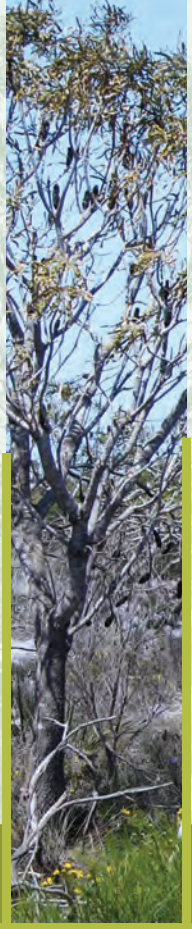

GERALDTON REGIONAL
Flora and Vegetation Survey

MARCH 2010

Prepared by the Department of Planning
and supported by
Ecoscape (Australia) Pty Ltd

Western Australian Planning Commission
Albert Facey House
469 Wellington Street
Perth, Western Australia

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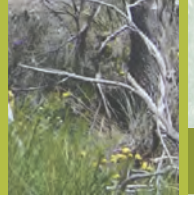

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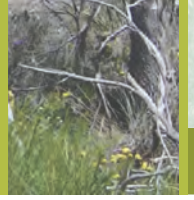
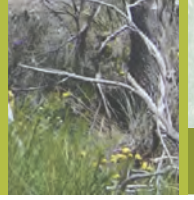


Tables, Figures, Plates & Maps

Tables

Figures

Plates



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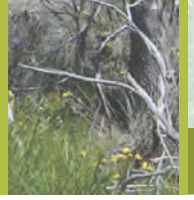

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EnviroPlanning, LandCorp and the City of Geraldton-Greenough for their financial contributions in 2007/08 and 2008/09.

Ecoscape (especially Lyn Atkins, project ecologist) for undertaking desktop and field assessments, mapping and preparing earlier versions of the technical report.

Members of the GRFVS project steering committee, including:

- Department of Planning: Danielle O'Neill, Senior Project Officer – EnviroPlanning; Jerom Hurley, Team Leader – Statutory Planning, Central Regions; Ryan Taylor, Project Manager – EnviroPlanning; Andrew Moore, Team Leader - Strategic Planning, Central Regions
- Department of Environment and Conservation: Anthony Desmond, Regional Leader – Nature Conservation, Midwest Region; Catherine Page, Operations Officer, Geraldton District; Kelly Gillen, Regional Manager, Midwest Region; Alanna Chant, Conservation Officer, Geraldton District; Kelly Freeman, Senior Environmental Officer – Terrestrial Ecosystems, Strategic Policy; Kathryn Schell, Environmental Officer – Planning and Infrastructure, Environmental Impact Assessment; Gerard O'Brien, Environmental Officer – Planning and Infrastructure, Environmental Impact Assessment; Bridget Hyder, Senior Environmental Officer – Terrestrial Ecosystems, Strategic Policy
- City of Geraldton-Greenough: Simon Lancaster, Senior Strategic Planner; Murray Connell, Manager Town Planning Services
- Shire of Chapman Valley: Kirrilee Warr, Planning Officer; Ian D'Arcy, Manager Planning and Development
- LandCorp: John Quilty, Quilty Environmental
- Department of Agriculture and Food: John Bruce, CRIS Research Officer

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Members of the Geraldton Regional Herbarium, including Jenna Brooker for her assistance with locating various vegetation types.

Summary

The Geraldton Regional Flora and Vegetation Survey (GRFVS) aims to provide a regional context for land use planning and the environmental impact assessment of proposals affecting native vegetation in the Geraldton region. This report provides information on vegetation types in the GRFVS area, mapped and described at the regional scale as Beard vegetation associations, and at the local scale as GRFVS plant communities. Each GRFVS plant community is discussed in terms of extent, rarity, representation, diversity, presence of wetland/streamline/estuarine fringing or coastal vegetation, vegetation condition, and relationship to Beard vegetation associations, in order to assist in determining conservation significance. Maps and datasets produced through the GRFVS are available from the Department of Planning.

The GRFVS area is 40,737 hectares and contains the parts of the City of Geraldton-Greenough and the Shire of Chapman Valley that are experiencing the most development pressure in the Geraldton region. The GRFVS covers an area between Coronation Beach Road (north of Geraldton), Devlin Pool Road (south of Greenough River), and east to the foothills of the Moresby Range. The GRFVS involved desktop analysis of existing information on vegetation and soils, field survey of 81 floristic quadrats, statistical analysis of quadrat data that identified floristic groups, and further interpretation of floristic groups that determined recognisable plant communities.

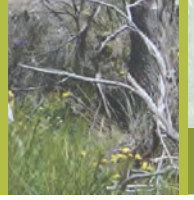
The GRFVS determined that 15% of the pre-European extent of native vegetation remains in the GRFVS area, in 625 discrete remnants. Analysis of remaining vegetation extent has indicated that, of the nine Beard vegetation associations occurring in the GRFVS area, three Beard vegetation associations (371, 387 and 675) have less than 10% remaining in the GRFVS area, and two have approximately 10% remaining in Western Australia (35 and 371), which is the level at which a vegetation association is regarded as 'endangered'. The GRFVS does not aim to replace Beard vegetation association mapping, but provides more detail on native vegetation occurring in the Geraldton region.

The most significant output from the GRFVS has been the identification of 17 'GRFVS plant communities', which are mapped and described at a finer scale than Beard vegetation associations. The most restricted of the GRFVS plant communities are 4 (Swale: *Ficinia nodosa*) and 5 (Swale: *Frankenia pauciflora*), each of which have only one mapped occurrence in the GRFVS area. Other restricted GRFVS plant communities include 6 (Coastal: *Thryptomene baeckeacea*), 7 (Coastal: *Melaleuca cardiophylla*), 9 (Coastal: *Acacia rostellifera / Eucalyptus spp.*) and 11 (Limestone ridge: *Melaleuca cardiophylla / Eucalyptus spp.*). Flora and vegetation surveys should be undertaken over a wider geographic area in order to determine the regional significance of the GRFVS plant communities.

