, *Scaevola parvifolia* subsp. *Pilbarae*, *Sida fibulifera*, *Sida platycalyx*, *Solanum centrale* and *Solanum lasiophyllum*. The most widely distributed perennial grasses included spinifex (*Triodia basedowii* and *Triodia schinzii*) and tussock grasses including *Aristida inaequiglumis*, *Cymbopogon obtectus*, *Eulalia aurea* and *Paraneurachne muelleri*. The annual grasses *Aristida contorta*, *Perotis rara* and *Yakirra australiensis* were widespread following seasonal rainfall. Common annual herbs included *Boerhavia coccinea*, *Bulbostylis barbata*, *Cleome viscosa*, *Dysphania kalpari*, *Evolvulus alsinoides* var. *villosicalyx*, *Fimbristylis dichotoma*, *Gomphrena kanisii*, *Goodenia triodiophila*, *Polycarpaea corymbosa*, *Ptilotus polystachyus* and *Tribulus astrocarpus*.

Table 11: Dominant families and the proportion of the total number of species recorded for flora surveys in Western Australia.

	Biota 2004	**Mattiske 2005/Biota 2004**	**FPP**
AMARANTHACEAE	39	36	18
ASTERACEAE	36	39	33
BORAGINACEAE	20	9	13
CONVOLVULACEAE	26	13	14
CHENOPODIACEAE	43	21	23
FABACEAE	165	143	95
GOODENIACEAE	26	20	22
MALVACEAE	31	77	49
MYRTACEAE	17	18	13
POACEAE	121	34	70
SCROPHULARIACEAE	11	16	18
% Species Recorded	70.2	68.8	76.3

Table 12: Comparison of floristic data from the current survey with previous flora surveys conducted in the Gascoyne and Pilbara bioregions.

Survey	**Area**	**Vegetation Types**	**Taxa**	**Families**	**Genera**
Van Vreeswyk *et al.* (2004)	~181723 km^2	44	1137	98	348
Mattiske (2005)	~250 km^2	18	234	41	106
Biota (2004)	>500 km^2	122	762	69	218
FPP	~160 km^2	19	484	49	166

3.2.2 Species Range Extensions

Utilising the combined species list from all surveys a review of the distribution of each of the recorded species on NatureMap (2011) and Florabase (2011) identified apparent range extensions for 12 species (**Table 13**).

Eremophila spuria, *Sida* sp. B Kimberley Flora (A.A. Mitchell 2745) and *Vittadinia pustulata* P2 were all recorded in a single quadrat in sub-formation 1b, *Eremophila georgei* was recorded in a different quadrat in the same vegetation. *Sida* sp. B Kimberley Flora (A.A. Mitchell 2745) was also recorded in quadrats in vegetation sub-formations 5 and 7.

Stemodia lathraia and *Wahlenbergia caryophylloides* were recorded in a single quadrat in riparian vegetation (sub-formation 3b). *Commelina ensifolia* was recorded in four quadrats also in riparian vegetation (3a and 3b).

Halgania gustafsenii var. Mid West (G. Perry 370) was recorded in a single quadrat in vegetation sub-formation 8.

Sida sp. Pilbara (A.A. Mitchell PRP 1543) was recorded in three quadrats, two in vegetation sub-formation 1 and one in sub-formation 7.

Sida sp. articulation below was recorded in seven quadrats, two on rocky hills in *Triodia wiseana* hummock grassland and the remainder on flat to undulating plains in *Acacia aneura* woodland.

Euphorbia schultzii was recorded in a single quadrat in vegetation sub-formation 1b on a flat plain.

Identification of range extensions for flora are a common occurrence of surveys conducted for environmental impact assessment. For example, range extensions for 10 species (Mattiske 2005) and 9 species (Biota 2004) were identified in surveys conducted in the Pilbara bioregion. These range extensions reflect the increased knowledge of the states flora that arises as comprehensive ground surveys are conducted in greenfield areas.

3.2.3 Declared Rare/Priority Flora

No T were recorded at FPP during the current or Ecologia (2007, 209) surveys.

A priority 2 species *Vittadinia*. *pustulata* (**Figure 8**) was found at a location recorded by Ecologia (2007) in vegetation sub-formation 1b that is widespread over the FPP survey area (**Figure 7).** The specimens were verified at the state herbarium.

Searches for the priority 1 species *Brachyscome* sp. Wanna Munna Flats were conducted at two locations recorded by Ecologia (2007) and at a location just outside the FPP survey area identified by the DEC database searches. Specimens and photographs (**Figure 9**) were collected at the database population and one of the Ecologia (2007) records. No plants were found at the second Ecologia (2007) location. Further specimens were collected or recorded at three other locations within the FPP survey area (**Figure 7**). The identity of the specimens was verified by the state herbarium.

A priority 2 species *Gompholobium karijini* was included in the species list of Ecologia (2007) but no record of the location of this species is available in the report or raw data and no plants were found in the current survey.

The search of the DEC database identified a record of the priority 1 species *Eremophila pilosa* (dated 21st June 1996) within the FPP survey area. Subsequently, foot searches were conducted for several hundred meters in all directions from the GPS co-ordinate provided by the database search. This intensive ground search failed to locate the species. The species was not recorded elsewhere at the FPP

by the Ecologia (2007, 2009) surveys or in the current survey. There was no apparent reason for the absence of the species at the recorded location, for example, evidence of clearing. It is possible that there was some inaccuracy in the co-ordinates provided by the database search, or alternatively, that the population has died out over the 15 years since the record was made

Table 13: Description of apparent range extensions for species based on the location of the survey area and the mapped range for each species provided on NatureMap (2010) and Florabase (2010).

SPECIES	RANGE EXTENSION DETAILS	SURVEY
Commelina ensifolia	Slight south-eastern extension of the mapped distribution	G&G Environmental 2011
Eremophila spuria	A substantial northern extension of the mapped range.	Ecologia 2007
Eremophila georgei	A substantial northern extension of the mapped range.	Ecologia 2007
Euphorbia schultzii	A substantial southern extension of mapped boundary, no previous records for the Gascoyne bioregion.	G&G Environmental 2011
Halgania gustafsenii var. Mid West (G. Perry 370)	The survey area represents a north-eastern extension of the mapped range.	Ecologia 2009
Sida sp. articulation below	A southern extension of mapped distribution, no previous records for the Gascoyne bioregion.	G&G Environmental 2011
Sida sp. B Kimberley Flora (A.A. Mitchell 2745)	The survey area represents a southern extension to the mapped range, no prior records for the Gascoyne bioregion.	Ecologia 2007 and 2009
Sida sp. Pilbara (A.A. Mitchell PRP 1543)	The survey area represents a south-eastern extension to the mapped range, no prior records for the Gascoyne bioregion.	Ecologia 2009
Stemodia lathraia	The survey area represents a southern extension to the mapped range, no prior records for the Gascoyne bioregion.	Ecologia 2007
Vittadinia pustulata **P2**	A single record of the species in the Great Victoria Desert bioregion, the survey area represents only the second record and a major northern extension of the mapped range.	Ecologia 2007
Wahlenbergia caryophylloides	The survey area represents an eastern extension of the mapped range in the Gascoyne bioregion.	Ecologia 2007
Yakirra australiensis var. *australiensis*	The survey area represents a southern-western extension to the mapped range, no prior records for the Gascoyne bioregion.	Ecologia 2009

3.2.4 Introduced Flora

Ecologia (2007) recorded four introduced species in the FPP survey area *Bidens bipinnata, Cenchrus ciliaris, Chloris virgata* and *Malvastrum americanum.* Ecologia (2009) recorded a single introduced species *Portulaca oleracea*. With the exception of *Chloris virgata* each of these species was recorded in the current survey as well as three additional species; *Citrullus lanatus, Cucumis melo* and *Tribulus terrestris.*

Bidens bipinnata was recorded in 21 of the quadrat surveys (19 G&G Environmental, 2 Ecologia 2007). Large infestations of the species form virtual monocultures in the lower canopy of riparian vegetation (**Figure 10**).

Cenchrus ciliaris, Citrullus lanatus and *Tribulus terrestris* were recorded in a single quadrat during the current survey in riparian vegetation. *Chloris virgata* was recorded at a single location by Ecologia (2009).

Malvastrum americanum and *Tribulus terrestris* were each recorded in two quadrat surveys and *Cucumis melo* in three quadrats.

Portulaca oleracea was the most widespread introduced species recorded in 50 of the quadrat surveys in various vegetation assemblages and habitats.

Distribution maps available on Florabase (2011) and Naturemap (2011) identify that each of the introduced species recorded have previously been recorded in the Gascoyne bioregion and all have wide distributions across Western Australia.

None of the species is a Declared Plant under the *Agriculture and Related Resources Protection Act 1976.*

3.3 DISTURBANCE IMPACT ASSESSMENT

3.3.1 Land Systems

Nine land systems of Van Vreeswyk (*et al*. 2004) occur in the flora survey areas (**Table 14**) with the Divide and Sylvania the most widespread accounting for over 77% of the survey area. Less than 1% of the Fortescue, Newman, Prairie and River occur at the FPP and each of these land systems are represented in both UCL and conservation reserves. Less than 1% of the Washplain and Robertson land systems occur at the FPP and although they are not present in the conservation estate thet have been recorded on UCL. More than 1% of the Cadgie, Divide and Sylvania land systems occur at the FPP and are found on UCL but none are present in a conservation reserve.

Fourteen land systems occur in the footprint currently proposed for clearing (**Figure 11)** but only eight in the area mapped in the vegetation surveys (**Table 14)**. Less than one percent of the total area of these land systems is proposed for clearing with the exception of Sylvania (1.99%).

3.3.2 Vegetation

Eight of the vegetation sub-formations defined for the FPP occupied an area of less than 2km^2(**Table 15**) and together covered just 7.92% of the area surveyed. Vegetation sub-formations 1a and 1b, that inhabit sand plain were the most extensive (57.88% of the survey area) followed by sub-formation 2 found on low rocky hills.

