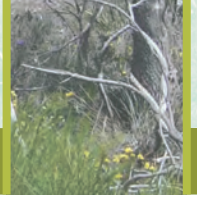
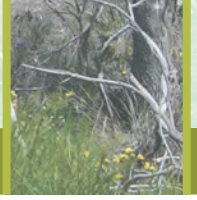


Appendices



Appendix one: GIS mapping methodology

Map datasets

The following map datasets along with metadata were provided by the DAFWA for use in the GRFVS project:

1. Beard vegetation original extent (DAFWA 2005), at 1:250,000. The following revisions were made by DAFWA:
   a. rectification of the dataset to topographic features from the State topographic dataset, primarily using the coastline and lakes
   b. correction of dataset attribution of the mapsheet edges
   c. correction of boundaries to some map units
   d. creation of a new vegetation systems map (based on 1:250,000 scale map unit boundaries) that forms a scale hierarchy with the 1:250,000 scale map units and IBRA (Interim Biogeographical Regionalisation of Australia (Thackway and Cresswell 1995)) regions and sub-regions.
2. Soil systems (DAFWA 2007). Soil-landscape mapping delineates repeating patterns of landscapes and associated soils which are proportionally allocated to mapping units. The dataset is based on a hierarchy of soil-landscape units which allows consistent mapping across different scales and varying levels of complexity. The GRFVS area is almost completely located within the Geraldton rural-residential land capability survey area. Mapping scale is 1:50,000 and position accuracy is ±50 m.
3. Vegetation extent (DAFWA 2006). This dataset was compiled as part of the national land and water resource audit (NLWRA). 1995 LandSat TM satellite imagery was used to map remnant vegetation, which was corrected using digital aerial photographs from 1996-1999 and field survey records. This dataset is continually updated by DAFWA. The Geraldton region was updated using 2006 high resolution colour digital aerial photography. Mapping scale is 1:20,000.

The following map datasets and metadata were provided by the Department of Planning (DoP) for use in the GRFVS project:

- tenure
- 1 m and 5 m contour data. Only the 5 m contour dataset (Landgate 2001) was used to assist with plant community mapping as the 1 m dataset covered a smaller area around the Geraldton town centre.
- declared rare flora and threatened ecological communities
- roads.

One linear remnant in the Oakajee industrial estate area was removed from the vegetation extent dataset at the request of the project steering committee, as it was revegetation planted on a ridgeline.

Mapping methodology

All maps included in this report were produced in ArcGIS.

The GPS waypoints recorded during the field assessment were uploaded into ArcGIS to illustrate vegetation condition and weed cover of the floristic quadrats. Two fields were added in the attribute table for vegetation condition and weed cover. The Keighery (1994) scale (appendix 2) was used to attribute vegetation condition and the Braun Blanquet (1983) scale for weed cover (appendix 2).

Interpreting and updating the Beard vegetation association dataset

During the desktop assessment it became apparent that there were discrepancies between the boundaries of the Beard vegetation maps and the more recent and smaller scale soil system mapping (map 1), with the boundaries sufficiently similar to anticipate that in most cases the soil system boundaries could be applied to the Beard vegetation maps. Michael O'Connor, in his PhD thesis centred on the Greenough alluvial flats (O'Connor 2001) also encountered the same problem, and for the purpose of his PhD, also updated the Beard vegetation association boundaries to match those of soil systems.

Appendix one: GIS mapping methodology

The Beard vegetation and soil system discrepancies were rectified in the following manner:

1. The Beard and soil system datasets were combined by a GIS spatial intersection.
2. A field was added to the attribute table and labelled 'match code' and 'anomalies', with the 'anomalies'.
3. The Beard boundaries were matched to the soil system boundaries (set as the default), as the soil boundaries were more recently and accurately mapped, and it is established that vegetation is closely allied with soils. Where there were obvious discrepancies between the two, the areas were classed as 'anomalies'.
4. The 'anomalies' between the two datasets were identified and kept as separate areas, and attributed using both the Beard and soil systems in the 'anomalies' field.
5. The polygons were attributed with a 'vegetation code' based on the Beard vegetation association number.
6. Dissolve the shapefile for 'vegetation code' and 'description' to create the updated Beard vegetation association map.

Interpretation of some of the anomalous polygons indicated that they should be included in one of the adjacent vegetation association polygons; however some anomalous areas could only be attributed to the relevant vegetation association after assessment during the verification survey. Map 1 in appendix 5 displays the rectified Beard vegetation association boundaries.

Calculating vegetation extents

The updated Beard vegetation association dataset was used to calculate the area (in hectares) of original extent, using the X tools extension in ArcGIS. The method used was as follows:

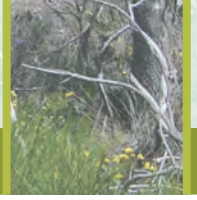
1. The updated Beard vegetation association dataset was intersected with the vegetation extent dataset and calculated the areas of the extent for the association number.
2. Dissolved intersected dataset for 'vegetation code' and 'description' resulting in one polygon per vegetation code.
3. In Excel, divided the current Beard vegetation association extent by the original pre-European Beard vegetation association extent to calculate the percentage remaining of each original vegetation association in the study area (table 2).

Plant community mapping

The vegetation extent mapping (DAFWA 2006) was used to define remnant vegetation in the GRFVS area. Some areas of vegetation, including an area south of the Greenough River and along the coastline, were not included in the vegetation extent. Where these were obvious they were added to the vegetation extent. Some areas had since been cleared: these were deleted from the vegetation extent although the boundaries were approximate only.

Plant community boundaries were initially delineated using aerial photography utilising colour and texture changes in both soil and vegetation, soil subsystem mapping, elevation mapping and Google Street View (Google Inc 2009) in urban areas, combined with knowledge from previous surveys, to estimate locations of plant community boundary changes and attribute plant communities. These were hand drawn onto printouts, then digitised using Arc GIS.

These anticipated boundaries were groundtruthed in June 2009, and boundaries and attribution, including vegetation extents, corrected using ArcGIS 9. The newly created vegetation extent boundaries were used to calculate plant community areas, but were not used for vegetation extent calculations for Beard vegetation associations.



Appendix two: Field methodology

The floristic quadrat survey was undertaken in accordance with the project brief, as modified by the project steering committee, which stated that:

- **The survey was required to be conducted according to EPA Guidance Statement 51 (2004), including the season that the survey was to be done (spring)**. The survey was conducted in August and October, 2008.
- **Supplementary surveys would be required if the conditions were non-optimal (eg drought)**. The long-term annual rainfall for Geraldton Airport (1941-present) is 444.4 mm. Annual rainfall in 2008 was 347.4 mm, which whilst only 78% of the mean, was considerably higher than recorded during the previous two years' (231.0 mm in 2007 and 197.4 mm in 2006) (BOM 2008) and is therefore not likely to constitute a drought. The vegetation appeared to not be suffering from lack of rainfall, although dead plants appeared to corroborate the drought conditions of the previous years.
- **The methodology would be comparable with Level 5 association NVIS mapping and describing vegetation**. Details of NVIS methodology are below.
- **All vascular plant species would be recorded for the floristic quadrats, with percent cover for dominant species recorded**. The original brief stated that all species should have their cover value recorded; however this was deemed to be unnecessary and only dominant species were recorded.
- **At least one floristic quadrat of 20 m x 20 m would be established in each vegetation association in each location**. Discussions with the project steering committee and DEC indicated that 10 m x 10 m quadrats were the usual dimension in the South-west Botanical Province, therefore this was adopted as the standard for the project to permit comparison with nearby data (eg Geraldton Sandplain). Two quadrats in linear habitats were 20 m x 5 m in dimension, which still met the 100 m2 standard required. In relation to establishing a quadrat in each vegetation association in each location: this would require establishing at least one quadrat in each vegetated remnant (or more than one quadrat, if there was more than one vegetation type present), which, with 625 remnants in the GRFVS area, is beyond the financial scope for the project. Instead, sites were carefully selected to represent the geographical and vegetation range of the project area.
- **Each plot was to be permanently marked**. This was achieved with a labelled fence dropper positioned at the north-west corner of the quadrat, which was orientated along a north south and east west bearing (except the two linear quadrats, where their direction was recorded). The fence dropper had the open side facing the quadrat.
- **At least one voucher specimen was to be collected for each species**. This was conducted, except where only one was specimen located within or near the quadrat (this plant was photographed and identified from the photograph as a declared rare flora species), or where there was no possibility of identifying the species from vegetative characteristics only (mostly orchids).
- **Targeted surveys for declared rare flora, priority flora and other significant flora would be undertaken**. The project steering committee determined that this was not required.
- **Vegetation mapping would include groundtruthing and refinement of vegetation association boundary mapping**. The refinement of the Beard vegetation association boundaries was undertaken as part of the desktop assessment and ground-truthed during a verification survey in July 2008. Refined mapping could not be undertaken until after floristic analysis.
- **Vegetation condition mapping, using the Keighery (1994) bushland condition rating scale** (detailed below). This was not possible within the financial scope of the project for all areas of native vegetation in the GRFVS area; however, the Keighery bushland condition was recorded for all floristic quadrats, and was used to assess the Glenfield-Waggrakine rural residential structure plan areas.
- **A GPS location and photograph, including the direction the photograph to be taken, of each floristic quadrat was recorded**. This was completed.