The GRFVS recorded a total of 376 species, including two declared rare flora, eight priority-listed species, and three species at the extent of or beyond their usual range. Based on the quadrats surveyed, the GRFVS plant communities that exhibit the greatest species diversity include 15 (Thicket: *Melaleuca spp. / mixed spp.*), 16 (Woodland: *Acacia acuminata / A. tetragonophylla / Hakea preissii*), 14 (Chapman River Reserve: *Acacia rostellifera / Melaleuca spp.*) and 13 (Sandplain: *Banksia prionotes / Acacia rostellifera*).

Less than 2% of the remaining native vegetation in the GRFVS area, containing only two GRFVS plant communities (15 and 16), is protected in Department of Environment and Conservation (DEC) reserves. Furthermore, the majority of vegetation in the GRFVS area is threatened by development, weed invasion, grazing, fire, or recreational use. Hence, it is likely that much of the vegetation in good or better condition in the GRFVS area will be considered important for conservation.

Information collected through the GRFVS and presented in this report will assist land use planning by the Department of Planning (DoP) and local governments, environmental impact assessments by the Environmental Protection Authority (EPA), and conservation planning by DEC. The report, associated maps and data provide useful information for landowners and developers, but do not preclude the requirement for site-based ecological assessments of areas likely to be impacted by development. Importantly, the GRFVS will inform conservation and regional planning in the Geraldton region, including the preparation of a local biodiversity strategy that will identify priority natural areas for consideration in future land use planning.



1 Introduction

1.1 Project background

In 1998 the Environmental Protection Authority (EPA) released Bulletin 891, a submission to the Western Australian Planning Commission (WAPC) on the draft Geraldton Region Plan. The Geraldton Region Plan is a framework for strategic regional land use planning, and incorporates the Greater Geraldton structure plan which identifies future areas for residential, industrial, transport, recreation and conservation. In its advice, the EPA highlighted the need for the identification, retention and conservation of remnant vegetation in the Geraldton region, including the retention and extension of conservation areas in regional parks and open space. The EPA also supported the proposal in the Geraldton Region Plan to compile an inventory of, and to conserve, regionally significant remnant vegetation in private and government ownership.

The Geraldton Regional Flora and Vegetation Survey (GRFVS) was initiated in 2007 by the Department for Planning and Infrastructure (now Department of Planning, DoP), Department of Environment and Conservation (DEC), Department of Agriculture and Food Western Australia (DAFWA), City of Geraldton-Greenough and Shire of Chapman Valley. The aim of the GRFVS is to provide a regional context for land use planning and environmental impact assessment of proposals affecting native vegetation in the Geraldton region. The first phase was to identify and describe native vegetation associations in Geraldton and surrounding areas, with a focus on mapping the extent of those vegetation associations where significant land use change or development is proposed.

1.2 Project phases

It was proposed that the GRFVS be undertaken in three phases:

Phase one (initial vegetation mapping):

- regional vegetation association mapping, interpreted from regional floristic plots covering typical, rare and other significant plant communities, and statistical analysis of floristic data;
- extrapolation of existing mapping, including native vegetation extent, soil and landform, and Beard vegetation association mapping to estimate the original extent of vegetation associations within the area;
- calculation of the proportion of each vegetation association remaining within the region; and
- this report, which defines representation and significance of the flora and vegetation associations in the region.

Phase two (conservation and regional planning):

- identify priority reservation/conservation areas including determining threats to condition of vegetation and maintenance of ecological linkages;
- use vegetation, soil and landform information to interpret fauna habitat and identify priority areas for fauna conservation;
- identify priority areas requiring restoration/ revegetation; and
- use this information to inform strategic regional land use planning.

Phase three (further regional flora and vegetation surveys):

- extend the methodology to other areas outside the initial project area.

GRFVS phase one has been completed for the area generally covered by the Greater Geraldton structure plan. Phases two and three are subject to further funding.

1.3 Project area

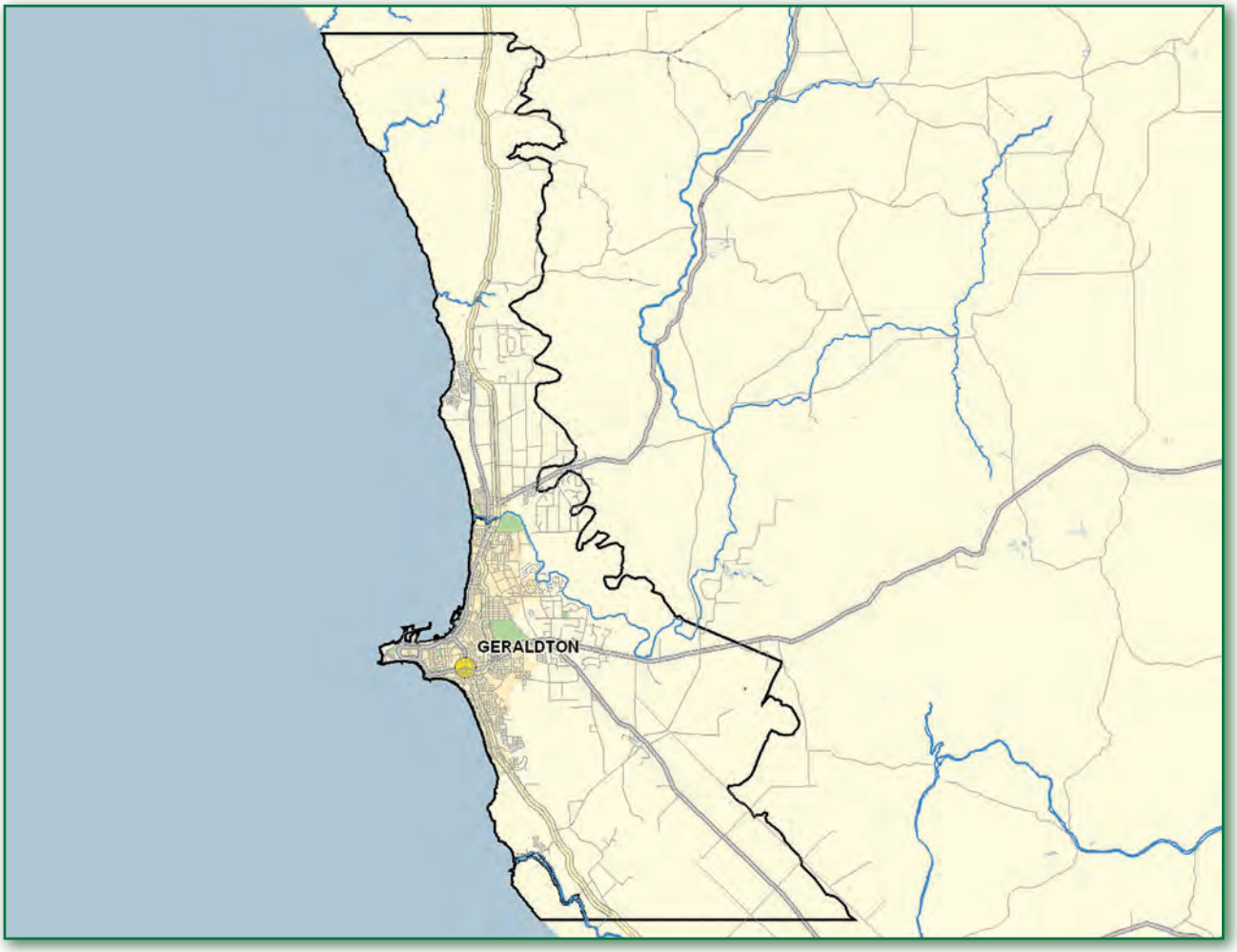
The GRFVS area is located approximately 424 km north of Perth on the Indian Ocean coast, in the Mid-West region of Western Australia (figure 1). The GRFVS area is 40,737 hectares and contains the parts of the City of Geraldton-Greenough and the Shire of Chapman Valley that are experiencing the most development pressure in the Geraldton region. The GRFVS covers an area between Coronation Beach Road (north of Geraldton), Devlin Pool Road (south of Greenough River), and east to the foothills of the Moresby Range.