In excess of 50% of eight of the vegetation subformations defined for the FPP occur within the disturbance footprint (**Table 15**). The highest proportion of all the sub-formations proposed for clearing are 5 and 1f with more than 95% followed by 4b and 8 more than 70%, and 1e and 4a more than 60% disturbance. More than 50% of the sub-formations 1a and 1b are proposed for clearing.

Table 14: Proportion of land systems at the FPP and the proportion that may potentially be disturbed.

Land System	Total Area (km$^{2)}$	Area at FPP (km$^{2)}$	% at FPP	% in Disturbance Footprint
Cadgie	495	7.887	1.59	0.18
Divide	5293	74.964	1.42	0.64
Fortescue	504	3.02	0.60	0.60
Newman	14580	7.118	0.05	0.05
Prairie	1221	1.745	0.14	0
River	4088	3.79	0.09	0.05
Robertson	2714	3.61	0.13	0.02
Sylvania	1077	46.67	4.33	1.99
Washplain	917	7.806	0.85	0.64

Table 15: Area of vegetation sub-formations at the FPP and he proportion that may potentially be disturbed.

Vegetation Sub formation	Total Area at FPP **($km^{2)}$**	% FPP Survey area	% in Disturbance Footprint
1a	39.1473	25.03	35.6
1a burnt	4.135	2.64	36
1b	51.3747	32.85	53
1c	7.349	4.70	8.8
1e	6.985	4.47	65.6
1f	7.27	4.65	96.9
2	14.719	9.41	13.9
2a	1.329	0.85	53.3
2b	1.212	0.78	0.13
3a	3.293	2.1	10
3b	6.796	4.35	52.4
4a	1.186	0.76	63.6
4b	1.912	1.22	75.3
4c	0.1695	0.11	36
5	1.646	1.05	95.4
5a	2.453	1.57	42.2
6	1.85307	1.18	55
7	1.36	0.87	0
8	1.728	1.10	74.9

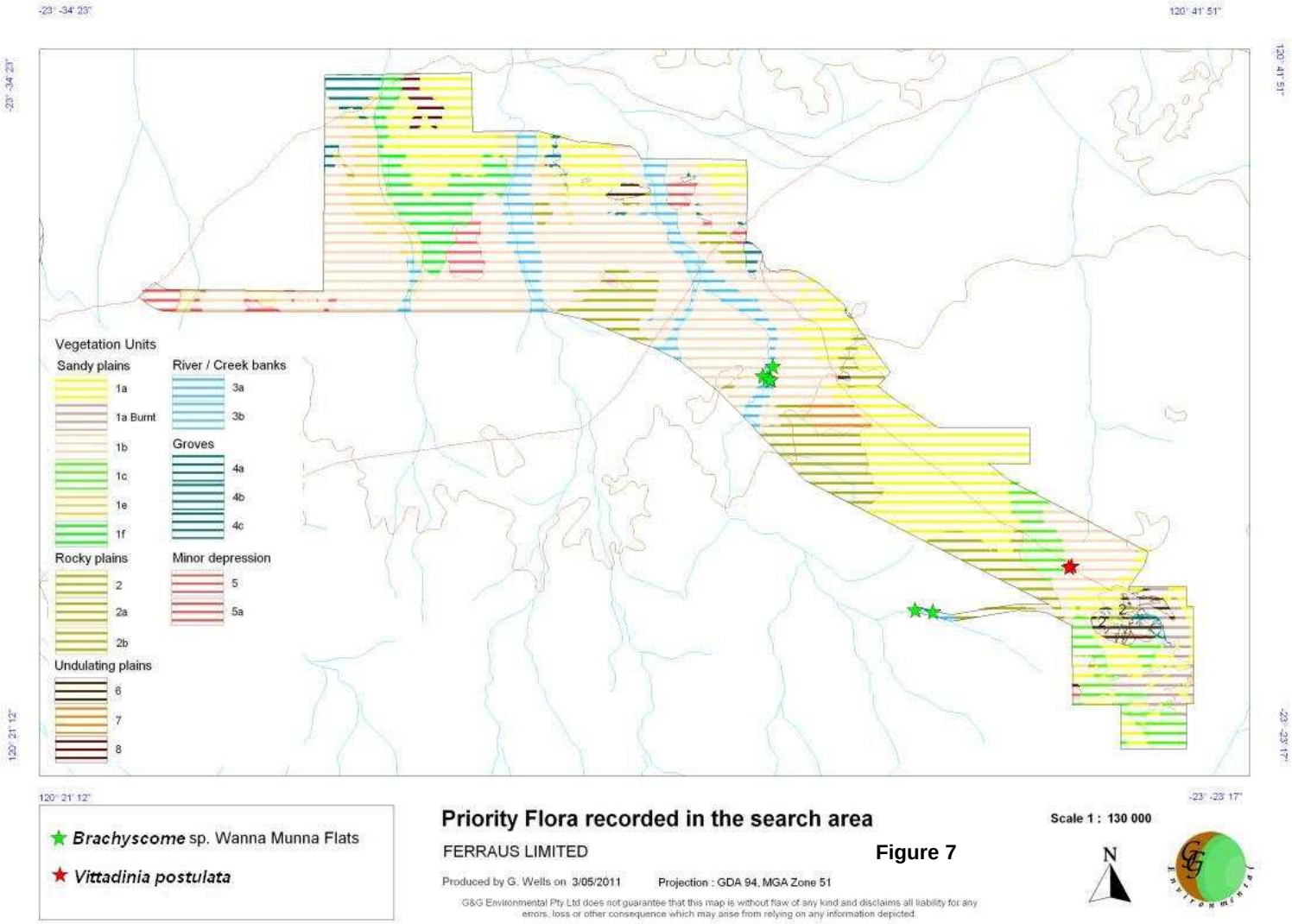

-23° -34' 23"
120° 41' 51"
120° 21' 12"
-23° -23' 17"
Vegetation Units
Sandy plains
1a
1a Burnt
1b
1c
1e
1f
Rocky plains
2
2a
2b
Undulating plains
6
7
8
River / Creek banks
3a
3b
Groves
4a
4b
4c
Minor depression
5
5a
Brachyscome sp. Wanna Munna Flats
Vittadinia postulata
Priority Flora recorded in the search area
FERRAUS LIMITED
Figure 7
Scale 1 : 130 000
N
Produced by G. Wells on 3/05/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.

Figure 8: Priority 2 species *Vittadinia pustulata* a low herbaceous shrub to 25cm height.

Figure 9: Priority 1 species *Brachyscome* sp. Wanna Munna Flats. Annual daisy to 15cm in height. Flowers light mauve to white.

Figure 10: Virtual monoculture of the introduced species *Bidens bipinnata* in riparian vegetation at the FPP.