Additional information was recorded for the floristic quadrats using standards equivalent to standard DEC vegetation recording forms. The data collected, additional to that detailed above, was:

- topography (landform);
- slope and aspect;
- surface soil type and colour;
- exposed rock type, percent of quadrat covered and fragment size;

Appendix two: Field methodology

- leaf litter cover (%) and depth;
- bare ground (%);
- weed cover (%), although this was displayed in Braun-Blanquet (1983) cover classes; and
- disturbance type.

NVIS recording system

The National Vegetation Information System (NVIS) (National Heritage Trust 2003) is a standardised nationally-consistent method of recording vegetation. It provides a comprehensive means of describing and representing vegetation information based on establishing relationships between structural and floristic data, and can be directly related to precise spatial areas as a vegetation map. A range of management and planning practices, including biodiversity conservation, salinity control, water quality control and fire management, can use the information collected by this system.

NVIS data is collected at various hierarchies, which equate to the level of detail and complexity of the information collected, shown below in table A2.1. Levels V and VI are those recommended for data compilation.

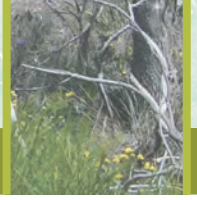
The GRFVS is recorded at Level V (association level). At this level, information is collected in the field using the traditional three strata (upper, mid and ground), recording the three dominant or characteristic species in each. There is a strict hierarchy assigned to how vegetation is recorded, with all species assigned to growth forms, strata confined to set height classes, and growth forms assigned to set strata (table A2.2). The result is a complex vegetation description, shown in floristic quadrat descriptions in appendix 6).

Keighery bushland condition

The Keighery bushland condition rating scale (1994) was designed so it could be used by people with little vegetation recording experience to record the condition of vegetation on the Swan Coastal Plain. The descriptive categories, detailed in table A2.3, are broadly applicable to many areas and have been adopted as a 'standard' for many vegetation surveys.

Table A2.1: NVIS information hierarchy (National Heritage Trust 2003)

Hierarchical Level	Description	NVIS Structural/Floristic Components Required
I	Class	Dominant growth form for the ecologically or structurally dominant stratum
II	Structural Formation	Dominant growth form, cover and height for the ecologically or structurally dominant stratum
III	Broad Floristic Formation	Dominant growth form, cover, height and dominant land cover genus for the upper most or the ecologically or structurally dominant stratum
IV	Sub-Formation	Dominant growth form, cover, height and dominant genus for each of the three traditional strata (ie Upper, Mid and Ground)
V	Association	Dominant growth form, height, cover and species (3 species) for the three traditional strata (ie Upper, Mid and Ground)
VI	Sub-Association	Dominant growth form, height, cover and species (5 species) for all layers/sub-strata



Appendix two: Field methodology

Table A2.2: NVIS height classes (National Heritage Trust 2003)

Height		Growth Form				
Height Class	Height Range (m)	tree, vine (M and U), palm (single-stemmed)	shrub*, fern, cycad, tree-fern, grass-tree, palm (multi-stemmed)	tree mallee, mallee shrub	grass**, sedge, rush, forb, vine (G)	moss, lichen, seagrass, aquatic
8	>30	tall	n/a	n/a	n/a	n/a
7	10-30	mid	n/a	tall	n/a	n/a
6	<10	low	n/a	mid	n/a	n/a
5	<3	n/a	n/a	low	n/a	n/a
4	>2	n/a	tall	n/a	tall	n/a
3	1-2	n/a	mid	n/a	tall	n/a
2	0.5-1	n/a	low	n/a	mid	tall
1	<0.5	n/a	low	n/a	low	low

* Shrubs can be divided into 'shrubs', 'heath shrubs', 'chenopod shrubs' and 'samphire shrubs'.

** Grasses can be divided into 'tussock grass', 'hummock grass', and 'other grass'.

Table A2.3: Keighery bushland condition rating scale

Condition	Description
Pristine	No obvious signs of disturbance
Excellent	Vegetation structure intact, disturbance only affecting individual species and weeds are non-aggressive species
Very Good	Vegetation structure altered, obvious signs of disturbance eg: repeated fires, aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure altered, obvious signs of disturbance. Retains basic vegetation structure or ability to regenerate it. The presence of very aggressive weeds at high density, partial clearing, dieback, logging and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Requires intensive management. The presence of very aggressive weeds at high density, partial clearing, dieback, logging and grazing.
Completely Degraded	Vegetation structure is no longer intact and the area is completely or almost completely without native flora. 'Parkland Cleared'.

Appendix two: Field methodology

Examples of each vegetation condition, recorded during the Glenfield-Waggrakine survey are illustrated below, except for the *pristine* condition photograph, from the Wokatherra Gap floristic quadrat (GRV0864).

Plate A2.1: Pristine condition vegetation, GRV0864 (Wokatherra Gap)

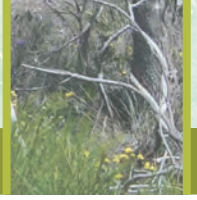
Plate A2.2: Excellent condition vegetation (Albert Street, Waggrakine)

Plate A2.3: Very good condition vegetation (Sutcliffe Road, Waggrakine)

Plate A2.4: Good condition vegetation (Cooper Road, Waggrakine)

Plate A2.5: Degraded condition vegetation (David Road, Waggrakine)

Plate A2.6: Completely degraded vegetation (Sutcliffe Road, Waggrakine)



Appendix two: Field methodology

Table A2.4: Braun-Blanquet cover abundance scale, used for weed cover

	Braun-Blanquet Cover Abundance Scale
R	solitary, with small cover (occurs once)
T	few, with small cover (<1%)
1	numerous, but less than 5% cover, or scattered with cover up to 5%
2	any number, with 5-25% cover
3	any number, with 25-50% cover
4	any number, with 50-75% cover
5	any number, with >75% cover

Botanical survey limitations

Possible Limitations	Constraints (Yes/No); Significant, Moderate or Negligible	Comment
Competency/experience of the consultant conducting the survey	No constraints	Senior botanist with extensive survey experience and taxonomic skills, environmental scientist with good observation.
Proportion of the flora identified	Negligible constraints	Approximately 300 person-hours spent on site and travelling between sites. Some species were not identified to species level, however none were likely to be threatened flora.
Proportion of the task achieved and further work that may need to be undertaken	No constraints	Estimated 95-100% of total likely floristic suite recorded. No additional survey considered necessary.
Timing/weather/season/ cycle	Negligible constraints	64% of average seasonal rainfall, with no observed affects of reduced rainfall on plant species
Intensity of survey (eg In retrospect was the intensity adequate?)	Negligible constraints	Vegetation was intensively surveyed.
Completeness (eg Was relevant area fully surveyed?)	Negligible constraints	All major vegetation types were adequately surveyed, and only a few uncommon variations were not assessed during the floristic quadrat survey.
Resources (eg Degree of expertise available for plant identification)	Negligible constraints	Plant identification completed in field and in-house. Problematic flowering species were identified in the Western Australian Reference Herbarium, where material was available.
Remoteness and/or access problems	No constraints	Some areas on private property could not be assessed; however adequate representation was recorded from accessible areas.
Availability of contextual (eg bioregional) information for the survey area	No constraints	The Geraldton region is generally well surveyed and well-known.