1.4 Technical report and mapping

The report discusses the methods and results of analysis of existing datasets, field survey site selection, floristic quadrat surveys, statistical analysis and vegetation mapping. The results are discussed in terms of vegetation extent, vegetation condition and conservation significance of the vegetation, both in relation to Beard vegetation associations (Beard 1976a; DAFWA 2005) and GRFVS plant communities identified through this project. Plant communities and species of conservation significance are also discussed.

The target audience for the technical report includes organisations and individuals involved in land use planning and the environmental impact assessment of proposals affecting native vegetation in the Geraldton region. The report provides a basis for describing vegetation that occurs in the GRFVS area, and should be referred to during flora and vegetation surveys for specific sites, which will generally be undertaken at a finer scale than this project.

Figure 1: Geraldton Regional Flora and Vegetation Survey (GRFVS) area



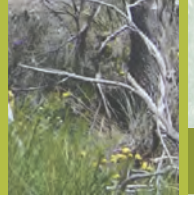


Table 1: The NVIS information hierarchy (National Heritage Trust 2003)

Level	Description	NVIS structure/floristic components required
1	Class	Dominant growth form for the ecologically dominant stratum
2	Structural Formation	Dominant growth form, cover and height for the ecologically dominant stratum
3	Broad Floristic Formation	Dominant growth form, cover, height and broad floristic code usually dominant land cover genus for the upper most or dominant stratum
4	Sub-Formation	Dominant growth form, cover, height and broad floristic code usually dominant genus and family for the three traditional strata (upper, mid and ground)
5	Association	Dominant growth form, height, cover and species (3 species) for the three traditional strata (upper, mid and ground)
6	Sub-Association	Dominant growth form, height, cover and species (5 species) for all layers/strata

1.5 Beard vegetation associations

A systematic survey of native vegetation in Western Australia was undertaken during the 1970s, which described vegetation systems in Western Australia at a scale of 1:250,000 in the south-west of Western Australia and at a scale of 1:1,000,000 in the less developed areas of the state. The vegetation survey of Western Australia maps and explanatory memoirs (1974-1981) are credited to J.S. Beard (or Beard with various co-authors).

Beard's vegetation maps attempted to depict the vegetation as it might have been at the time of settlement, ie pre-European vegetation type and extent (Beeston et al. 2001). The Beard vegetation association dataset (also referred to as the pre-European native vegetation extent dataset) has since been developed in digital form by Shepherd et al. (2002). This dataset has been critical to setting and meeting targets for biodiversity conservation (Commonwealth of Australia 2001) as it is the only Western Australian-wide dataset that can be used to calculate clearing against historical extent of native vegetation.

The EPA advises that native vegetation should be assessed at international, national, regional and local levels. The Beard vegetation association dataset is used outside of the area covered by EPA Guidance Statement 10 as a determination of regional significance of vegetation to support studies undertaken at a local scale.

Beard vegetation associations have been described to a minimum standard of Level 3 'Broad Floristic Formation' for the National Vegetation Inventory System (NVIS). The GRFVS has described plant communities to NVIS Level 5 'Association', which is in more detail and at a finer scale than Beard vegetation associations (refer to table 1).

The GRFVS plant communities are considered to represent vegetation types mapped and described at the sub-regional to local scale, between the level of Beard vegetation associations (statewide to regional scale) and site-specific ecological assessments (usually undertaken to support development proposals). Other examples of vegetation mapping undertaken at a finer scale than Beard vegetation associations include:

- the vegetation complexes of the Swan Coastal Plain and Darling Range (Heddle et al. 1980), which are based on landform and soil units and provide the pre-European extent of vegetation types;
- the *Floristic Survey of the Southern Swan Coastal Plain* (Gibson et al. 1994), which involved floristic quadrat survey and analysis to identify floristic community types. These types have not been mapped, but the floristic quadrats have been used to define threatened ecological communities and some priority ecological communities on the Swan Coastal Plain; and
- the Albany regional flora and vegetation survey, which is currently underway in a study area of approximately 100,000 ha in the vicinity of Albany, with approximately 37% remnant vegetation. Plant communities are being assessed and described to NVIS Level 5 standard, to provide a regional context for decision-making, in a similar process to the GRFVS.