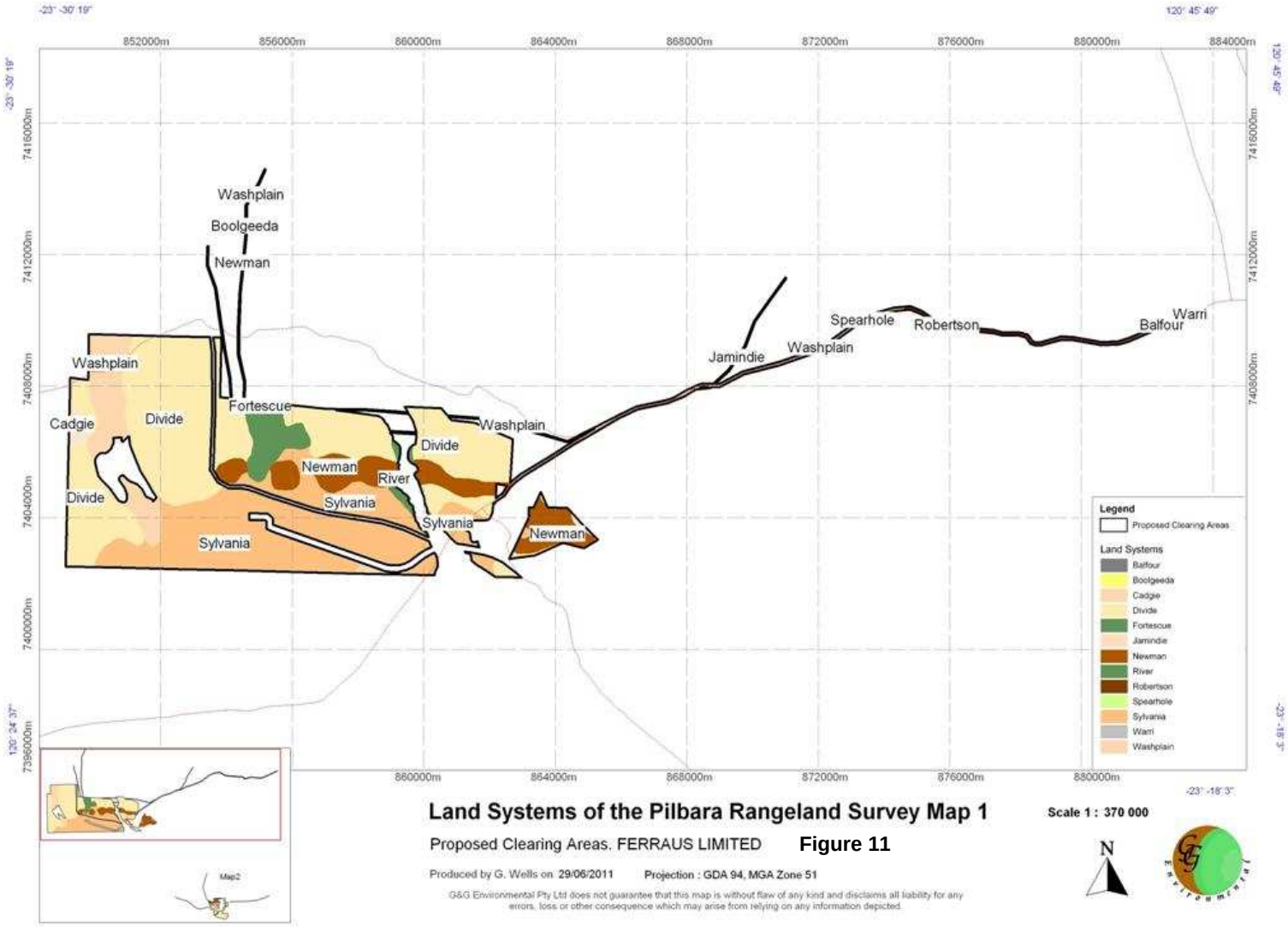
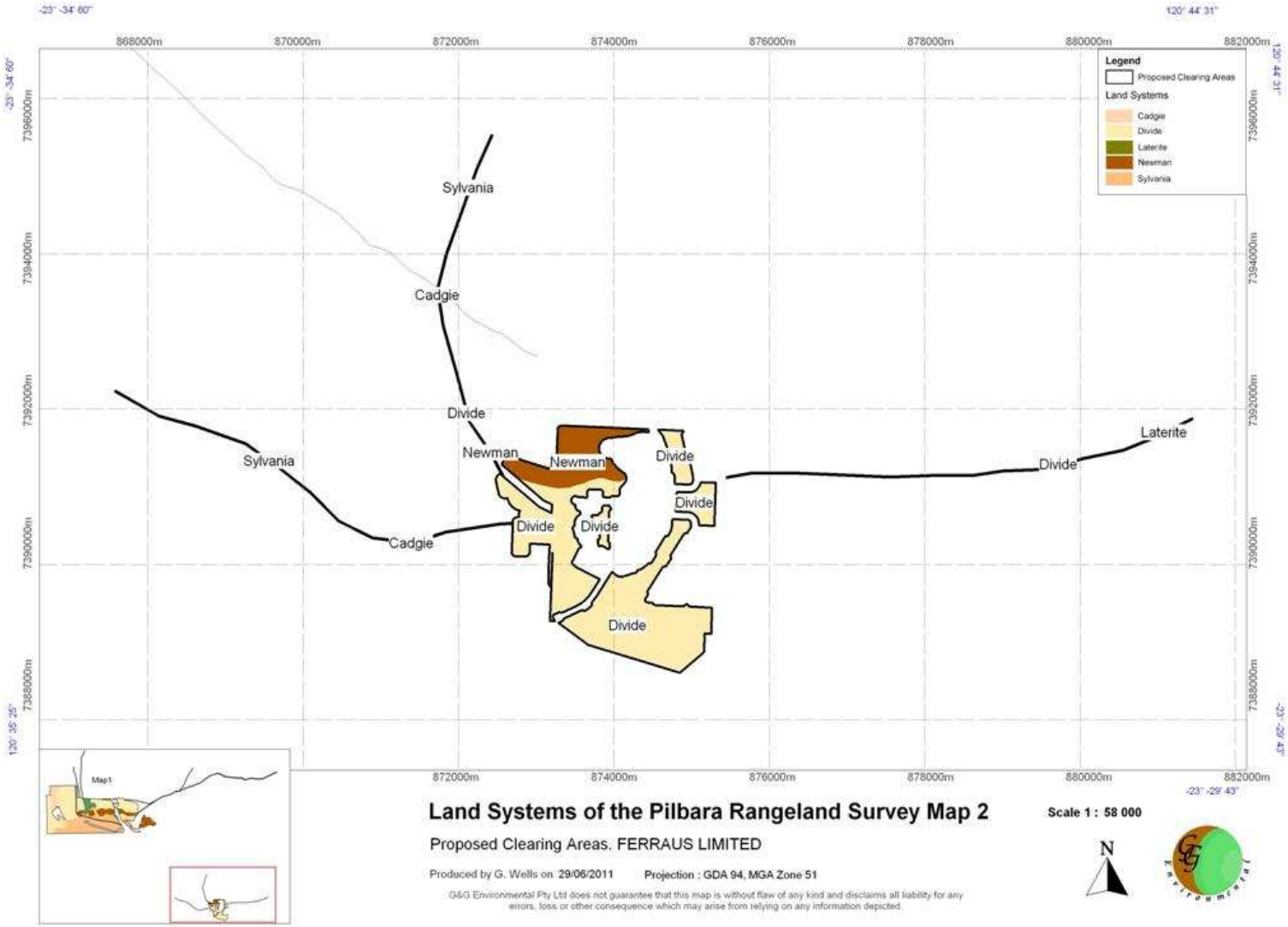
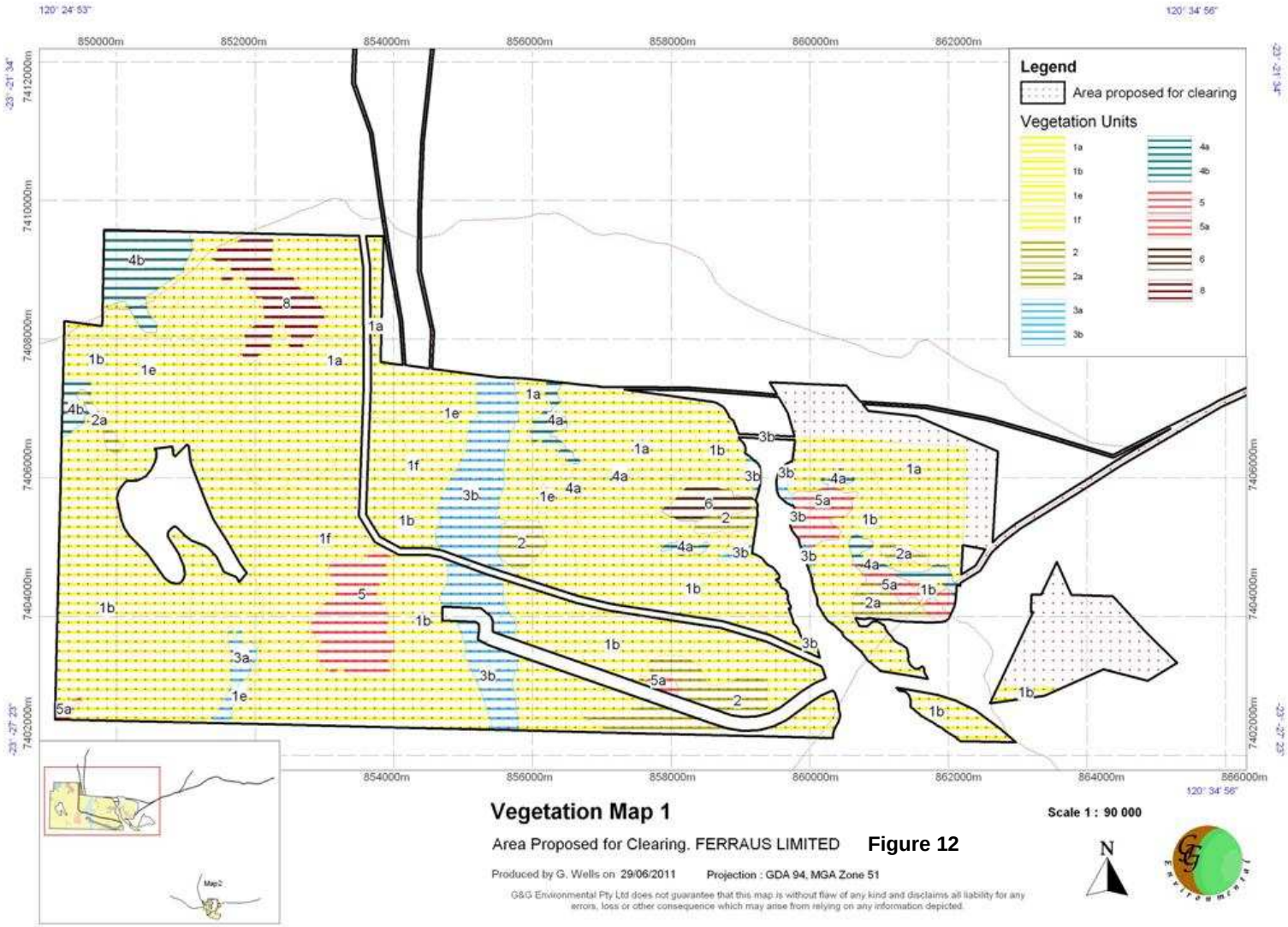
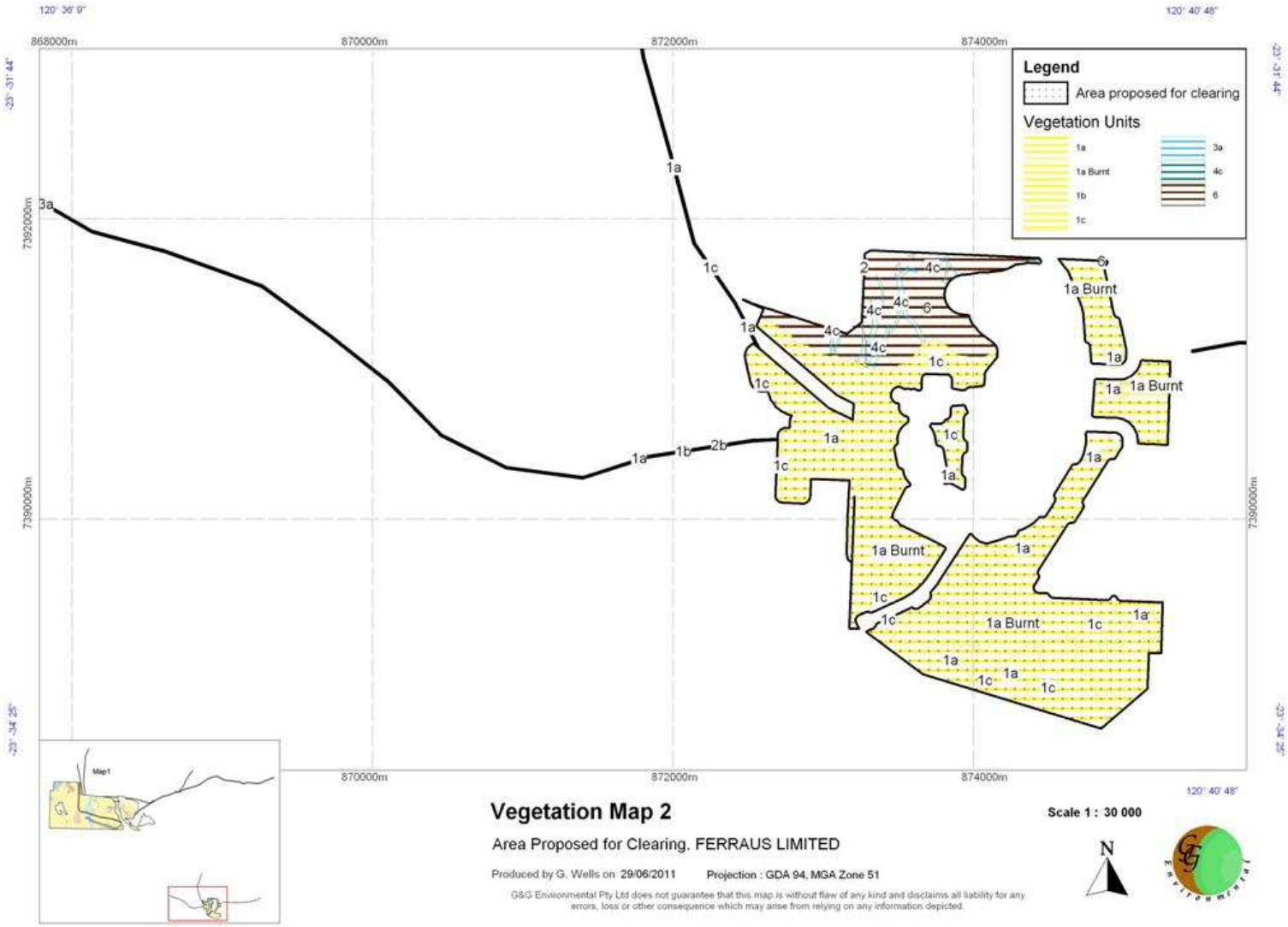