Appendix three: Statistical analysis and interpretation

Statistical methods

Multivariate analysis is the usual statistical analysis used to sort site and species data so that patterns in species composition can be more easily seen (eg Gibson *et al*. 1994). Sites are classified into groups according to the occurrence (presence / absence) of species using the Bray and Curtis, 1957 similarity coefficient followed by UPMGA fusion. The Bray and Curtis measure is one of the best proven association measures in the field of ecology (Clarke and Warwick 2001), and is the measure of choice when differences between high data values are considered more significant than the same difference between low data values.

However since the data being analysed is presence/absence only, the Kulczynski coefficient is the more appropriate association to use. It has similar properties to the Bray and Curtis measure, but was originally formulated specifically for presence/absence data. Like the Bray and Curtis measure, the Kulczynski coefficient has proven to be a good estimation of association for ecological applications (Belbin and Collins 2006).

The number of site and species groups defined is subjective and relates to the scale of pattern of interest (Gibson et al. 1994). In this analysis 15 groups were defined, which was thought to best reflect the scale of pattern seen in the field. This classification will not be definitive and as more data becomes available new floristic communities will emerge.

Representation of the species for each site is by a dendrogram, which is a tree-like diagram that displays the relationships between the objects being classified (either rows or columns) and links the sites in hierarchal groups on the basis of some similarity between each site. The x-axis represents the full set of samples and the y-axis defines a similarity level at which two samples or groups are considered to have fused (Clarke and Warwick 2001).

PATN© analysis

PATN© statistical analysis (Belbin and Collins 2006), or earlier versions, have been used for several local floristic analyses including Gibson et al (1994) for the Swan Coastal Plain, Markey (1997) for the northern Darling Scarp, and initially by Craig et al. (2008) for the Ravensthorpe Ranges, and was the statistical method specified in the project brief.

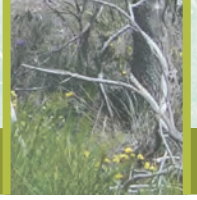
PATN© is a multivariate analysis tool that generates estimates of association (resemblance, affinity, distance) between sets of objects described by a suite of variables (attributes), and classifies the objects into groups and condenses the information and displays the patterns in the data graphically.

Presence/absence data recorded from the 81 floristic quadrats was used, with all species included in the analysis.

The fusion type used on the data was UPGMA (unweighted pair group mean average also known as average link method) and is a simple agglomerative or bottom-up data clustering method. While the association measure used was the Kulczynski coefficient. Calculating association, resemblance, differences, correlation or affinity between objects or variables of the data table is one of the most important steps in pattern analysis. All classification, ordination and network techniques in pattern analysis use estimates of association (Belbin and Collins 2006). Stated previously in the report, the Bray Curtis association is one of the best proven association measures in the field of ecology and is set as the default measure in PATN©. However, in this instance the Kulczynski coefficient was used as it was originally formulated for presence/absence data and it doesn't place the assumption on the data that differences between high data values are considered more significant than the same difference between low data values, as it does with the Bray Curtis association (Clarke and Warwick 2001).

The results were displayed using a dendogram (figure A3). The number of hierarchical groups (in this case floristic groups) is not predetermined, but is chosen to best represent the pattens in the data emerging from the analysis. For the GRFVS data, it was considered that 15 floristic groups may be an appropriate number, thus figure A3 displays this number.

Generally, when interpreting a dendogram, the earlier (further to the right) that a quadrat separates (splits) from the others, the more distinctive it is, and the later (further to the left), the greater the number of elements (in this case, species) in common. For the GRFVS quadrat data, the first split separates the foredune and estuarine quadrats from the others, which are subsequently divided into their separate floristic groups. The position of the splits (to the right) indicates that these groups have little similarity.



Appendix three: Statistical analysis and interpretation

The second split on the dendogram separates the more coastal and riparian quadrats from the more inland quadrats, indicating little similarity between these groups, then separates the coastal and riparian groups.

This has resulted in five supergroups, described below:

Supergroup 1: Estuarine

This supergroup, which also forms a floristic group and plant community, occurs on clay soils associated with saline riparian (estuarine) areas, and are largely sparse *Casuarina obesa* woodlands over samphire species (*Tecticornia* and *Sarcocornia* spp) shrublands. Two quadrats were recorded, but the vegetation type is common and distinctive, although it is restricted in area.

Supergroup 2: Riparian

The riparian supergroup, which is also a floristic group and plant community, occurs in riparian areas (associated with watercourses), and is characterised by *Eucalyptus camaldulensis*, *Melaleuca rhaphiophylla* and *Casuarina obesa* woodlands.

Three quadrats occurring in this supergroup were located in the area informally known as Rum Jungle (Glenfield), which appears to be a former watercourse with no obvious exit to the ocean. Although not discussed further in this report, additional statistical analyses[6] were undertaken whilst attempting to explain some of the results of the PATN© analysis (largely without success, thus why not discussed further), which grouped the two Rum Jungle sites dominated by Casuarina obesa with the estuarine sites. This indicates some degree of similarity, which is apparent in the field as samphire species occur sporadically (but not within the floristic quadrats) in this area. It also indicates that Rum Jungle may be becoming more saline, and eventually may be included in the estuarine plant community, despite having no contact with the ocean.

Supergroup 3: Foredune

This supergroup is also common and distinctive, but can be easily degraded as it occurs only on the foredunes, immediately above the beach where human access and subsequent wind erosion reduce plant cover. Atriplex isatidea and Spinifex longifolius are the characteristic species of this supergoup, which is geographically restricted to a narrow band usually less than 20 m wide adjacent to the beach, and merging with *Acacia rostellifera* dominated low shrublands inland.

Supergroup 4: Near Coastal

The Near Coastal supergroup is formed by plant communities that occur on the coastal and near coastal dunes and swales, and limestone ridges. Within this supergroup, *Acacia rostellifera*, *Melaleuca cardiophylla* and various mallee Eucalypts would be the characteristic species, with two distinctive floristic groups characterised by *Ficinia nodosa* (sedge) and *Frankenia pauciflora* occurring in swales included (with *Acacia rostellifera* also occurring in both of these).

This supergroup is confined to the Quindalup and Tamala soil systems, which are extensive in the area.

Supergroup 5: Sandplain and Thickets

The Sandplain and Thickets supergroup is composed of the more inland floristic communities occurring on the sandplain soils of the Tamala soil system, and the Greenough, Moresby and Northampton soil systems.