1.6 Conservation significance determined by previous studies

Native Vegetation Management Plan Northern Agricultural Region

The Native Vegetation Management Plan (DEC 2008) identifies strategic priorities for the protection of the region's native vegetation and knowledge gaps that should be filled to maximise the efficiency of strategic vegetation management in the Northern Agricultural Region.

The Native Vegetation Management Plan prioritises vegetation in the Northern Agricultural Region, using Beard vegetation associations, into four classes:

- last stand sites;
- rare and restricted (or rare and endangered) vegetation associations;
- representative samples of the region's vegetation; and
- all remaining vegetation in the region.

Last stand sites are the most spatially restricted vegetation associations in the region and are at risk of regional extinction, and rare and restricted vegetation associations are described as some of most threatened ecosystems in the region.

The Native Vegetation Management Plan recommends further scrutiny of conservation priorities based on Beard vegetation association. Although Beard's mapping is important for determining the significance of vegetation at a regional scale, conservation significance should also be supported by evidence at a local scale. The GRFVS aims to map and describe plant communities at a finer scale than Beard vegetation associations.

Australian National Resources Atlas

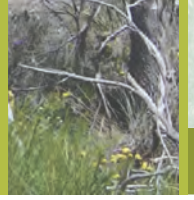
The Australian National Resources Atlas states numerous vegetation associations and 'at risk' ecosystems need to be reserved, listing several of the Beard vegetation associations (35, 359, 371, 431, 675) and Moresby Ranges communities with rare plants as 'natural values' in the area covered by the GRFVS. Although the Moresby Range itself is not included in the GRFVS area, vegetation of the Moresby Range foothills supports similar species.

Biodiversity Audit

The national biodiversity audit conducted in 2002 provides useful information on the Geraldton Sandplains 2 (GS2 – Geraldton Hills sub-region) (refer to Desmond and Chant 2002). The Geraldton Sandplains 2 report identifies all Beard vegetation associations (except for 129) occurring in the GRFVS area as high priorities for reservation. The Geraldton Sandplains 2 report also highlights the need for vegetation and regional ecosystem mapping and floristic data, which would assist the identification of biodiversity values and management responses. The GRFVS aims to address these data gaps for the portion of the Geraldton region experiencing most development pressure.

Threatened and Priority Ecological Communities

There are no DEC-listed or Commonwealth-listed (*Environment Protection and Biodiversity Conservation Act 1999*) threatened ecological communities in the GRFVS area. However, the priority one (P1) priority ecological community 'Plant assemblages of the Moresby Range system' is considered to be synonymous with Beard vegetation association 675, which occurs within the GRFVS area.



2 Methods

2.1 Project outline

The methodology for the project involved three components.

Component one of the project included a desktop study and literature review to identify and map the extent of Beard vegetation associations interpreted to exist in the GRFVS area, particularly in areas proposed for future development. Proposed locations for floristic quadrats were identified from Beard vegetation association mapping and with input from the project steering committee.

Component two involved field surveys to groundtruth the vegetation interpreted from the desktop study and collect quadrat-based floristic data suitable for statistical analysis and interpretation. The field surveys commenced in July 2008, and the main floristic surveys were undertaken in August and October 2008.

Component three was the statistical analysis and interpretation of floristic quadrat data, production of maps and report writing. Groundtruthing and mapping the vegetation of the GRFVS area using plant communities identified from the statistical analysis was undertaken in June 2009.

2.2 Analysis of existing datasets

Existing datasets were assessed and interpreted, and available literature was reviewed prior to field assessment.

The following map datasets were used:

- Beard vegetation associations (DAFWA 2005);
- soil landscape map units (subsystem level) (DAFWA 2007a, 2007b);
- vegetation extent (DAFWA 2006); and
- topography (Landgate 2001).

Mapping was undertaken using ArcGIS v9 software. The Beard vegetation association boundaries were re-interpreted to produce an updated map for the project area to reflect the finer scale soil-landscape mapping undertaken by DAFWA (2006). Further detail on mapping methodology is provided in appendix 1. DEC's 'comprehensive and adequate reserve analysis' data ('CAR' data, 2007) was used for representation of Beard vegetation associations in Western Australia.

Relevant literature was reviewed to provide information on historic and current vegetation of the GRFVS area, and to identify areas of particular interest for surveys. The project steering committee members identified literature to assist with this stage of the project. Relevant literature is included in the references section of this report.

2.3 Field verification and site selection

Prior to the main floristic quadrat survey, a survey was undertaken to verify Beard vegetation association boundaries identified from analysis of existing datasets, identify plant communities not identified at the scale of Beard vegetation association mapping, and assist with locating floristic quadrats.

The verification survey was conducted 8-10 July 2008. During the survey, as much of the GRFVS area was visited as possible, and the observed vegetation was compared to the mapped Beard vegetation association descriptions to determine the description validity. Areas outside of the GRFVS were also visited to determine whether the vegetation outside the project area was represented within it. Due to time and access constraints, few areas north of the project area were surveyed, however areas as far south as Walkaway were visited.

Many of the proposed sites were in poor condition (grazed) or not accessible, so alternative sites were identified. Quadrats were also added in areas where the vegetation did not match Beard vegetation association descriptions.

The approximate locations of field survey sites were selected on the basis that they encompassed the expected vegetation types identified from dataset analysis and the field verification survey. The sites were:

- scattered spatially from north to south and east to west, to cover the geographical range of the project area;
- representative of variations in the catenary sequence from coast to uplands;
- in proportion to the percentage of the expected Beard vegetation associations extents, to sample the range within them;
- located in areas that did not appear to be covered at the scale of the Beard vegetation association mapping, including riparian and foredune areas;
- representative and in the best observed condition for the vegetation type selected; and
- accessible for survey.