-23° -30' 19"
120° 45' 49"
852000m
856000m
860000m
864000m
868000m
872000m
876000m
880000m
884000m
7416000m
7412000m
7408000m
7404000m
7400000m
7396000m
120° 24' 37"
-23° -18' 3"
Washplain
Boolgeeda
Newman
Washplain
Cadgie
Divide
Fortescue
Divide
Newman
River
Divide
Sylvania
Sylvania
Washplain
Sylvania
Newman
Jamindie
Washplain
Spearhole
Robertson
Warri
Balfour
Legend
Proposed Clearing Areas
Land Systems
Balfour
Boolgeeda
Cadgie
Divide
Fortescue
Jamindie
Newman
River
Robertson
Spearhole
Sylvania
Warri
Washplain
Map2
Land Systems of the Pilbara Rangeland Survey Map 1
Proposed Clearing Areas. FERRAUS LIMITED
Produced by G. Wells on 29/06/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
Scale 1 : 370 000
N

Figure 11


-23° -34' 60"
120° 44' 31"
868000m
870000m
872000m
874000m
876000m
878000m
880000m
882000m
7396000m
7394000m
7392000m
7390000m
7388000m
120° 35' 25"
-23° -29' 43"
Legend
Proposed Clearing Areas
Land Systems
Cadgie
Divide
Laterite
Newman
Sylvania
Sylvania
Cadgie
Divide
Newman
Newman
Divide
Divide
Divide
Divide
Divide
Sylvania
Cadgie
Divide
Laterite
Divide
Map1
Land Systems of the Pilbara Rangeland Survey Map 2
Proposed Clearing Areas. FERRAUS LIMITED
Produced by G. Wells on 29/06/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
Scale 1 : 58 000
N


120° 24' 53"
120° 34' 56"
850000m
852000m
854000m
856000m
858000m
860000m
862000m
864000m
866000m
-23° 21' 34"
-23° 27' 23"
7412000m
7410000m
7408000m
7406000m
7404000m
7402000m
Legend
Area proposed for clearing
Vegetation Units
1a
1b
1e
1f
2
2a
3a
3b
4a
4b
5
5a
6
8
Vegetation Map 1
Area Proposed for Clearing. FERRAUS LIMITED
Figure 12
Scale 1 : 90 000
Produced by G. Wells on 29/06/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
N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120° 40' 48"
868000m
870000m
872000m
874000m
-23° 31' 44"
-23° 34' 25"
7392000m
7390000m
Legend
Area proposed for clearing
Vegetation Units
1a
1a Burnt
1b
1c
3a
4c
6
Map1
Vegetation Map 2
Area Proposed for Clearing. FERRAUS LIMITED
Produced by G. Wells on 29/06/2011
Projection : GDA 94, MGA Zone 51
G&G Environmental Pty Ltd does not guarantee that this map is without flaw of any kind and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted.
Scale 1 : 30 000
N

4.0 DISCUSSION

A comprehensive assessment of the flora and vegetation has been conducted for the FerrAus Pilbara Project by Ecologia (2007, 2009) and G&G Environmental (current survey). Field observations were conducted over six different seasons, April 2007, September 2007, June 2008, April 2010, October 2010 and April 2011 and produced a combined 151 quadrat surveys across the ~160km^2 FPP area.

Each survey was conducted to record the vascular plant species present, search for and describe populations of plants of conservation significance and populations of exotic plant species (weeds), to define and map vegetation types present and assess their potential local and regional significance, and to record the condition of vegetation in the survey area. The combined surveys recorded in excess of 400 plant taxa of which approximately one third were annual species recorded following both winter and summer rainfall.

It is considered that the with the high number of taxa recorded, the intensity and timing of each survey effort by experienced field botanists, and the assistance obtained with plant identification from the Western Australian herbarium that the flora of the FPP has been adequately described. With the review of both regional and more localised previous botanical surveys, adherence to methodology provided by government guidelines for flora surveys and adoption of the National Vegetation Inventory System (NVIS 2003) to describe vegetation it is considered that adequate resources were utilised to define and assess the conservation significance of the vegetation defined. As the vegetation boundaries were drawn from apparent changes in the vegetation from aerial photographs some inaccuracies in the depiction of the boundaries may be expected.

4.1 LAND SYSTEMS

With the exception of Sylvania, areas that may potentially be disturbed at the FPP account for less than 1% of the land systems present. The FPP survey area is therefore considered to represent low conservation value for these systems. Conversely, a considerable proportion of the Sylvania land system occurs at the FPP, of which approximately half occurs within the disturbance footprint. It is recommended that where possible disturbance to this land system be minimised and all areas outside of the disturbance footprint be protected to minimise impacts to this system.

4.2 VEGETATION

A total of 19 vegetation types were defined for the FPP to the level of sub-formation of the NVIS 2003. None of the sub-formations resembled a TEC of national or regional significance and each of them resembled vegetation types previously mapped that are common and widespread. It is therefore considered that none of the sub-formations represent regionally significant vegetation.

In accordance with government guidelines (EPA 2004) each of the eight vegetation sub-formations that covered less than 2km^2 area may be considered potentially locally significant as they are scarce within

the survey area. This is particularly true for sub-formation 4c that covered the least area and for sub-formation 7 that occurred at only one location. However, each of these sub-formations were composed of common species and were considerd to resemble site types of Van Vreeswyk *et al* (2004) that are widespread outside the survey area and have been recorded in a conservation estate and on UCL. It is considered that these sub-formations may potentially occur in the surrounding landscape.

In accordance with government guidelines (EPA 2004) the vegetation sub-formations 3a and 1b may be considered potentially locally significant as they represent habitat for priority flora (*Brachyscome* sp. Wanna Munna Flats and *Vittadinia pustulata* respectively). Vegetation unit 1b is widespread at the FPP and is likely to occur extensible outside of the survey area. Vegetation associatin 3a is common along creeklines within the survey area and is also likely to occur in the broader landscape.

Large proportions of four of the sub-formations defined in the survey areas (5 and 1f more than 95%, 4b and 8 more than 70%) occur in the disturbance footprint. In excess of 50% of a further four sub-formations (1a, 1d, 1e and 4a) also occur within the disturbance footprint. Each of these vegetation tepes are composed of common species and were considered to resemble site types of Van Vreeswyk *et al* (2004) and are represented in a conservation estate. It is considered that these sub-formations may potentially occur in the surrounding landscape.

4.3 FLORA

Two priority flora were recorded at the FPP by Ecologia (2007), *Brachyscome* sp. Wanna Munna Flats (P1), *Vittadinia pustulata* (P2). Both of these species were also recorded in the current survey with the identity of each verified by taxonomist specialists at the state herbarium. It is recommended that site personnel be familiarised with the priority flora to facilitate reporting of further sightings and minimise the potential for disturbance to populations.

Brachyscome sp. Wanna Munna Flats (**P1**) was recorded at five locations in riparian vegetation sub-formation 3a along a single creek system. The species was also observed in an *Acacia aneura* grove outside of the FPP survey area at a population identified by the DEC database search. Florabase (2011) shows nine locations for the species occurring in the south of the Pilbara bioregion and along the northern boundary of the Gascoyne bioregion in the vicinity of the FPP. The records of the species at the FPP are located within the mapped range of the species and represent a large increase in the known number of populations.