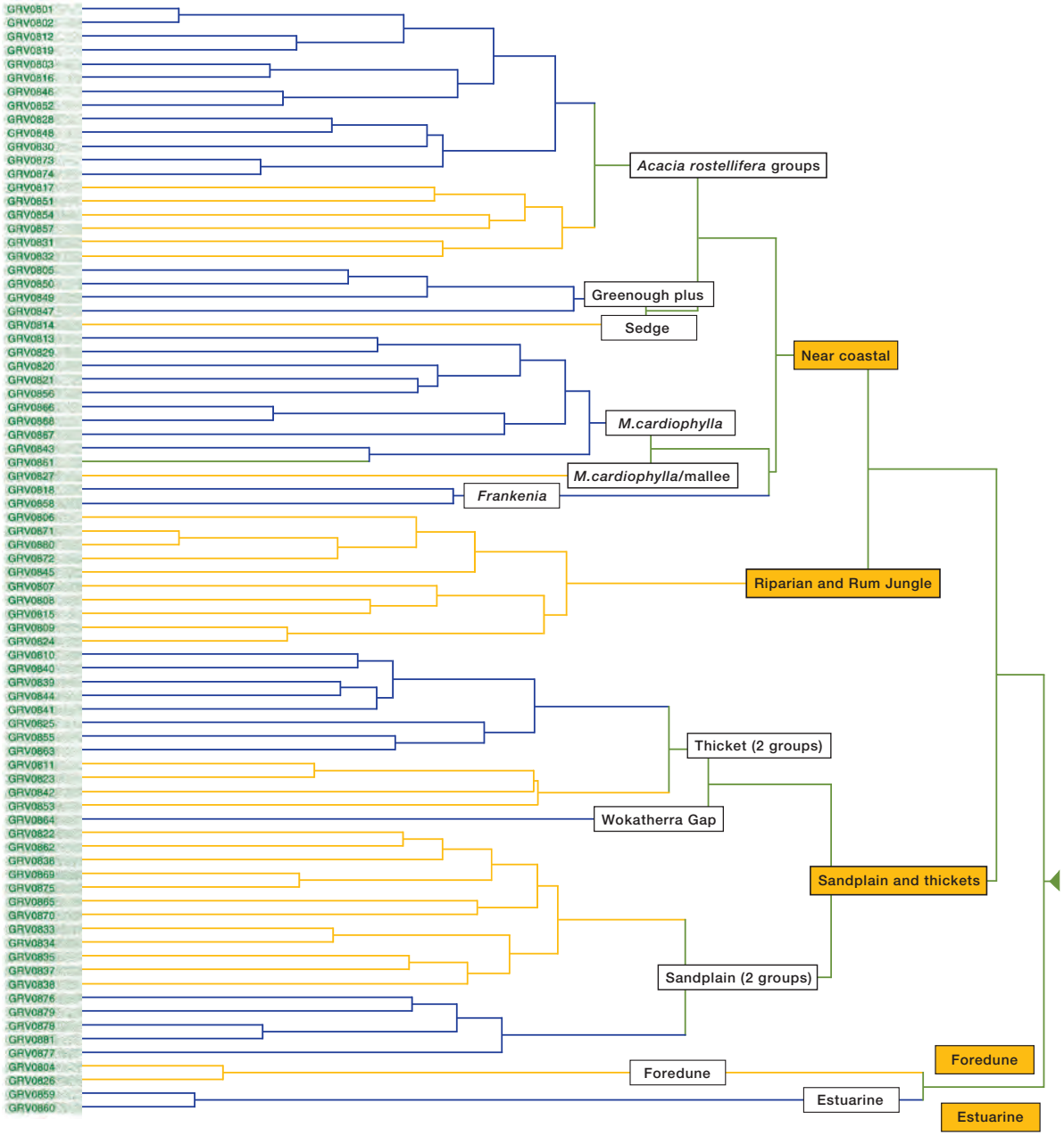
Later splits in the dendogram indicate this supergroup comprises the Sandplain plant communities (including Chapman River Reserve) and the woodlands and thickets of the loamy and rocky soils of the Moresby and Northampton soil systems.

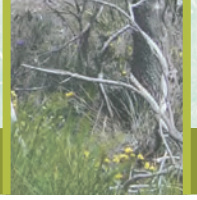
[6] The relevant analysis in this case was PATN© Bray and Curtis analysis, using cover values of dominant species rather than the Kulczynski analysis using presence/absence data.

Appendix three: Statistical analysis and interpretation

Figure A3: Dendogram from PATN© Kulczynski analysis

Uncoloured text boxes indicate the floristic group name assigned (M.car is an abbreviation for *Melaleuca cardiophylla*). Descriptions and discussions are detailed below. Supergroups are displayed as orange text boxes





Appendix three: Statistical analysis and interpretation

Interpretation

As the aim of the project is to develop relevant plant community descriptions for the GRFVS project area, it is important that plant communities can be recognisable on-ground. PATN© analysis, producing floristic groups, is a tool for recognising groups that are floristically related, but does not take other aspects into account, including dominant species or vegetation structure, when formulating these groups. As an example, a tree or mallee-dominated plant community containing most species found in adjacent shrublands is not differentiated by floristics, but is obviously structurally different.

Therefore, further interpretation of floristic groups was required to develop plant communities relevant to the GRFVS area. This interpretation took into account vegetation structure, soil systems and subsystems, landform and geography, together with discussions with Geraldton-based members of the project steering committee and others familiar with the vegetation of the area (eg members of the local herbarium), to develop relevant plant communities that are recognisable in the field.

This further interpretation resulted in 18 plant communities. One plant community, identified from one quadrat in the Moresby Range (included at the request of a project steering committee member) but not within the GRFVS project area, separated from other similar vegetation during floristic analysis. As this floristic group is not from within the project area, and was recorded from only one quadrat within a large and diverse area, this Moresby Range floristic group is not included in the discussion for the project area.

Therefore, there are 17 plant communities identified from the GRFVS area, described in appendix 8:

- 1. Estuarine: *Casuarina obesa / Tecticornia / Sarcocornia (Co/Te/Sa)*
- 2. Riparian: *Eucalyptus camaldulensis / Casuarina obesa / Melaleuca rhaphiophylla (Ec/Co/Mr)*
- 3. Foredune: *Atriplex isatidea / Spinifex longifolius (Ati/Spl)*
- 4. Swale: *Ficinia nodosa (Fin)*
- 5. Swale: *Frankenia pauciflora (Frp)*
- 6. Coastal: *Thryptomene baeckeacea (Thb)*
- 7. Coastal: *Melaleuca cardiophylla (cMc)*
- 8. Coastal: *Acacia rostellifera low shrubland (cAr)*
- 9. Coastal: *Acacia rostellifera / Eucalyptus* spp. (*Ar*/Espp)
- 10. Near Coastal: *Acacia rostellifera* shrubland (nc*Ar*)
- 11. Limestone ridge: *Melaleuca cardiophylla /Eucalyptus* spp. (*Mc*/Espp)
- 12. Limestone ridge: *Melaleuca cardiophylla* (r*Mc*)
- 13. Sandplain: *Banksia prionotes / Acacia rostellifera (Bp/Ar)*
- 14. Chapman River Reserve: *Acacia rostellifera /Melaleuca* spp (Ar/Mspp)
- 15. Thicket: *Melaleuca* spp / mixed spp (*M*spp/mx)
- 16. Woodland: *Acacia acuminata / A. tetragonophylla / Hakea preissii (Aa/At/Hp)*
- 17. Woodland: *Eucalyptus loxophleba (El)*.