Seventy proposed quadrat locations were identified and selected on the basis of the results of the dataset analysis and verification survey. An additional 15 sites were selected in areas where there is expected to be development pressure. One quadrat was located in the Wokatherra Gap at the foot of the Moresby Ranges, outside the GRFVS area. This area was assessed to provide comparative information on the vegetation of the Moresby Ranges in relation to potentially similar vegetation to the west. The approximate positioning of all quadrat locations was approved by the project steering committee prior to conducting the field survey.

All sites were in areas mapped as 'native vegetation' in the supplied vegetation extent (DAFWA 2006) dataset, except immediately south of the Greenough River which was not included but was obviously native vegetation. Urban parks (except Chapman River Reserve) were not sampled due to the high degree of disturbance and the prospect of permanent quadrat markers being removed by members of the public. Only sites on public lands or where landholders had given permission for access were surveyed.

2.3.1 Consideration of alternative approaches to site selection

The locations of the floristic quadrats were selected to represent the geographic range of the GRFVS area. Other possible approaches to floristic quadrat locations include transect or grid-based surveys and selection of sites based on soil subsystems.

Surveys based on transects or grids, locating quadrats in a linear arrangement from the coast to inland (west to east) and, for a grid-based survey, north to south would have provided detailed information on the landscape of the GRFVS area. This survey method was not used because of the need to select sites that are in the best condition and representative of the vegetation of the area. Having floristic quadrat sites located in particular areas purely because of their geographic location within a predetermined pattern would have resulted in many quadrats being recorded from poor condition vegetation, thus providing less useful information, including a lower number of native plant species recorded from the area. This approach would have provided additional information if a larger number of quadrats could be surveyed, however logistical constraints limited the number of quadrats that could be recorded.

Analysis of existing datasets and the verification survey identified soil subsystems as being an important factor in the occurrence of some vegetation types in the GRFVS area, particularly riparian vegetation and *Melaleuca cardiophylla*-dominated shrublands on exposed limestone. However, field observations and discussions with the project steering committee indicated that, for most of the vegetation types known to occur in the GRFVS area, soil system, catenary position and land use history were more likely to determine the current vegetation than soil subsystems.

The dataset analysis determined that there were 52 soil subsystems within the GRFVS area. However, not all had vegetated areas. Logistical constraints associated with identifying vegetation from each of these subsystems, then verifying their condition to confirm the requirement of surveying vegetation in the best possible condition, precluded this approach. However, the selection of quadrat locations based on a combination of factors has included 23 of the soil subsystems, and most of the vegetation variation with the GRFVS area. Soil subsystems in the Greenough Alluvial (221Ga_) and Greenough (225Ge_) systems were not well represented by floristic quadrats, most likely as a result of the lack of native vegetation on the Greenough Alluvial plains. Soil subsystems in the Moresby (225Mo_) system were also under-represented by floristic quadrats due to inaccessibility or lack of native vegetation.

2.4 Floristic quadrat survey

The floristic quadrat field survey was conducted during 11-22 August 2008 and 1-3 October 2008. The field survey was undertaken according to the EPA's requirements as outlined in Guidance Statement No. 51 – *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessments in Western Australia*, as well as using NVIS Level 5 'association' mapping. Level 5 mapping describes and maps vegetation, recording dominant growth form, height, cover and species for three traditional strata: upper, mid and ground.

2.4.1 Information recorded for each quadrat

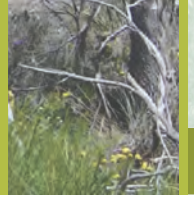
The floristic quadrat survey used permanently marked 10 m x 10 m floristic quadrats to record NVIS description data (detailed in appendix 2), and identify and record all vascular plant species within the quadrat, with cover value, height and lifeform for the dominant species.

Additional information including GPS location, aspect, slope, topographic position, soil type and colour, exposed rock details, litter cover and depth, extent of bare ground, disturbance type and extent and relevant notes were recorded. Weed invasion, which is a primary cause of vegetation degradation, was recorded as a per cent cover in each of the floristic quadrats and grouped into Braun-Blanquet (1983) Cover Abundance Classes. The GPS location was recorded using a hand-held Garmin GPS72, with positional accuracy of approximately 5 m (except where detailed on the individual quadrat recording sheet).

A Keighery (1994) bushland condition score (detailed in appendix 2) was recorded for each quadrat. A detailed vegetation condition survey for the Glenfield and Waggrakine local structure plan areas was undertaken during the survey to provide information to assist the City of Geraldton-Greenough. Results specific to this survey are not presented in this report; however, the survey has permitted discussion in relation to the vegetation of this area.

A digital photograph of each quadrat was taken from approximately 5 m from the north-west corner of the quadrat (except where vegetation obscured the corner marker, where the photograph was taken closer), looking diagonally across the quadrat in a south-easterly direction.

All vascular plant species occuring in quadrats during the field survey, with the exception of weeds, were collected for vouchering with the Western Australian Herbarium, with a duplicate specimen collected for the Geraldton Regional Herbarium.



2.4.2 NVIS data entry

The NVIS is a standardised nationally consistent method of recording vegetation that includes common descriptions of vegetation using standardised formats. This permits direct comparison of vegetation between different regions in Australia.

At this stage there is no formal Western Australia database for managing and storing NVIS data. However, the data custodian is the Department of Agriculture and Food Western Australia (DAFWA) Geographic Information Services which should be contacted for all enquiries.

NVIS data is collected using standardised methodology detailed in appendix 2 and the NVIS Australian Vegetation Attribute Manual Version 6.0. There is no standardised form for recording the information and no standardised format for data entry. Data is entered using a Microsoft Excel spreadsheet with appropriate field names, and the data custodian enters the data onto the existing Oracle database at DAFWA.

Standardised vegetation descriptions were produced from the NVIS database, using formats detailed in the attribute manual, eg M+^ *Stylobasium spathulatum*, *Acacia rostellifera*\^shrub\3\i;G^*Tetragonia implexicoma*, *Acanthocarpus preissii*, *Rhagodia preissii* subsp. *obovata*\^shrub,forb,chenopod shrub\2\i. The long description of this quadrat would be: dominant mid-stratum open shrubland 1-2m high, characterised by *Stylobasium spathulatum* shrub, with *Acacia rostellifera* shrub, over ground stratum 0.5-1m high, characterised by *Tetragonia implexicoma* shrub, with *Acanthocarpus preissii* forb and *Rhagodia preissii* subsp. *obovata* chenopod shrub. The dominant structural formation would be 'open shrubland', with 'open forbland' and 'open chenopod shrubland' applying to the non dominant stratum (strata, if more than one other is present).