None of the populations of *Brachyscome* sp. Wanna Munna Flats occurs within the disturbance footprint. It is recommended that the recorded populations be protected as they represent may be considered locally significant.

Vittadinia pustulata (**P2**) was recorded in vegetation sub-formation 1b that is widespread across the FPP survey area. The presence of *Vittadinia pustulata* represents a large increase in the known range of the species which previously had only been recorded at two locations in the Great Victoria Desert bioregion.

The *Vittadinia pustulata* population occurs approximately 50m outside of the disturbance footprint adjacent to a proposed service corridor where an access road to the current FPP camp site already exists. It is recommended that this population be protected as it represents the only population recorded in the Gascoyne bioregion and may therefore be considered regionally significant.

The vegetation in which each of the priority species were recorded at the FPP resemble widespread communities which are typical of the Pilbara and Gascoyne regions (Ecologia 2007) and are generally well represented in the surrounding area (Ecologia 2009). This indicates that suitable habitat for each of the species occurs not only within the survey areas but also in the broader landscape.

Review of the distribution of each of the species recorded at the FPP by Ecologia (2007, 2009) and current survey identified range extensions for 12 species. In accordance with government guidelines (EPA2004) these species may be considered potentially locally significant as they represent recent increases to the known range of the taxa. All of the species were recorded in vegetation sub-formations that resemble widespread communities which are typical of the Pilbara and Gascoyne regions (Ecologia 2007) and are generally well represented in the surrounding area (Ecologia 2009). This indicates that suitable habitat for each of the species occurs not only within the survey areas but also in the broader landscape.

4.4 INTRODUCED FLORA (WEEDS)

Eight introduced taxa were recorded at the FPP, *Bidens bipinnata*, *Cenchrus ciliaris*, *Chloris virgata*, *Citrullus lanata*, *Cucumis melo*, *Portulaca oleracea* and *Tribulus terrestris*. None of the species are a Declared Plant and all have broad distributions in Western Australia and have been previously recorded in the Gascoyne and Pilbara bioregions.

Portulaca oleracea was the most widespread species and was recorded in almost half of the quadrat surveys conducted by G&G Environmental in a variety of habitat types and vegetation communities. The remaining species were all recorded in riparian vegetation along both major and minor creek systems.

Large infestations of one of the species, *Bidens bipinnata* reduced the condition of the vegetation to very good while the majority of the surrounding vegetation remained pristine. Despite the widespread distribution of *Portulaca oleracea* and the *Bidens bipinnata* at a few locations, in general, the level of weed infestation at the FPP was considered low.

REFERENCES

ANRA (2010) Available at www.anra.gov.au

Beard, J. S. (1975) Vegetation Survey of Western Australia Pilbara 1: 1 000 000 Vegetation Series Explanatory noted to Sheet 5. University of Western Australia Press, Perth, Western Australia.

Biota (2004) Vegetation and flora survey of the proposed FMG Stage A rail corridor. Consultants report by Biota Environmental Sciences for Fortescue Metals Group, August 2004.

BoM (2011) Available at www.bom.gov.au.

Desmond, A., Kendrick, P. and Chant, A. (2003). Gascoyne 3 (GAS3 Augustus subregion). In: A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002 (Eds J.E. May & N.L. McKenzie). Department of Conservation and Land Management, pp. 240-251.

Ecologia (2007) FerrAus Limited, Robertson Range – Proposed Haul Road Biological Survey. December 2007. Consultants report for FerrAus Ltd.

Ecologia (2009) FerrAus Limited, Robertson Range – (M52/1034) Vegetation and Flora Report. March 2009. Consultants report for FerrAus Ltd.

English, V. (2003) Threatened Ecological communities - Methods, Listing, Examples. *In*, Proceedings of the Threatened ecological Communities Symposium. Technology Park, Bentley, Western Australia, December 2003.

Environ (2004) Pilbara Iron Ore and Infrastructure Project; Stage A port and north-south railway, Public Environmental Review.

EPA (2002). Environmental Protection Authority.Position Statement 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection. Environmental Protection Authority, Perth, Western Australia.

EPA (2004). Environmental Protection Authority. Guidance statement No. 51 “Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia”. Environmental Protection Authority of Western Australia.

Florabase (2011) Available at http://florabase.calm.wa.gov.au

G&G Environmental (2006) Flora and vegetation survey of the Woodie Woodie borefield to Spinifex Ridge project proposed pipeline corridor. Internal Consultant report by G&G Environmental Pty Ltd for Outback Ecology Services.

G&G Environmental (2007a) Flora and vegetation survey of the proposed De Grey borefield and a pipeline corridor to the Moly Mines Spinifex Ridge project. Internal Consultant report by G&G Environmental Pty Ltd for Outback Ecology Services.

G&G Environmental (2007b) Flora and vegetation survey of the proposed Canning A borefield and an access corridor to the Moly Mines, Spinifex Ridge project. Internal Consultant report by G&G Environmental Pty Ltd for Outback Ecology Services.

G&G Environmental (2008) Flora and Vegetation Survey of the Proposed Gas Pipeline Corridor from Port Hedland to the Moly Mines Spinifex Ridge Project. Internal Consultant report by G&G Environmental Pty Ltd for Outback Ecology Services.

G&G Environmental (2009a) Flora and Vegetation Survey of a Proposed Transport Corridor at the Murray Hill Project. Internal Consultant report by G&G Environmental Pty Ltd for Hancock Prospecting Pty Ltd.

G&G Environmental (2009b) Flora and vegetation survey of a proposed borefield for the Roy Hill 1 Iron Ore Project. Internal Consultant report by G&G Environmental Pty Ltd for Roy Hill Iron Ore Pty Ltd.

Keighery, B. (1994) Bushland Plant Survey - A guide to plant community survey for the community, Wildflower Society of WA (Inc.)

Mattiske (2005) Mattiske Consulting Pty Ltd. Flora and vegetation on the Cloud Break and White Knight leases. Internal Consultant report for Fortescue Metals Group Ltd.

NatureMap (2011) Available at http://NatureMap.dec.wa.gov.au/default.aspx

NVIS (2003) National Vegetation Information System – Australian Vegetation Attribute Manual (Version 6.0) Department to Environment and Heritage, Canberra, August 2003Royce, R. D. (1948). Botanical observations along the No. 1 rabbit-proof fence. *West. Aust. Nat.* 1: 89-95.

Outback Ecology (2006) Spinifex Ridge Baseline Survey - Vegetation and Flora. Internal Consultant report for Outback Ecology Services prepared for Moly Mines Limited. October, 2005.

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. and Hennig, P. (2004) An inventory and condition survey of the Pilbara Region, Western Australia. Technical Bulletin No. 92. Department of Agriculture, Perth, Western Australia.

APPENDIX A – DEFINITIONS OF DECLARED RARE FLORA, PRIORITY FLORA, THREATENED ECOLOGICAL COMMUNITIES AND PRIORITY ECOLOGICAL COMMUNITIES

Source: http://florabase.calm.wa.gov.au, April 2011

Code	Definition
T	**T- Threatened Flora** 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. Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria: ▪ CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild ▪ EN: Endangered – considered to be facing a very high risk of extinction in the wild ▪ VU: Vulnerable – considered to be facing a high risk of extinction in the wild.
P1	**Priority One - Poorly Known Taxa** Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
P2	**Priority Two - Poorly Known Taxa** Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
P3	**Priority Three - Poorly Known Taxa** Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
P4	**Priority Four - Rare Taxa** **(**a) **Rare.** Taxa 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 taxa are usually represented on conservation lands. (b) **Near Threatened**. Taxa 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) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
P5	**Priority Five - Conservation Dependent Species** Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxa becoming threatened within five years.

Reference: - English (2003).

TEC Classification	Status	Definition
Presumed Totally Destroyed	X	Community is unlikely to be able to be rehabilitated.
Critically Endangered	R	There are immediate threats throughout its range.
Endangered	E	Threatened throughout most of its range in the near future.
Vulnerable	V	Vulnerable to threatening processes/may move into higher threat category.

PEC Categories	Definition
Priority One: Poorly-known ecological communities	Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤ 100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority Two: Poorly-known ecological communities	Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority Three: Poorly known ecological communities	(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, 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.
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.	(i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (iii) Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority Five: Conservation Dependent ecological communities	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

APPENDIX B - PRIORITY SPECIES LIST FOR THE GASCOYNE BIOREGION OF WESTERN AUSTRALIA

Source: http://florabase.calm.wa.gov.au, April 2011

FAMILY	Species	Priority Code
Aizoaceae	*Gunniopsis propinqua*	3
	Tetragonia coronata	3
Amaranthaceae	*Ptilotus chrysocomus*	1
	Ptilotus crosslandii	3
	Ptilotus lazaridis	3
	Ptilotus mitchellii	1
	Ptilotus trichocephalus	4
Asteraceae	*Calocephalus beardii*	1
	Helichrysum oligochaetum	1
	Rhodanthe frenchii	2
	Rhodanthe sphaerocephala	1
Chenopodiaceae	*Maireana murrayana*	3
	Maireana prosthecochaeta	3
Colchicaceae	*Wurmbea saccata*	3
Cyperaceae	*Schoenus* sp. Kalbarri	2
Euphorbiaceae	*Euphorbia sarcostemmoides*	1
Fabaceae	*Acacia atopa*	3
	Acacia speckii	3
	Acacia wilcoxii	1
	Gompholobium karijini	2
	Senna sp. Barlee Range	2
Frankeniaceae	*Frankenia confusa*	2
	Frankenia glomerata	3
Goodeniaceae	*Goodenia berringbinensis*	4
	Goodenia virgata	2
	Selliera radicans	1
Lamiaceae	*Dicrastylis linearifolia*	3
	Hemigenia tysonii	3
	Pityrodia augustensis	T
Malvaceae	*Lawrencia* sp. Anna Plains	3
	Sida sp. Barlee Range	3
	Triumfetta echinata	3
Myrtaceae	*Aluta quadrata*	1
	Calytrix praecipua	3
	Eucalyptus semota	1
	Homalocalyx echinulatus	3
	Thryptomene wittweri	T
Phyllanthaceae	*Sauropus ramosissimus*	3
Poaceae	*Sporobolus blakei*	3
Proteaceae	*Grevillea subterlineata*	3
Restionaceae	*Lepidobolus densus*	3
Scrophulariaceae	*Eremophila appressa*	1
	Eremophila arguta	1
	Eremophila campanulata	3
	Eremophila coacta	3
	Eremophila flaccida subsp. *attenuata*	3
	Eremophila gracillima	3
	Eremophila humilis	1