These 17 plant communities were largely identified from the floristic analysis; however interpretation was used to differentiate some of these:

- the two *Acacia rostellifera* groups identified from the floristic analysis were separated into a different arrangement based on:
  - vegetation structure, which separated the coastal mallee (into plant community 9)
  - a combination of landform (including distance from the coast and primary/secondary dune interpretation) and structure (height), which separated into two groups; low coastal shrubland (plant community 8) and near coastal (taller) shrubland (plant community 10)

Appendix three: Statistical analysis and interpretation

- the 'Greenough plus' group, which included one floristic quadrat near Glenfield Beach, was determined to not be a recognisable group, and the two of the quadrats were included in plant community 8 (Coastal *Acacia rostellifera* shrubland), with two retained as separate plant communities based on their dominant species (plant community 6 *Thryptomene baeckeacea* and plant community 7 *Melaleuca cardiophylla*)
- one quadrat that, based on floristic analysis, was grouped with the *Melaleuca cardiophylla* on limestone ridge plant community (12) was removed and placed into plant community 11 limestone ridge *Melaleuca cardiophylla / Eucalyptus* spp (mallee), based on structure (the inclusion of a mallee species)
- the two thicket groups identified from the floristic analysis were separated into a different arrangement, based on vegetation structure, dominant species and soil, and resulted in the identification of three plant communities:
  - plant community 17 *Eucalyptus loxophleba* (York gum) woodland
  - plant community 16 *Acacia acuminata / A. tetragonophylla / Hakea preissii* woodland on loamy soils of the Northampton soil system
  - plant community 15 *Melaleuca* spp / mixed species thicket (usually tall, dense shrubland on rocky soil)
- the two Sandplain groups were rearranged slightly to form two groups based on soil and geography, and became:
  - plant community 13 *Banksia prionotes / Acacia rostellifera*, which occurs mostly on yellow sandplain soils and has a characteristic subset of species including *Banksia* spp, but also includes *Grevillea candelabroides*, *Melaleuca depressa*, *Hibbertia* spp., *Conostylis* spp. and several sedges and rushes
  - plant community 14 Chapman River Reserve: *Acacia rostellifera /Melaleuca* spp, which generally does not contain the characteristic species of plant community 13 (or not as dominant or characteristic species), and occurs only on the shallow soils close to the Chapman River. Most of the Chapman River Reserve is plant community 13.

It is possible that many areas that are now occupied by plant community 10, Near Coastal *Acacia rostellifera* shrubland, were probably formerly plant community 13, *Banksia prionotes / Acacia rostellifera*, but have been altered by clearing and grazing to now be dominated by *Acacia rostellifera*, which appears to be a colonising species.

Table A4.1: Soil landscape map unit (subsystem level) of the GRFVS area

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
221Ga_1Dr	phase	Greenough Alluvium 1 Drainage line Phase	Drainage lines in the alluvial plain. Red sandy earth with cracking clay and Semi-wet soils	Drainage lines in the alluvial plain	Recent alluvial deposits from the Greenough River	Red sandy earth with cracking clay and Semi-wet soils		between the Quindalup dunes and Tamala limestone in the Geraldton Coastal Zone
221Ga_1G1	phase	Greenough Alluvium 1 Plain Phase	Level to very gently undulating alluvial plain. Hard setting, cracking uniform clayey soils with an alkaline soil reaction trend.	Level to very gently undulating alluvial plain	Recent alluvial deposits from the Greenough River	Hard setting, cracking uniform clayey soils with an alkaline soil reaction trend.	Mainly cleared	between the Quindalup dunes and Tamala limestone in the Geraldton Coastal Zone
221Ga_1G2	phase	Greenough Alluvium 1 rises Phase	Slight rises bordering the Greenough alluvial plain.	Slight rises bordering the Greenough alluvial plain.	Recent alluvial deposits from the Greenough River	Yellow brown shallow loamy duplex with Red shallow loamy duplex	Mainly cleared	between the Quindalup dunes and Tamala limestone in the Geraldton Coastal Zone
221Ga_2Bwd	phase	Greenough Alluvium 2 Bootenal well drained Phase	Well drained plain	Well drained level to very gently undulating plain	Alluvium	Red sandy and loamy duplex soils with Brown deep sands	Mainly cleared. Acacia acuminata (jam) on road verges.	the eastern side of the Tamala limestone in the Geraldton Coastal Zone, nth of Narngulu
221Ga_4Af	phase	Greenough Alluvium 4 lower river terraces Phase	Recent alluvium subject to flooding	Lower terraces of the major rivers, subject to regular flooding	Recent alluvial deposits from the Greenough River	Brown loamy earth is dominant with Semi-wet soil	Eucalyptus camaldulensis mid - high open woodland.	between the Quindalup dunes and Tamala limestone in the Geraldton Coastal Zone

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
221Ga_4Bid	phase	Greenough 4 Bootenal imperfectly drained Phase	Level to very gently undulating relict alluvial plain in the southern sector of the Bootenal alluvial plain.	Level to very gently undulating relict alluvial plain	Alluvium	Semi-wet soils with a gradational or uniform heavy textured profile	Mainly cleared	the eastern side of the Tamala limestone in the Geraldton Coastal Zone, nth of Narngulu
221Ga_4Bpd	phase	Greenough 4 Bootenal poorly drained Phase	Poorly drained plain. Convergence of surface drainage. Wet soil with poorly drained clayey soils.	Poorly drained plain. Convergence of surface drainage.	Alluvium	Wet soil with poorly drained clayey soils.	Mainly cleared, a community of Hakea preisii and some Eucalyptus camaldulensis individuals remain.	the eastern side of the Tamala limestone in the Geraldton Coastal Zone, nth of Narngulu
221Ga_4Bwd	phase	Greenough 4 Bootenal well drained Phase	Level to very gently undulating prior alluvial depositional plain (1-3% slope). Red sandy and loamy duplex soils with Brown deep sands	Level to very gently undulating prior alluvial depositional plain (1-3% slope).	Alluvium	Red sandy and loamy duplex soils with Brown deep sands	Mainly cleared. Acacia acuminata (jam) on road verges.	eastern side of the Tamala limestone in the Geraldton Coastal Zone, nth of Narngulu
221Ga_4Dr	phase	Greenough Alluvium 4 Drainage line Phase	Drainage lines in the alluvial plain. Red sandy earth is dominant	Drainage lines in the alluvial plain	Alluvium	Red sandy earth is dominant		between the Quindalup dunes and Tamala limestone in the Geraldton Coastal Zone
221GaX_ MINE	phase	Greenough Alluvium, MINE Phase	Mine site. Disturbed soils					

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
221Qu_1Dr	phase	Quindalup Central 1 Drainage Line Phase	Drainage lines which cut through the Quindalup dunes. Calcareous deep sand with wet and Semi wet soils	Drainage lines which cut through the Quindalup dunes	aeolian calcareous sands and minor limestone	Calcareous deep sand with wet and Semi wet soils		North Coastal Plain, adjacent to the coast from Jurien Bay to Horrocks
221Qu_1Qf	phase	Quindalup Central 1 foredune Phase	Narrow frontal dunes with relief from 5-10 m. Calcareous deep sand	Narrow frontal dunes with relief from 5-10 m.	aeolian calcareous sands and minor limestone	Calcareous deep sand	Mid-high to tall isolated shrubs of Atriplex isatidea, Nitraria billardierei (nitre bush) and Scaevola crassifolia.	North Coastal Plain, adjacent to the coast from Jurien Bay to Bluff Point
221Qu_1Qm	phase	Quindalup Central mobile parabolic dune Phase	Active parabolic dunes and blowouts. Calcareous deep sand	Active parabolic dunes and blowouts	aeolian calcareous sands and minor limestone	Calcareous deep sand	Low isolated clumps of long leaved spinifex, angular pigface, knotted club rush and coastal daisy bush.	North Coastal Plain, adjacent to the coast from Jurien Bay to Bluff Point
221Qu_1Qp1	phase	Quindalup Central stable parabolic dune Phase1	Low stable parabolic dunes with relief 5-15 m. Calcareous deep sand	Low stable parabolic dunes with relief 5-15 m.	aeolian calcareous sands and minor limestone	Calcareous deep sand	Acacia rostellifera low woodland with Scaevola crassifolia, Stylobasium spathulatum and Lycium ferocissimum as other common plants.	North Coastal Plain, adjacent to the coast from Jurien Bay to Bluff Point
221Qu_1Qp2	phase	Quindalup Central stable parabolic dune Phase2	Large scale parabolic dunes with relief 20-40 m. Calcareous deep sand	Large scale parabolic dunes with relief 20-40 m	aeolian calcareous sands and minor limestone	Calcareous deep sand	Acacia rostellifera low woodland with mixed lower shrubs and ground plants.	North Coastal Plain, adjacent to the coast from Jurien Bay to Bluff Point