Standardised structural formation terminology is used to integrate growth form, height and cover within each stratum, eg the term 'shrubland' is specific to shrubs, cycads, grass trees and tree-ferns with stratum cover value of 30-70%, whereas if the cover value was 10-30% the correct terminology is 'open shrubland'.

2.4.3 Specific quadrat site selection

The position of the quadrats were randomly located to be generally representative of the vegetation type selected for sampling during the dataset analysis and verification survey, but representing the 'best' (ie least disturbed) condition vegetation available in the location. The actual position of the quadrat was not chosen to deliberately include or exclude any particular species, but did endeavour to avoid bare or weedy areas as these were not considered to be in the 'best' condition areas. Despite efforts to select the 'best' condition vegetation, some quadrats, particularly in riparian areas, were in *degraded* condition vegetation, according to the Keighery (1994) bushland condition rating scale, as this was the 'best' condition available in the target vegetation type.

2.4.4 Quadrat orientation and marking

The quadrats were all 100m^2 in area, with all but two being 10 m x 10 m in dimension. The 10 m x 10 m quadrats were:

- oriented north/south and east/west;
- permanently marked on the north-west corner with a fence dropper angled so the open side was towards the quadrat; and
- labelled with a round aluminium tag stamped 'GRV08xx', where 'GRV 'is an abbreviation for 'Geraldton Regional Vegetation', '08' refers to the year (2008) and the final two digits refer to the quadrat number (01-81).

Two of the quadrats were linear (transects), 20 m x 5 m in dimension due to the linear nature of the riparian vegetation in which they were located. In both cases the transect direction (of the 20 m dimension) is detailed on the quadrat description, including the compass bearing of the transect (recorded by walking the transect length with a hand-held GPS), and the marking stake (fence dropper) was positioned with the open side facing towards the longest dimension, in the centre of the shortest dimension. One transect was along the river bank, and the other across steep banks and a narrow stream.

2.4.5 Species voucher collection

With few exceptions, a voucher specimen was collected, pressed and dried for every native vascular plant species recorded within the floristic quadrats, and submitted to the WA Herbarium with collection data. By submitting voucher specimens to the WA Herbarium, accurate identification using current taxonomy is ensured and any taxonomic changes are updated. Where possible, a duplicate specimen was collected for lodging with the regional herbarium. Sterile specimens and some common species already well represented in the collection were excluded.

Where there were few individual plants within a quadrat, voucher specimens were collected immediately adjacent to the quadrat. In a few cases where there were few individuals within or near the quadrat, and it was unlikely that they could be identified (mostly non-flowering orchids), the plant was not collected but was identified to at least genus level where possible. In one circumstance a single flowering specimen of an orchid species was located within the quadrat, but was not found outside it. A photograph of the flower was taken to assist with identification of the plant.

Plants recorded but not confidently identified by the survey botanist were identified using reference taxonomic texts, and comparison with descriptions, distribution and

photographs in FloraBase (WA Herbarium and DEC 2009). Where there was any uncertainty, the specimen was taken to the Herbarium Reference Collection for comparison with known species, and on occasion, specialist taxonomists were consulted. Some specimens could not be identified as they had no reproductive material. Where possible these were identified by comparison with known species; however, in some cases their identity could not be confirmed. Despite the inability to name some plants to species level, they have been determined to be discrete species and have been named as 'sp. A' or equivalent in this report.

2.5 Statistical analysis

PATN© software (Belbin and Collins 2006) was used to undertake statistical analysis and generate floristic groups using the data collected from the floristic quadrats. PATN© analysis has 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. These studies provided methodological guidance for the GRFVS project.

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.

PATN© offers a choice of data transformations prior to multivariate analysis. In this case, because the analysis used presence/absence data, the Kulczynski similarity coefficient was the appropriate association to use as it has proven to be a good estimation of association for ecological applications (Belbin and Collins 2006). This was followed by Flexible UPMGA (un-weighted pair group using arithmetic averaging) fusion to produce clusters of related objects (species); these are the floristic groups, which are displayed as a dendogram.

Interpolation of these purely floristic groups into recognisable units on-ground was, in some cases, not obvious or appeared to be artificial. Therefore, further interpretation was undertaken to refine the floristic groups into vegetation associations that describe the vegetation of the GRFVS area.

Details of statistical analysis, including PATN©, and other measures used to interpret the vegetation patterns of the project area, are included in appendix 3.

2.6 Vegetation mapping

Plant communities within the GRFVS area were mapped, based on the groupings from the statistical analysis of the floristic data and interpretation of the results. This mapping exercise, which included groundtruthing, was conducted in June 2009.

2.6.1 Desktop vegetation extent mapping

Prior to the vegetation mapping and groundtruthing field survey, expected boundaries of plant communities were delineated using aerial photography and other available information, detailed below, and digitised using ArcGIS software. The digitising largely used existing vegetation extent mapping to determine remnant boundaries.

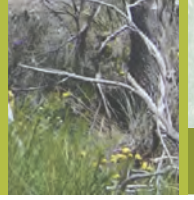
Some additional areas were included where significant areas of remnant vegetation had not been included in the vegetation extent mapping (eg south of the Greenough River). Other areas were excluded where they were not native vegetation or had been cleared since the mapping. Cleared areas were largely identified through Google Street View (Google Inc 2009), although boundaries of these were approximate only.

2.6.2 Interpretation of plant communities

Interpretation of aerial photography included interpolation of vegetation boundary changes based on changes in colour, texture and density of vegetation, as well as using field-based experience to delineate probable plant communities. Google Street View (Google Inc 2009) was used to assist with interpretation in urban areas. Areas that could not be satisfactorily identified using this technique were groundtruthed.