	Eremophila lanata	3
	Eremophila magnifica subsp. *velutina*	3
	Eremophila micrantha	3
	Eremophila obliquisepala	3
	Eremophila petrophila subsp. *densa*	3
	Eremophila prolata	1
	Eremophila pungens	4
	Eremophila rhegos	1
	Eremophila rigens	3
	Eremophila rigida	3
	Eremophila shonae subsp. *diffusa*	3
	Eremophila warnesii	1
	Eremophila youngii subsp. *lepidota*	4
Stylidiaceae	*Stylidium weeliwolli*	2

APPENDIX C – WEED SPECIES LIST FOR THE GASCOYNE BIOREGION OF WESTERN AUSTRALIA

Source: http://florabase.calm.wa.gov.au, April 2011

FAMILY	Species
Amaranthaceae	*Aerva javanica*
Asphodelaceae	*Asphodelus fistulosus*
Asteraceae	*Bidens bipinnata*
	Sonchus oleraceus
	Urospermum picroides
Boraginaceae	*Heliotropium europaeum*
Brassicaceae	*Lepidium africanum*
	Lepidium didymum
	Sisymbrium erysimoides
	Sisymbrium irio
	Sisymbrium orientale
Chenopodiaceae	*Chenopodium murale*
Convolvulaceae	*Cuscuta planiflora*
	Ipomoea indica
Cucurbitaceae	*Citrullus colocynthis*
	Citrullus lanatus
	Cucumis melo
	Cucumis melo subsp. *agrestis*
Gentianaceae	*Centaurium erythraea*
Malvaceae	*Malva parviflora*
	Malvastrum americanum
Papaveraceae	*Argemone ochroleuca*
	Argemone ochroleuca Sweet subsp. *ochroleuca*
Poaceae	*Cenchrus ciliaris*
	Chloris virgata
	Cynodon dactylon
	Eragrostis cilianensis
	Eragrostis curvula
	Lolium multiflorum
	Polypogon monspeliensis
	Setaria verticillata
Polygonaceae	*Acetosa vesicaria*
	Emex australis
Portulacaceae	*Portulaca oleracea*
	Anagallis arvensis
	Anagallis arvensis var. *caerulea*
Solanaceae	*Datura leichhardtii*
	Lycium ferocissimum
	Solanum nigrum
Zygophyllaceae	*Tribulus terrestris*

APPENDIX D – VEGETATION STRUCTURAL CLASSES (NVIS 2003)

Height Classes

Height		***Growth Form***				
Height Class	**Height Range (m)**	tree, vine (M & U), palm (single-stemmed)	shrub, heath shrub, chenopod shrub, ferns, samphire shrub, cycad, tree-fern, grass-tree, palm (multi-stemmed)	tree mallee, mallee shrub	tussock grass, hummock grass, other grass, sedge, rush, forbs, vine (G)	bryophyte, lichen, seagrass, aquatic
8	**>30**	tall	NA	NA	NA	NA
7	**10-30**	mid	NA	tall	NA	NA
6	**<10**	low	NA	mid	NA	NA
5	**<3**	NA	NA	low	NA	NA
4	**>2**	NA	tall	NA	tall	NA
3	**1-2**	NA	mid	NA	tall	NA
2	**0.5-1**	NA	low	NA	mid	tall
1	**<0.5**	NA	low	NA	low	low

Structural Formation Classes

Growth Form	**Height Ranges (m)**	**Structural Formation Classes**					
Foliage cover% (Cover#)		**70-100% (5)**	**30-70% (4)**	**10-30% (3)**	**<10% (2)**	**0-5% (1)**	**≈0% (N)**
tree, palm	<10,10-30, >30	closed forest	open forest	woodland	open woodland	isolated trees	isolated clumps of trees
tree mallee	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	open mallee woodland	isolated mallee trees	isolated clumps of mallee trees
shrub, cycad, grass-tree, tree-fern	<1,1-2,>2	closed shrubland	shrubland	open shrubland	sparse shrubland	isolated shrubs	isolated clumps of shrubs
mallee shrub	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	sparse mallee shrubland	isolated mallee shrubs	isolated clumps of mallee shrubs
heath shrub	<1,1-2,>2	closed heathland	heathland	open heathland	sparse heathland	isolated heath shrubs	isolated clumps of heath shrubs
chenopod shrub	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	sparse chenopod shrubland	isolated chenopod shrubs	isolated clumps of chenopod shrubs
samphire shrub	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	sparse samphire shrubland	isolated samphire shrubs	isolated clumps of samphire shrubs
hummock grass	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	sparse hummock grassland	isolated hummock grasses	isolated clumps of hummock grasses
tussock grass	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	sparse tussock grassland	isolated tussock grasses	isolated clumps of tussock grasses
other grass	<0.5,>0.5	closed grassland	grassland	open grassland	sparse grassland	isolated grasses	isolated clumps of grasses
sedge	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	sparse sedgeland	isolated sedges	isolated clumps of sedges
rush	<0.5,>0.5	closed rushland	rushland	open rushland	sparse rushland	isolated rushes	isolated clumps of rushes
forb	<0.5,>0.5	closed forbland	forbland	open forbland	sparse forbland	isolated forbs	isolated clumps of forbs
fern	<1,1-2,>2	closed fernland	fernland	open fernland	sparse fernland	isolated ferns	isolated clumps of ferns
bryophyte	<0.5	closed bryophyteland	bryophyteland	open bryophyteland	sparse bryophyteland	isolated bryophytes	isolated clumps of bryophytes
lichen	<0.5	closed lichenland	lichenland	open lichenland	sparse lichenland	isolated lichens	isolated clumps of lichens
vine	<10,10-30, >30	closed vineland	vineland	open vineland	sparse vineland	isolated vines	isolated clumps of vines
aquatic	0-0.5,<1	closed aquatic bed	aquatic bed	open aquatic bed	sparse aquatics	isolated aquatics	isolated clumps of aquatics
seagrass	0-0.5,<1	closed seagrass bed	seagrassbed	open seagrassbed	sparse seagrassbed	isolated seagrasses	isolated clumps of seagrasses

APPENDIX E - NATIONAL VEGETATION INFORMATION SYSTEM INFORMATION HIERARCHY.

Hierarchical level	Description	National Vegetation Information System structural/floristic components required
I	Class	Dominant growth form of the ecologically dominant stratum.
II	Structural formation	Dominant growth form, cover and height of the ecologically dominant stratum
III	Broad floristic formation	Dominant growth form, cover and height of the ecologically dominant stratum
IV	Sub- formation	Dominant growth form, cover, height and broad floristic code usually dominant genus and family of the three traditional strata (i.e. upper, mid and ground)
V	Association	Dominant growth form, height, cover and species (three species) of the three traditional strata (i.e. upper, mid and ground).
VI	Sub-association	Dominant growth form, height, cover and species (five species) of all layers/strata.

APPENDIX F –SPECIES LIST FOR THE FERRAUS PILBARA PROJECT

Family	Species	Ecologia 2009	Ecologia 2007	G&G Environmental 2010/2011
AIZOACEAE	*Trianthema glossostigma*	x	x	x
	Trianthema pilosa			x
	Trianthema triquetra			x
AMARANTHACEAE	*Alternanthera angustifolia*		x	x
	Alternanthera nana		x	
	Gomphrena affinis			x
	Gomphrena canescens subsp. *canescens*		x	
	Gomphrena cunninghamii			x
	Gomphrena kanisii	x	x	x
	Ptilotus astrolasius var. *astrolasius*		x	x
	Ptilotus carinatus			x
	Ptilotus exaltatus var. *exaltatus*	x	x	x
	Ptilotus gaudichaudii var. *gaudichaudii*		x	x
	Ptilotus helipteroides		x	x
	Ptilotus macrocephalus			x
	Ptilotus obovatus var. *obovatus*	x	x	x
	Ptilotus polystachyus var. *polystachyus*	x	x	x
	Ptilotus roei	x	x	x
	Ptilotus rotundifolius	x	x	x
	Ptilotus schwartzii	x	x	x
	Ptilotus schwartzii var. *schwartzii*	x	x	
APOCYNACEAE	*Rhyncharrhena linearis*	x	x	x
	Sarcostemma viminale subsp. *australe*	x		x
ARALIACEAE	*Trachymene bialata*		x	
	Trachymene oleracea	x		x
ASPARAGACEAE	*Thysanotus* sp. Eremaean			x
ASTERACEAE	Asteraceae sp.		x	
	*Bidens bipinnata**		x	x

Brachyscome ciliocarpa			x
Brachyscome sp. Wanna Munna Flats (S. van Leeuwen 4662) **P1**		x	x
Calotis plumulifera			x
Centipeda minima subsp. *macrocephala*			x
Chrysocephalum apiculatum			x
Chrysocephalum eremaeum		x	x
Chrysocephalum gilesii			x
Chrysocephalum pterochaetum	x	x	x
Chrysocephalum sp. Nov. 'Little Sandy Desert'		x	
Chrysocephalum ? sp. Pilbara			x
Erymophyllum ramosum			x
Pluchea dentex	x	x	x
Pluchea dunlopii		x	x
Pluchea ferdinandi-muelleri		x	x
Pluchea rubelliflora		x	
Podolepis capillaris	x		
Pterocaulon serrulatum			x
Pterocaulon sphacelatum	x	x	x
Pterocaulon sphaeranthoides	x	x	
Rhodanthe charsleyae		x	x
Rhodanthe propinqua			x
Rhodanthe sterilescens			x
Rutidosis helichrysoides		x	
Rutidosis helichrysoides subsp. *helichrysoides*		x	x
Schoenia cassiniana		x	
Streptoglossa ? *liatroides*			x
Streptoglossa bubakii		x	
Streptoglossa decurrens	x		x
Streptoglossa macrocephala	x	x	x
Streptoglossa odora			x
Vittadinia pustulata **P2**		x	x