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
221Qu_1Qs1	phase	Quindalup Central 1 frontal plain Phase	Low lying plain adjoining foredune or beach. Calcareous deep sand	Low lying plain adjoining foredune or beach.	aeolian calcareous sands and minor limestone	Calcareous deep sand		North Coastal Plain, adjacent to the coast from Jurien Bay to Bluff Point
221Qu_1Qs2	phase	Quindalup Central 1 swale Phase	Gently undulating plains surrounded by parabolic dunes. Calcareous deep sand	Gently undulating plains surrounded by parabolic dunes.	aeolian calcareous sands and minor limestone	Calcareous deep sand	Olearia axillaris - Acacia rostellifera tall shrubland	North Coastal Plain, adjacent to the coast from Jurien Bay to Bluff Point
221Qu_1 URBAN	phase	Quindalup Central 1 urban Phase	Urban development on Quindalup 1 coastal dune subsystem. Man made, disturbed soils; originally Calcareous deep sand	Urban development on Quindalup 1 coastal dune subsystem	aeolian calcareous sands and minor limestone	Man made, disturbed soils; originally Calcareous deep sand		North Coastal Plain, adjacent to the coast from Jurien Bay to Horrocks
221QuX_ BEACH	phase	Quindalup Central beach Phase	Beach. Calcareous deep sand	Beach	Holocene shoreline deposits	Calcareous deep sand		on the coast north of Jurien
221Ta_2Tst	phase	Tamala South 2 steep rocky slopes Phase	Steep dune slopes with very common limestone outcrop. Shallow (10-50 cm) uniform brownish sands, non-calcareous	Steep dune slopes with very common limestone outcrop	Pleistocene limestone and aeolian sand	Shallow (10-50 cm) uniform brownish sands, non-calcareous	Tall closed shrubland.	area adjacent to the coast from Jurien Bay to Kalbarri

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
221Ta_3	subsystem	Tamala South 3 Subsystem	Low hills with relict dunes and some limestone outcrop; Deep and shallow yellow sand over limestone	Low hills and rises with relict dunes and some limestone outcrop	Lithified Pleistocene calcareous dune deposits with Recent dunes.	Deep and shallow yellow sand over limestone	Heath with some Banksia prionotes low open woodland	South of Dongara to Kalbarri
221Ta_3Ysp	phase	Tamala South 3 yellow sandplain Phase	Level to undulating sandplain. Yellow deep sand	Level to undulating sandplain.	Lithified Pleistocene calcareous dune deposits with Recent dunes.	Yellow deep sand	Largely cleared, remnants include open banksia-Acacia woodland.	South of Dongara to Kalbarri
221Ta_4Ty	phase	Tamala South 4 yellow deep sand Phase	Gently undulating plain on the eastern side of the Tamala Limestone. Slopes 2-8%. Yellow deep sand	Gently undulating plain on the eastern side of the Tamala Limestone. Slopes 2-8%.	Lithified Pleistocene calcareous dune deposits	Yellow deep sand	Mixed tall closed shrubland. Common species are Acacia rostellifera, Melaleuca oldfieldii and Allocasuarina campestris.	South of Dongara to Kalbarri
221Ta_5Dr	phase	Tamala South 5 Drainage line Phase	Drainage lines dissecting the dunes and hills. Calcareous deep sand with Wet and Semi-wet soils	Drainage lines dissecting the dunes and hills	Lithified Pleistocene calcareous dune deposits and Recent calcareous sand	Calcareous deep sand with Wet and Semi-wet soils		Cliff Head to Geraldton
221Ta_5Tb	phase	Tamala South 5 grey-brown sand Phase	Mid to lower slopes of Tamala Limestone ridges and some isolated rises. Calcareous deep and shallow sands	Mid to lower slopes of Tamala Limestone ridges and some isolated rises	Lithified Pleistocene calcareous dune deposits and Recent calcareous sand	Calcareous deep and shallow sands	Mainly cleared. Acacia acuminata (jam) on road verges.	Cliff Head to Geraldton

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
221Ta_5Tr	phase	Tamala South 5 red sand Phase	Lower lying and swale areas. Red deep sand	Lower lying and swale areas.	Lithified Pleistocene calcareous dune deposits and Recent calcareous sand	Red deep sand	Acacia rostellifera low woodland with Lycium ferocissimum and Stylobasium spathulatum as other common trees.	Cliff Head to Geraldton
221Ta_5Ts	phase	Tamala South 5 shallow sand Phase	Undulating to gently undulating relict dune crests with shallow sand and common limestone rock outcrop. Shallow red and brown sands	Undulating to gently undulating relict dune crests with shallow sand and common limestone rock outcrop	Lithified Pleistocene calcareous dune deposits and Recent calcareous sand	Shallow red and brown sands	Low mixed open woodland.	Cliff Head to Geraldton
221Ta_6	subsystem	Tamala South 6 Subsystem	Low hills with relict dunes and some limestone outcrop.	Low rises and ridges		Red shallow sand and limestone outcrops		
221TaX_ MINE	phase	Tamala South mine Phase	Mine site. Disturbed soil					
225Ge_5Af	phase	Greenough 5 recent alluvium Phase	Lower terraces of the major rivers, subject to regular flooding. Brown loamy earth is dominant with Semi-wet soil	Lower terraces of the major rivers, subject to regular flooding	Recent alluvial deposits	Brown loamy earth is dominant with Semi-wet soil	Eucalyptus camaldulensis mid - high open woodland.	
225Ge_5Bwd	phase	Greenough 5 Bootenal well drained Phase	Level to very gently undulating prior alluvial depositional plain. Red sandy and loamy duplexes and Red deep sands	Level to very gently undulating prior alluvial depositional plain.	Alluvium	Red sandy and loamy duplexes and Red deep sands	Mainly cleared. Acacia acuminata (jam) on road verges.	Greenough, Murchison, Hutt and Chapman River alluvial plains

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
225Ge_5Dr	phase	Greenough Dartmoor Phase	Drainage line in level to very gently undulating prior alluvial depositional plain. Red sandy earth with Yellow/brown shallow sandy duplex, Wet and Semi-wet soils	Drainage line in level to very gently undulating prior alluvial depositional plain	Alluvium	Red sandy earth with Yellow/brown shallow sandy duplex, Wet and Semi-wet soils		Greenough, Murchison, Hutt and Chapman River alluvial plains
225Mo_1GrS	phase	Moresby 1 Sandstone rises Phase	Steep to very steep sandstone mesas and peaks within the granulite country. Shallow, very gravelly sands	Steep to very steep sandstone mesas and peaks within the granulite country	colluvium, sandstone, limestone and shale overlain by laterite on summit surfaces	Shallow, very gravelly sands	Tall sparse shrubland and isolated Eucalyptus loxophleba (mallee form).	Geraldton hinterland
225Mo_1Mss	phase	Moresby 1 Sideslopes Phase	Steep to precipitous sideslopes of the Moresby Range and isolated mesas.	Steep to precipitous sideslopes and isolated mesas of the Moresby Range.	colluvium, sandstone, limestone and shale overlain by laterite on summit surfaces	Eroded duplex soils.	Mixed mid-high closed shrubland.	Geraldton hinterland
225Mo_2	subsystem	Moresby 2 Subsystem	Gently inclined footslopes. Soils yellowish brown sandy duplex, well to poorly drained.					
225Mo_2Dr	phase	Moresby 2 Drainage line Phase	Drainage line through gently inclined footslopes below steep sideslopes of range. Yellow/ brown shallow sandy duplex with Semi-wet soils	Drainage line through gently inclined footslopes below steep sideslopes of range	Recent colluvium	Yellow/brown shallow sandy duplex with Semi-wet soils		Geraldton hinterland

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
225Mo_2Mf1	phase	Moresby 2 yellow duplex footslopes Phase	Moresby footslopes with yellow duplex soils. Yellow/ brown deep sandy duplexes are common with Brown deep sand and Semi-wet soils	Moresby footslopes with yellow duplex soils	Recent colluvium	Yellow/brown deep sandy duplexes are common with Brown deep sand and Semi-wet soils	Mainly cleared, small remnants of mid-high mixed Melaleuca and Allocasuarina heugeliana (rock oak) woodland	Geraldton hinterland
225Mo_2Mf2	phase	Moresby 2 red duplex footslopes Phase	Moresby footslopes with red duplex soils. Red deep sandy duplex with red and brown sandy to loamy earths and Red deep sand	Moresby footslopes with red duplex soils	Recent colluvium	Red deep sandy duplex with red and brown sandy to loamy earths and Red deep sand	Mainly cleared	Geraldton hinterland
225Mo_2R	phase	Moresby 2 rock outcrop Phase	Rock outcrops on the Moresby footslopes. Bare rock	Rock outcrops on the Moresby footslopes	Recent colluvium	Bare rock		Geraldton hinterland
225Mo_2Sw	phase	Moresby 2 swamp Phase	Swamps on the Moresby footslopes. Wet and Semi-wet soils	Swamps on the Moresby footslopes	Recent colluvium	Wet and Semi-wet soils		Geraldton hinterland
225Mo_3	subsystem	Moresby 3 Subsystem	Gently inclined footslopes. Well drained gradational red sandy loams.					