Existing mapping was also used to assist in determining vegetation boundary changes, and included:

- part of the area south of the Greenough River (Tauss 2002);
- Southgate/Cape Burney (ATA Environmental 2008);
- Chapman River Reserve (McCotter and Ecoscape 1993);
- Glenfield Beach (Cardno BSD 2006);
- Oakajee (Maunsell Australia 2008);
- Karloo (Ecoscape 2007); and
- Buller (GHD 2008).



Soil subsystem boundaries were used to provide an indication of plant community boundaries as some plant communities were observed to respond to soil changes during the floristic survey. These included:

- the Tamala South 5 shallow sand Phase (221Ta_5Ts), which was the most common soil for the limestone ridge plant communities (11 and12);
- the boundary between the Tamala (221Ta) and Northampton (225No) soil groups, which was the boundary for the Sandplain plant communities (13 and 14) and the Thicket/Woodland plant communities (15, 16 and 17); and
- riparian soils plant communities (1 and 2).

Topographic mapping was used in the Chapman River Reserve to determine the location of river banks, which formed the boundary between plant community 2 (Riparian: *Eucalyptus camaldulensis / Casuarina obesa / Melaleuca rhaphiophylla*) and plant community 14 (Chapman River Reserve: *Acacia rostellifera / Melaleuca* spp.). In the Oakajee coastal area, topographic mapping was also used to assist in delineating boundaries between the limestone ridge plant communities (11 and 12) and plant community 10 (Near Coastal: *Acacia rostellifera* shrubland).

Plant communities identified from the floristic quadrats data were also extrapolated into adjacent areas.

2.6.3 Field verification

Following aerial photography interpretation and preparation of field maps for the study area, accessible remnants were groundtruthed to delineate plant community boundaries during 16-19 June 2009.

The plant community verification survey did not include establishment and recording of further floristic quadrats, or accessing private property for detailed assessment. The mapped vegetation boundaries were assessed for accuracy and corrected on field maps where necessary. Additional plant species (where observed) were recorded for inclusion in the plant community descriptions, plant community recognition was assessed and a search for historical plant communities was undertaken.

Where vegetation did not match any GRFVS plant community definition, a community description was recorded and a photograph taken. The decision to either include the plant community variant within existing plant communities or create a new community was made through further interpretation of the data and discussion with the project steering committee at the conclusion of the field survey.

Following the groundtruthing survey, plant community boundaries and attributes were digitally corrected using ArcGIS software, and areas of plant communities were calculated.

2.7 Botanical survey limitations

A summary table of botanical survey limitations is included in appendix 2.

The GRFVS project ecologist Lyn Atkins has over 20 years of botanical survey and plant identification experience in Western Australia. Therefore it is considered there are no constraints in relation to the surveyor's competence.

In accordance with EPA Guidance Statement 51, the field survey was undertaken in spring 2008, which is within the optimal period to recognise flora species in the south-west botanical province. Thirty-seven (approximately 10%) of the 375 collected voucher species could not be identified to species level; in many cases this was due to lack of diagnostic flowering material at the time of survey. Poaceae and other herbaceous species formed the majority of specimens that could not be identified to species level, as they have a later flowing period. It is unlikely that any of the unidentified species were declared rare flora. It is considered that the floristic quadrat survey was conducted at an optimal time to recognise as many species as possible from a single survey and therefore there are negligible limitations in relation to the ability to recognise species.

The floristic quadrat survey was conducted over 15 10-hour days by two surveyors. Each quadrat was surveyed for between 40 minutes and 2 hours, depending on vegetation density and number of species. It is considered that the time spent assessing each quadrat was adequate to identify the presence of approximately 95-100% of species present, and therefore there are negligible limitations in terms of the time spent surveying each quadrat.

In terms of the floristic quadrats' representation of the vegetation of the GRFVS area, it is considered that the survey adequately recorded most of the variation within the area at the scale of a sub-regional survey. Therefore there are negligible limitations in relation to the representation of the survey that are discussed in section 2.3, and it is not considered that further work is required.

The 2008 winter-spring rainfall for Geraldton Airport was approximately 64% of the long-term average for the season (May-September average rainfall 359.7mm, 2008 rainfall 231.9mm (BOM 2008)). Despite the lower than average rainfall, there were no discernible effects on the seasonal health and flowering of any species observed in the study area. Therefore, there are negligible limitations in relation to the presence of ephemeral species or the ability to recognise them.

2.7.1 Plant identification

Except for the occasional non-flowering specimens that could not be determined to species or genus level, and where there was more than one possible species in the area (eg *Rhagodia* sp. seedling, which could have been either of the two species common in the area), all voucher specimens were identified to species level. Therefore some

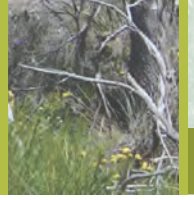
of these 'discrete' species are actually not discrete, but could not be determined to be a specific species and could not be combined accurately with identified species.

2.7.2 Plant community mapping

The accuracy of plant community boundaries varied according to the plant community. For the purpose of this study, the accuracy of communities with distinct boundaries (eg riparian and estuarine communities) was estimated to be approximately 20 m. However, where vegetation communities graded from one to another (eg the catenary sequence of plant communities 3 Foredune: *Atriplex isatidea / Spinifex longifolius*, 8 Coastal: *Acacia rostellifera* low shrubland and 10 Near Coastal: *Acacia rostellifera* shrubland), the actual plant community boundary may be up to 50 m from the mapped boundary. In general, accuracy of the mapped plant community boundaries is between 20 m to 50 m.

Plant communities covering less than 100 m^2 were not mapped unless they occupied an area mapped as an entire polygon in the vegetation extent mapping, for which a plant community was attributed.

Although as much as possible of the GRFVS area was groundtruthed, privately owned areas not visible from roads (generally occurring in the south-eastern and north-eastern portions of the GRFVS area), areas with no road access (eg along the coast between Coronation Beach and the Oakajee River), and burnt areas in Chapman River Reserve were not groundtruthed and were mapped and attributed using available information. Therefore, the confidence of attributing plant communities in these areas is lower than in groundtruthed areas, but is still very high (estimated as 90% confidence).