BORAGINACEAE	*Halgania* aff. *gustafsenii* var. *gustafsenii*		x	
	Halgania erecta		x	
	Halgania gustafsenii var. *gustafsenii*		x	
	Halgania gustafsenii var. Mid West (G. Perry 370)	x		
	Halgania solanacea	x		x
	Halgania solanacea var. Mt Doreen (G.M. Chippendale 4206)	x		
	Halgania solanacea var. *solanacea*	x		
	Heliotropium chrysocarpum	x		x
	Heliotropium diversifolium			x
	Heliotropium heteranthum			x
	Heliotropium pachyphyllum	x	x	
	Heliotropium tenuifolium			x
	Trichodesma zeylanicum		x	x
BORAGINACEAE	*Trichodesma zeylanicum* var. *zeylanicum*		x	
BRASSICACEAE	*Lepidium echinatum*		x	x
	Lepidium muelleri-ferdinandii			x
	Lepidium pedicellosum		x	
BRASSICACEAE	*Lepidium pholidogynum*		x	
	Lobelia quadrangularis		x	
CAMPANULACEAE	*Wahlenbergia caryophylloides*		x	
CARYOPHYLLACEAE	*Polycarpaea corymbosa*		x	x
	Polycarpaea corymbosa var. *corymbosa*	x		
	Polycarpaea holtzei			x
CELASTRACEAE	*Macgregoria racemigera*		x	x
	Maytenus sp. Mt Windell (S. van Leeuwen 846)	x		
	Stackhousia intermedia			x
	Stackhousia muricata		x	
CHENOPODIACEAE	*Dissocarpus paradoxus*			x
	Dysphania kalpari	x		x
	Dysphania melanocarpa			x
	Dysphania rhadinostachya			x
	Dysphania sp.		x	

	Enchylaena tomentosa		x	x
	Enchylaena tomentosa var. *tomentosa*	x	x	
	Maireana eriosphaera			x
	Maireana georgei	x	x	x
	Maireana melanocoma	x		x
	Maireana planifolia		x	x
	Maireana thesioides		x	
	Maireana tomentosa subsp. *tomentosa*		x	
	Maireana triptera	x	x	x
	Maireana villosa	x	x	x
	Rhagodia eremaea	x	x	x
	Salsola australis		x	x
	Salsola tragus			x
	Sclerolaena cornishiana	x	x	x
	Sclerolaena cuneata		x	
	Sclerolaena densiflora		x	
	Sclerolaena eriacantha	x	x	
	Sclerolaena tetragona			x
CLEOMACEAE	*Cleome oxalidae*			x
	Cleome viscosa		x	x
COMMELINACEAE	*Commelina ensifolia*			x
CONVOLVULACEAE	*Bonamia erecta*			x
	Bonamia rosea	x	x	x
	Bonamia sp.	x		
	Convolvulus angustissimus subsp. *angustissimus*			x
	Duperreya commixta	x	x	x
	Evolvulus alsinoides		x	
	Evolvulus alsinoides var. *decumbens*	x		x
	Evolvulus alsinoides var. *villosicalyx*	x	x	x
	Ipomoea calobra			x
	Ipomoea lonchophylla			x
	Ipomoea muelleri			x

	Ipomoea pes-caprae subsp. *brasiliensis*		x	
	Ipomoea plebeia			x
	Polymeria ambigua			x
CUCURBITACEAE	*Citrullus lanatus**			x
	Cucumis maderaspatanus		x	x
	*Cucumis melo**			x
CYPERACEAE	*Bulbostylis barbata*	x		x
	Bulbostylis turbinata			x
	Cyperus bifax		x	
	Cyperus iria			x
	Cyperus ixiocarpus		x	
	Fimbristylis dichotoma	x		x
	Fimbristylis rara	x		
EUPHORBIACEAE	*Euphorbia alsiniflora*			x
	Euphorbia australis			x
	Euphorbia boophthona		x	x
	Euphorbia coghlanii		x	x
	Euphorbia drummondii			x
	Euphorbia schultzii			x
	Euphorbia wheeleri			x
	Euphorbia tannensis subsp. *eremophila*	x		
FABACEAE	*Acacia abrupta*			x
	Acacia adoxa var. *adoxa*		x	
	Acacia adsurgens	x	x	x
	Acacia aff. *catenulata*	x		
	Acacia ancistrocarpa	x	x	x
	Acacia aneura	x		x
	Acacia aneura var. *aneura*	x	x	x
	Acacia aneura var. *conifera*		x	x
	Acacia aneura var. *microcarpa*	x	x	
	Acacia aneura var. *pilbarana*		x	x
	Acacia aneura var.?		x	

Acacia bivenosa		x	x
Acacia citrinoviridis	x	x	
Acacia coriacea			x
Acacia coriacea subsp. *pendens*	x	x	
Acacia dictyophleba	x	x	x
Acacia distans		x	x
Acacia hilliana		x	x
Acacia kempeana	x	x	x
Acacia ligulata	x	x	x
Acacia maitlandii	x	x	x
Acacia marramamba	x	x	x
Acacia minyura			x
Acacia monticola		x	
Acacia pachyacra		x	
Acacia paraneura		x	x
Acacia pruinocarpa	x	x	x
Acacia pyrifolia var. *morrisonii*		x	
Acacia rhodophloia	x	x	x
Acacia sclerosperma subsp. *sclerosperma*		x	x
Acacia sericophylla	x	x	
Acacia sibilans		x	
Acacia sibirica	x	x	x
Acacia sp.		x	
Acacia sp. Hamersley Range hilltops (S. van Leeuwen 3552)	x		
Acacia spondylophylla	x		
Acacia ? *stenophylla*			x
Acacia synchronicia	x	x	x
Acacia tenuissima	x		x
Acacia tetragonophylla	x	x	x
Acacia trudgeniana	x	x	x
Acacia walkeri		x	
Acacia wanyu		x	x

Acacia xiphophylla			x
Cullen leucochaites		x	
Corchorus tridens			x
Glycine canescens		x	x
Glycine ? tabacina			x
Gompholobium karijini **P2**		x	
Gompholobium polyzygum	x	x	x
Indigofera colutea			x
Indigofera georgei	x	x	x
Indigofera linifolia		x	
Indigofera linnaei			x
Indigofera monophylla	x	x	
Isotropis atropurpurea	x	x	x
Isotropis forrestii		x	x
Kennedia prorepens	x	x	x
Leptosema chambersii	x	x	x
Mirbelia viminalis	x		x
Muelleranthus trifoliolatus	x		
Petalostylis cassioides	x	x	x
Petalostylis labicheoides		x	x
Rhynchosia minima		x	
Senna ? sp. Meekatharra (E. Bailey 1-26)		x	
Senna artemisioides			x
Senna artemisioides subsp. *filifolia*	x	x	x
Senna artemisioides subsp. *helmsii*	x	x	x
Senna artemisioides subsp. *oligophylla*	x	x	x
Senna artemisioides subsp. x *sturtii*	x		x
Senna artemisioides subsp. x *artemisioides*		x	x
Senna curvistyla	x		
Senna glaucifolia	x	x	x
Senna glutinosa			x
Senna glutinosa subsp. *chatelainiana*		x	x

	Senna glutinosa subsp. *glutinosa*	x	x	
	Senna glutinosa subsp. *pruinosa*	x	x	x
	Senna glutinosa subsp. x *luerssenii*	x	x	x
	Senna hamersleyensis		x	
	Senna notabilis	x	x	x
	Senna sericea	x	x	x
	Senna sp.		x	
	Senna stricta	x		x
	Senna symonii	x	x	x
	Senna venusta			x
	Sesbania cannabina			x
	Swainsona canescens			x
	Swainsona decurrens		x	
	Swainsona oroboides		x	x
	Tephrosia clementii			x
	Tephrosia aff. *clementii*	x		
	Tephrosia rosea var. *clementii*		x	x
	Tephrosia rosea var. *glabrior*		x	
	Tephrosia supina			x
	Vigna lanceolata			x
FRANKENIACEAE	*Frankenia setosa*			x
GOODENIACEAE	*Brunonia australis*		x	x
	Dampiera candicans	x	x	
	Dampiera cinerea			x
	Dampiera dentata		x	
	Goodenia armitiana		x	x
	Goodenia azurea subsp. *hesperia*		x	
	Goodenia lamprosperma		x	
	Goodenia microptera		x	x
	Goodenia muelleriana		x	x
	Goodenia prostrata			x
	Goodenia ramelii			x

	Goodenia sp			x
	Goodenia sp.		x	
	Goodenia stobbsiana		x	
	Goodenia tenuiloba		x	x
	Goodenia triodiophila	x	x	x
	Goodenia vilmorinae			x
	Scaevola browniana		x	x
	Scaevola parvifolia	x	x	
	Scaevola parvifolia subsp. *pilbarae*	x	x	x
	Scaevola spinescens	x		x
	Velleia glabrata		x	
GYROSTEMONACEAE	*Codonocarpus cotinifolius*	x	x	x
HALORAGACEAE	*Gonocarpus ephemerus*			x
	Haloragis gossei var. *gossei*		x	x
	Haloragis ondontocarpa forma *pterocarpa*			x
LAMIACEAE	*Dicrastylis cordifolia*	x	x	x
	Newcastelia hexarrhena	x		x
	Spartothamnella teucriiflora		x	x
LAURACEAE	*Cassytha capillaris*	x		
	Cassytha racemosa			x
	Cassytha sp.			x
LORANTHACEAE	*Amyema hilliana*		x	x
	Lysiana casuarinae		x	
MALVACEAE	*Abutilon cryptopetalum*	x	x	
	Abutilon fraseri			x
	Abutilon lepidum		x	
	Abutilon leucopetalum	x	x	x
	Abutilon macrum		x	x
	Abutilon otocarpum		x	
	Alyogyne pinoniana	x		x
	Brachychiton gregorii	x		
	Corchorus sidoides	x		x