Appendix four: Dataset analysis results

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
225MoSD	subsystem	Moresby Saline Drainage Subsystem	Narrow drainage lines to broad level salt plains in broad mature valleys.					
225No_1Dr	phase	Northampton 1 Drainage Line Phase	Drainage lines in gently undulating to rolling rises and low hills. Red shallow loamy duplex with Red loamy earth and Bare rock	Drainage lines in gently undulating to rolling rises and low hills	Granulites dominate with dolerite dykes and remnants of some Jurassic sediments in areas	Red shallow loamy duplex with Red loamy earth and Bare rock		Northern agricultural area between Geraldton and Northampton
225No_1GrD	phase	Northampton 1 Dissected Granulite Phase	Dissected country dominated by granulite parent material	Moderately inclined to steep rocky slopes (10-20%) often strongly dissected. Rock outcrop is very common.	Granulites dominate with dolerite dykes and remnants of some Jurassic sediments in areas	Shallow sands, sandy earths and shallow gravels.	Mixed tall closed shrubland, including Calothamnus homalophyllus, Waitzia aurea, and Ptilotus manglesii	Northern agricultural area between Geraldton and Northampton
225No_1GrR	phase	Northampton 1 Rolling granulite Phase	Gently rolling terrain. Red shallow loam with deep and shallow red duplex soils, occasionally alkaline, Pale deep sand and Yellow/brown duplexes.	Gently rolling terrain	Granulites dominate with dolerite dykes and remnants of some Jurassic sediments in areas	Red shallow loam with deep and shallow red duplex soils, occasionally alkaline, Pale deep sand and Yellow/brown duplexes.	Largely cleared. Remaining individuals include Acacia acuminata, Eucalyptus loxophleba, Acacia rostellifera and Hakea preissii (needle tree).	Northern agricultural area between Geraldton and Northampton

Appendix four: Dataset analysis results

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
225No_1GrS	phase	Northampton 1 sandstone rises Phase	Steep to very steep sandstone mesas and peaks generally less than 40 m within the granulite country. Shallow sands and gravels	Steep to very steep sandstone mesas and peaks generally less than 40 m within the granulite country	Remnants of Jurassic sediments over granulites	Shallow sands and gravels	Tall sparse shrubland and isolated Eucalyptus loxophleba (mallee form). Common shrubs are Acacia tetragonaphylla (kurara) and Hakea preisii.	Northern agricultural area between Geraldton and Northampton
225No_1R	phase	Northampton 1 Rock outcrop Phase	Rock outcrop. Bare rock	Rock outcrop	Granulites dominate with dolerite dykes and remnants of some Jurassic sediments in areas	Bare rock		Northern agricultural area between Geraldton and Northampton
225No_2Af	phase	Northampton 2 recent alluvium Phase	Lower terraces of the major rivers, subject to regular flooding. Brown loamy earth is dominant	Lower terraces of the major rivers, subject to regular flooding	Recent alluvial deposits	Brown loamy earth is dominant	Eucalyptus camaldulensis mid - high open woodland.	Northern agricultural area between Geraldton and Northampton
225No_2An1	phase	Northampton 2 well drained Phase	Well drained recent alluvium on higher terraces of the major rivers and along minor tributaries. Red sandy earth is dominant	Well drained recent alluvium on higher terraces of the major rivers and along minor tributaries	Alluvium	Red sandy earth is dominant	Completely cleared. No remaining native vegetation remnants	Northern agricultural area between Geraldton and Northampton

Appendix four: Dataset analysis results

MAP_UNIT	MU_RANK	MU_NAME	MU_SUM_DESC	MU_LFORM	MU_GEOL	MU_SOIL	MU_VEG	MU_LOCAT
225No_2An2	phase	Northampton 2 imperfectly drained Phase	Imperfectly to poorly drained recent alluvium on higher terraces of the major rivers and along minor tributaries. Red loamy earths with Semi wet soils and non-cracking clays. Soils are often alkaline.	Imperfectly to poorly drained recent alluvium on higher terraces of the major rivers and along minor tributaries	Alluvium	Red loamy earths with Semi wet soils and non-cracking clays. Soils are often alkaline.	Partly cleared, tall Casuarina obesa (swamp oak) closed forest with scattered Eucalyptus camaldulensis on uncleared areas.	Northern agricultural area between Geraldton and Northampton
225NoX_MINE	phase	Northampton mine Phase	Mine site. Disturbed soil					
225SuDU2	phase	Sugarloaf Durawarra, Phase 2	Undulating to rolling rises.	Undulating to rolling rises	marine sediments, including sandstones, shales and limestone	Red shallow loamy duplex soils		Northern agricultural area east of Geraldton

Appendix four: Dataset analysis results

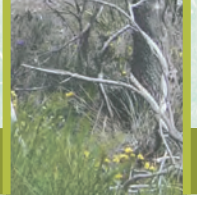
Beard vegetation associations

Research of Beard's vegetation reports have not disclosed references that use any Beard vegetation association numbers, which have been allocated since the Beard publications (eg by Shepherd *et al* 2002).

The vegetation described by Beard (1976a; 1976b) is detailed below, with partial NVIS level V descriptions from the vegetation extent GIS dataset (DAFWA 2006) (truncated due to the field size allocated to the data) listed when the equivalent to Beard's description can be allocated.

Northampton system:

- Scrub Heath "coastal association" on laterite and sand.
  - On laterite the species are: *Gastrolobium oxylobioides*, *Casuarina campestris* (now *Allocasuarina campestris*), *Dryandra ashbyi* (now *Banksia fraseri* var. *ashbyi*), *Isopogon divergens* with *Baeckea grandiflora*, *Bossiaea eriocarpa*, *Calothamnus quadrifidus*, *Hakea cristata*, *H. trifurcata*, *Halgania sericiflora*, *Hibbertia hypericoides*, *Melaleuca radula*, *Patersonia* sp., *Verticordia chrysantha*, *Xanthorrhoea preissii* and *Nuytsia floribunda.*
  - On sand the species are: *Banksia attenuata*, *B. menziesii*, *B. prionotes*, *Acacia rostellifera*, *Dryandra sessilis* (now *Banksia sessilis*), *Casuarina humilis* (now *Allocasuarina humilis*), *Conospermum stoechadis*, *Eremaea beaufortioides*, *Gastrolobium spinosum*, *Hibbertia hypericoides*, *Lachnostachys* sp., *Nuytsia floribunda*, *Petrophile* sp.
  - There appears to be no direct Beard vegetation association equivalent of this vegetation association
- *Melaleuca-Hakea* thicket; the equivalent of **Beard vegetation association 675**
  - *Melaleuca megacephala – Hakea pycnoneura* on stony slopes and mesas. The species listed are: *Nuytsia floribunda*, *Santalum acuminatum* over *Eucalyptus redunca* (probably now refers to *E. subangusta*) over *Melaleuca megacephala*, *Hakea pycnoneura*, *Acacia ericifolia*, *A. saligna*, *A. ulicina*, *Calothamnus quadrifidus*, *Gastrolobium spinosum* var. *triangulare* (now *G. triangulare*), *G. oxylobioides*, *Hakea trifurcata*, *Jacksonia sternbergiana*, *Melaleuca uncinata* (now includes *M. concreta*) over *M. scabra*, *M. cardiophylla* (this may now refer to *M. coronicarpa*), *Baeckea* and *Thryptomene* spp, *Hemigenia diplanthera*, *Verticordia chrysantha* (probably now includes *V. chrysanthella*), *V. picta*, *V. monadelpha*.
  - *Casuarina campestris* (now *Allocasuarina campestris*) and *Melaleuca uncinata* (now probably includes *M. concreta*) on *superficial laterite*. The species listed are: *Casuarina campestris* (now *Allocasuarina campestris*), *Melaleuca uncinata* (now probably includes *M. concreta*) and patches of *Gastrolobium spinosum*, *Dryandra fraseri* (now *Banksia fraseri*), *Acacia tetragonophylla*, *Hakea trifurcata*, *Hibbertia hypericoides*, *Verticordia chrysantha* (probably now includes *V. chrysanthella*) and *V. picta*.
  - Shallow soil is dominated by *Hibbertia*, *Verticordia* and *Borya* spp.
  - The truncated NVIS description is: U1 *Nuytsia floribunda*, *Santalum acuminatum*, *Eucalyptus redunca*\tree,shrub,mallee\6\bi;M1+*Melaleuca megacephala*,+*Hakea pycnoneura*, *Acacia ericifolia*, *Calothamnus quadrifidus*, *Gastrolobium spinosum* var. *triangulare*\shrub\4\d;G1 *Melaleuca scabra*, *Verticordi*.
- *Acacia acuminata* scrub ("jam"); the equivalent of **Beard vegetation association 35**
  - The vegetation is described as having York gum in patches. The species listed are: *Acacia acuminata*, *A. rostellifera*, *A. tetragonophylla*, *Hakea preissii*, *H. recurva*, *Jacksonia cupulifera* over *Dryandra sessilis* (now *Banksia sessilis*), *Calothamnus quadrifidus*, *Grevillea pinaster*, *Hibiscus huegelii*, *Labichea* sp., *Scholtzia umbellifera*, *Xanthorrhoea preissii* over *Cephalipterum drummondii*, *Goodenia pinnatifida*, *Schoenia cassiniana*, *Waitzia aurea*.
  - *Casuarina campestris* (now *Allocasuarina campestris*) occurs on gravel, with *Melaleuca-Hakea* thicket vegetation on "rough country".
  - The rivers and creeks have *Eucalyptus camaldulensis*, *Casuarina obesa* and *Melaleuca rhaphiophylla.*
  - The truncated NVIS description is: U1 *Eucalyptus loxophleba*, *Eucalyptus camaldulensis*\tree\7\bi;M1+*Acacia acuminata*, *Acacia tetragonophylla*, *Hakea preissii*, *Jacksonia cupulifera*, *Acacia rostellifera*\shrub\4\i;M2 *Dryandra sessilis*, *Calothamnus quadrifidus*, *Grevillea pinaster*, *Hibiscus hueg*.



Appendix four: Dataset analysis results

Greenough system:

- *Acacia rostellifera / Melaleuca cardiophylla* thickets on rocky ridges, with vegetation 6 m or more high
  - *Acacia rostellifera*, *A. scirpifolia*, *A. xanthina*, *Eucalyptus eudesmioides*, *E. oleosa* (possibly now *Eucalyptus kochii* subsp. *borealis*), *Melaleuca cardiophylla* over *Alyogyne cuneiformis*, *Calothamnus quadrifidus*, *Grevillea biformis*, *Labichea* sp., *Helichrysum* sp., *Hibiscus huegelii*, *Pimelea floribunda*, *Solanum simile*.
  - The rockiest and steepest parts have *Melaleuca cardiophylla* and (south of Geraldton) *M. huegelii.*
  - The deeper sandier areas form a transition to the *Acacia – Banksia* scrub.
  - There is no obvious direct Beard vegetation association equivalent for this vegetation, however some elements appear to be similar to **Beard vegetation association 387** *Melaleuca cardiophylla* thicket. If this is the case, the NVIS description is: U1 *Acacia rostellifera*,+*Melaleuca cardiophylla*, *Acacia ligulata*, *Acacia scirpifolia, Acacia xanthina*\shrub\4\d;G1 *Alyogyne cuneiformis*, *Calothamnus quadrifidus*, *Grevillea biformis*, *Labichea* sp., *Hibiscus huegelii*\shrub,forb\2\r.
- *Acacia – Banksia* scrub on sand covered limestone; the equivalent of **Beard vegetation association 359**
  - The species listed are: *Acacia rostellifera*, *Banksia prionotes*, *A. scirpifolia*, *A. xanthina*, *B. attenuata*, *B. menziesii*, *Bursaria spinosa*, *Dryandra sessilis* (now *Banksia sessilis*), *Eucalyptus dongarraensis* (now *E. obtusiflora* subsp. *dongarraensis*), *Grevillea biformis*, *Gyrostemon ramulosus* over *A. spathulifolia*, *Conostylis aculeata*, *Grevillea argyrophylla*, *Hibbertia* affin. *hypericoides*, *Lechenaultia linarioides*, *Melaleuca ?undulata* (not found in the area: may refer to *M. cardiophylla* or *M. coronicarpa*), *Scholtzia umbellifera*, *Stylobasium spathulatum* and grasses and sedges.
  - The NVIS description is: U1+*Acacia rostellifera*,+*Banksia prionotes*, *Acacia scirpifolia*, *Banksia attenuata*, *Bursaria spinosa*\tree,shrub,mallee\6\c;M1 *Acacia spathulata*, *Conostylis aculeata*, *Grevillea argyrophylla*, *Hibbertia* sp. aff. *hypericoides*, *Lechenaultia linarioides*\shrub\4\.
- *Acacia rostellifera* low forest on alluvial flats; the equivalent of **Beard vegetation association 371**
  - This vegetation is described as a taller version of *Acacia rostellifera* thicket, exceeding 10 m in height, with few native species.
  - Creeklines and soaks are *Eucalyptus camaldulensis*.
  - The NVIS description is: U1 *Eucalyptus camaldulensis*\tree\7\bi;M1+*Acacia rostellifera*\shrub\4\c.
- Acacia ligulata on recent dunes; the equivalent of **Beard vegetation association 440**
  - The vegetation of the coastal dunes is *Spinifex longifolius*, *Atriplex isatidea*, *Salsola kali* (now *S. tragus*) and *Threlkeldia diffusa*. Inland of these is *Scirpus nodosus* (now *Ficinia nodosa*), *Olearia axillaris* and *Myoporum insulare*. The stable inner dunes are *Acacia rostellifera*, *Olearia axillaris* and *Scaevola crassifolia*.
  - *Acacia rostellifera* replaces *A. ligulata* in the GRFVS area.
  - The NVIS description is U1+*Acacia ligulata*,+*Acacia rostellifera*, *Olearia axillaris*, *Scaevola crassifolia*, *Lechenaultia linarioides*\shrub\3\i.

No descriptions of the vegetation included in **Beard vegetation associations 129**, **413** or **431** have been located. The NVIS descriptions for these are:

- **Beard vegetation association 129** Bare areas; drift sand is described as “bare or poorly vegetated” and has no NVIS description.
- **Beard vegetation association 413** Shrublands; *Acacia neurophylla* and A. species thicket: U1+*Acacia neurophylla*, *Acacia* sp.\shrub\4\c.
- **Beard vegetation association 431** Shrublands; *Acacia rostellifera* open scrub: G1+*Spinifex longifolius*,+*Atriplex isatidea*\tussock grass,chenopod\2\i.