Corchorus sidoides subsp. *sidoides*	x	x	x
Corchorus sp.	x		
Hannafordia bissillii subsp. *bissillii*	x		
Hibiscus aff. *coatesii*	x		
Hibiscus brachychlaenus	x		
Hibiscus burtonii	x	x	x
Hibiscus coatesii		x	x
Hibiscus gardneri			x
Hibiscus leptocladus	x	x	
Hibiscus sturtii		x	
Hibiscus sturtii var. aff. *truncatus* (site 1 016)		x	
Hibiscus sturtii var. *campylochlamys*	x		
Hibiscus sturtii var. *platychlamys*		x	
Hibiscus sturtii var. *truncatus*	x	x	x
Hibiscus sturtii var.?		x	
Keraudrenia nephrosperma			x
Keraudrenia velutina subsp. *elliptica*	x	x	x
*Malvastrum americanum**		x	x
Melhania oblongifolia	x	x	
Rulingia loxophylla	x	x	x
Rulingia luteiflora	x	x	
Sida sp. B Kimberley Flora (A.A. Mitchell 2745)	x	x	
Sida aff. *fibulifera*		x	
Sida arenicola	x	x	x
Sida arsiniata			x
Sida calyxhymenia			x
Sida cardiophylla	x	x	x
Sida clementii			x
Sida echinocarpa		x	
Sida ectogama	x		
Sida fibulifera	x	x	x
Sida platycalyx		x	x

	Sida sp.		x	
	Sida sp. articulation below			x
	Sida sp. dark green fruits (S. van Leeuwen 2260)	x		
	Sida sp. excedentifolia			x
	Sida sp. Pilbara (A.A. Mitchell PRP 1543)		x	
	Sida sp. spiciform panicles (E. Leyland s.n. 14/8/90)		x	
	Sida sp. tiny glabrous fruits			x
	Waltheria indica			x
MARSILEACEAE	*Marsilea hirsuta*		x	
	Marsilea mutica			x
MYRTACEAE	*Calytrix carinata*	x	x	x
	Corymbia aspera	x	x	x
	Corymbia candida subsp. *dipsodes*	x		x
	Corymbia deserticola subsp. *deserticola*	x	x	x
	Corymbia hamersleyana	x	x	x
	Corymbia opaca		x	
	Eucalyptus ? *victrix*		x	x
	Eucalyptus camaldulensis subsp. *obtusa*		x	x
	Eucalyptus gamophylla	x	x	x
	Eucalyptus leucophloia subsp. *leucophloia*		x	
	Lamarchea sulcata	x	x	x
	Melaleuca glomerata		x	
NYCTAGINACEAE	*Boerhavia coccinea*			x
	Boerhavia repleta			x
OLEACEAE	*Jasminum didymum* subsp. *lineare*	x		
OPHIOGLOSSACEAE	*Ophioglossum aff reticulatum*			
OROBANCHACEAE	*Striga squamigera*			x
PHRYMACEAE	*Mimulus uvedaliae*			x
	Peplidium muelleri			x
PHYLLANTHACEAE	*Phyllanthus erwinii*			x
	Phyllanthus maderaspatensis			x
PLANTAGINACEAE	*Stemodia grossa*		x	

	Stemodia lathraia		x	
	Stemodia viscosa			x
POACEAE	*Amphipogon caricinus* var. *caricinus*		x	x
	Amphipogon sericeus	x	x	x
	Aristida contorta	x	x	x
	Aristida holathera var. *holathera*	x	x	x
	Aristida inaequiglumis		x	x
	Aristida ingrata	x		
	Bothriochloa ewartiana		x	
	Brachyachne convergens			x
	Brachyacne prostrata			x
	*Cenchrus ciliaris**		x	x
	Chloris pumilio			x
	*Chloris virgata**		x	
	Chrysopogon fallax			x
	Cymbopogon ambiguus	x	x	x
	Cymbopogon obtectus	x	x	x
	Cymbopogon sp.	x		
	Dactyloctenium radulans		x	x
	Dicanthium sericeum ? subsp. *humilis*			x
	Digitaria ammophila			x
	Digitaria brownii	x	x	
	Digitaria ctenantha			x
	Enneapogon caerulescens		x	x
	Enneapogon intermedius	x		
	Enneapogon polyphyllus	x	x	
	Enneapogon pallidus			x
	Enteropogon ramosus		x	x
	Eragrostis cumingii	x	x	x
	Eragrostis dielsii		x	x
	Eragrostis eriopoda	x	x	x
	Eragrostis pergracilis			x

Eragrostis tenellula			x
Eragrostis xerophila			x
Eragrostis sp.	x		
Eriachne aristidea	x	x	x
Eriachne flaccida		x	x
Eriachne helmsii	x	x	
Eriachne mucronata	x	x	x
Eriachne obtusa		x	
Eriachne pulchella subsp. *dominii*		x	x
Eriachne pulchella subsp. *pulchella*	x		
Eriachne tenuiculmis			x
Eulalia aurea	x	x	x
Iseilema membranaceum			x
Leptochloa fusca subsp. *fusca*			x
Monochather paradoxus			x
Panicum effusum	x		
Paraneurachne muelleri	x		x
Paspalidium rarum			x
Paspalidium reflexum	x		
Perotis rara			x
Poaceae sp.		x	
Schizachyrium fragile	x		
Setaria dielsii		x	x
Setaria surgens			x
Sporobolus actinocladus			x
Sporobolus australasicus		x	x
Themeda triandra		x	x
Thyridolepis xerophila		x	x
Tragus australianus			x
Triodia basedowii	x	x	x
Triodia epactia	x	x	
Triodia lanigera	x		

	Triodia melvillei	x		x
	Triodia schinzii	x	x	x
	Triodia sp. Shovelanna Hill (S. van Leeuwen 3835)	x		x
	Triodia wiseana			x
	Triraphis mollis	x		
	Urochloa holosericea subsp. *velutina*			x
	Xerochloa laniflora			x
	Yakirra australiensis			x
	Yakirra australiensis var. *australiensis*	x		
POLYGALACEAE	*Polygala* aff. *isingii*	x		
	Polygala isingii			x
PORTULACACEAE	*Calandrinia balonensis*	x		x
	Calandrinia ptychosperma		x	x
	Calandrinia reticulata		x	
	Calandrinia schistorhiza		x	
	Calandrinia sp.		x	
	Portulaca filifolia			x
	Portulaca oleracea	x		x
	Portulaca pilosa		x	x
PROTEACEAE	*Grevillea berryana*	x	x	x
PROTEACEAE	*Grevillea eriostachya*	x	x	
	Grevillea juncifolia			x
	Grevillea wickhamii subsp. *hispidula*	x	x	x
	Hakea chordophylla	x	x	x
	Hakea lorea subsp. *lorea*	x	x	x
PTERIDACEAE	*Cheilanthes sieberi* subsp. *sieberi*		x	x
RUBIACEAE	*Oldenlandia galioides*			x
	Psydrax latifolia	x	x	x
	Psydrax rigidula	x		x
	Psydrax suaveolens	x	x	x
SANTALACEAE	*Anthobolus leptomerioides*	x	x	x
	Santalum acuminatum			x

	Santalum lanceolatum	x	x	x
	Santalum spicatum		x	x
SAPINDACEAE	*Diplopeltis stuartii* var. *stuartii*	x	x	x
	Dodonaea coriacea	x	x	x
	Dodonaea petiolaris	x	x	
SCROPHULARIACEAE	*Eremophila* ? *spuria*		x	
	Eremophila clarkei			x
	Eremophila cuneifolia		x	x
	Eremophila exilifolia	x	x	x
	Eremophila forrestii	x		
	Eremophila forrestii subsp. *forrestii*	x	x	x
	Eremophila fraseri		x	x
	Eremophila fraseri subsp. *fraseri*		x	
	Eremophila galeata		x	
	Eremophila georgei		x	
	Eremophila jucunda subsp. *pulcherrima*	x	x	x
	Eremophila lanceolata			x
	Eremophila latrobei subsp. *filiformis*	x	x	x
	Eremophila latrobei subsp. *glabra*		x	x
	Eremophila latrobei subsp. *latrobei*	x	x	x
	Eremophila longifolia	x	x	x
	Eremophila margarethae			x
	Eremophila platycalyx subsp. *platycalyx*		x	x
SOLANACEAE	*Nicotiana occidentalis* subsp. *occidentalis*		x	
	Nicotiana rosulata subsp. *rosulata*			x
	Solanum centrale	x	x	x
	Solanum ellipticum		x	x
	Solanum esuriale			x
	Solanum ferrocissimum			x
	Solanum lasiophyllum	x	x	x
	Solanum phlomoides			x
	Solanum sturtianum	x	x	

STYLIDIACEAE	*Stylidium adenophorum*		x	
SURIANACEAE	*Stylobasium spathulata*			x
VIOLACEAE	*Hybanthus aurantiacus*	x	x	x
ZYGOPHYLLACEAE	*Tribulopis angustifolia*			
	Tribulus astrocarpus			
	Tribulus cistoides			
	Tribulus macrocarpus			
	Tribulus occidentalis			
	Tribulus suberosus	x	x	x
	*Tribulus terrestris**			