3 Results

3.1 Analysis of existing data

The review of existing data indicated that within the GRFVS area there are:

- nine Beard vegetation associations (table 1);
- seven DAFWA soil systems and 52 subsystems (table a4.1 in appendix 4, displayed on map 1 in appendix 5); and
- the current (2006) vegetation extent is 6,112 ha from within 625 discrete remnants, which is approximately 15% of the original pre-European vegetation extent.

3.2 Beard vegetation associations

The GRFVS area contains Beard vegetation associations 35, 129, 359, 371, 387, 413, 431, 440 and 675. The Beard vegetation association boundaries for the GRFVS area were re-interpreted using soil system and subsystem data, as detailed in appendix 1. The recommended boundaries are shown on map 2 in appendix 5. The re-interpreted Beard vegetation association boundaries are used throughout this report.

3.2.1 Representation of Beard vegetation associations

Representation of Beard vegetation associations is shown in table 2, as a proportion of the pre-European extent and the area in DEC estate, both in the GRFVS area and for the whole of Western Australia (DEC 2007). Data provided in the table is based on vegetation extent mapping (DAFWA 2006) and the newly re-interpreted Beard vegetation association boundaries. It does not include changes to vegetation extent mapping described in section 3.3.3.

Coloured cells in table 2 indicate Beard vegetation associations with approximately less than 10% of the original (pre-European) extent remaining (red) and less than 30% remaining (orange). The 10% and 30% ecological thresholds are defined in national and state policies on native vegetation protection and biodiversity conservation (Environment Australia 2001; EPA 2000, 2008).

The green coloured cells in table 2 highlight Beard vegetation associations that had more than 30% of their total (WA) original extent occurring in the GRFVS area, and those that have more than 30% of their total (WA) remaining extent occurring in the GRFVS area. Map 3 in appendix 5 shows the total (WA) extent of Beard vegetation associations originally occurring in the GRFVS area.

Mapping errors, largely as a result of differences in scale, are generally recognised as an issue associated with Beard vegetation association mapping, so areas and percentages should be regarded as approximate rather than definitive values. Hence, Beard vegetation associations with slightly more than 10% of the original extent remaining in WA (35 and 371) have been coloured red in table 2. Mapping is further complicated by the use of reinterpreted Beard vegetation association areas (within the GRFVS area) in this report and existing mapping. For example, Beard vegetation association 359 is reinterpreted as having 1.41 ha in secure tenure in the GRFVS area and only 1.25 ha in secure tenure in all of Western Australia. Minor discrepancies of this sort do not impact on the overall conservation significance attributed to vegetation associations.

Original and current extent of Beard vegetation associations

Beard vegetation association 35 (Shrublands; jam scrub with scattered York gum) originally occupied 7.16% of the pre-European extent of the GRFVS area, and 18.8% of the pre-European extent remains in the GRFVS area. Within WA approximately 10.56% of the original extent of this vegetation association remains.

Beard vegetation association 129 (Bare areas; drift sand) originally occupied 2.49% of the pre-European extent of the GRFVS area, and 40% of the pre-European extent remains in the GRFVS area. Within WA approximately 63.57% of the original extent of this vegetation association remains.

Beard vegetation association 359 (Shrublands; *Acacia* and *Banksia scrub*) originally occupied 43.71% of the pre-European extent of the GRFVS area, and 17.3% of the pre-European extent remains in the GRFVS area. Within WA approximately 18.8% of the original extent of this vegetation association remains.

Beard vegetation association 371 (Low forest; *Acacia rostellifera*) originally occupied 29% of the pre-European extent of the GRFVS area, and 2.9% of the pre-European extent remains in the GRFVS area. Within WA approximately 10.1% of the original extent of this vegetation association remains.

Beard vegetation association 387 (Shrublands; *Melaleuca cardiophylla* thicket) originally occupied 0.29% of the pre-European extent of the GRFVS area, and 1.4% of the pre-European extent remains in the GRFVS area. Within WA approximately 89.6% of the original extent of this vegetation association remains.

Beard vegetation association 413 (Shrublands; *Acacia neurophylla* thicket) originally occupied 4.17% of the pre-European extent of the GRFVS area, and 18.6% of the pre-European extent remains in the GRFVS area. Within WA approximately 46.62% of the original extent of this vegetation association remains.

Beard vegetation association 431 (Shrublands; *Acacia rostellifera* open scrub) originally occupied 1.71% of the pre-European extent of the GRFVS area, and 52.7% of the pre-European extent remains in the GRFVS area. Within WA approximately 73.76% of the original extent of this vegetation association remains.

Table 2: Representation of Beard vegetation associations

Beard vegetation association	GRFVS area						Comparison of GRFVS area and WA		In WA			
	Original extent (ha)	Current extent (ha)	% Remaining[1]	Current extent in DEC estate (ha)	Original proportion of GRFVS area (%)[2]	Current proportion of GRFVS vegetation (%)[3]	Original proportion of WA extent in GRFVS (%)[4]	Current proportion of WA extent in GRFVS (%)[5]	Original extent (ha)	Current extent (ha)	% Remaining[1]	Current extent in DEC estate (ha)
35 Shrublands; jam scrub with scattered York gum	2915	549	18.83	45.82	7.16	8.98	1.58	2.82	184502	19486	10.56	655.85
129 Bare areas; drift sand	1015	406	40.00	0	2.49	6.64	1.07	0.67	95286	60570	63.57	28372.2
359 Shrublands; *Acacia* and *Banksia* scrub	17805	3077	17.28	1.41	43.71	50.35	40.02	36.78	44493	8366	18.80	1.25
371 Low forest; *Acacia rostellifera*	11812	348	2.95	0	29.00	5.69	30.43	10.50	38816	3315	10.10	199.65
387 Shrublands; *Melaleuca cardiophylla* thicket	117	1.6	1.37	0	0.29	0.03	0.79	0.01	14898	13348	89.60	393.71
413 Shrublands; *Acacia neurophylla* thicket	1698	316	18.61	0	4.17	5.17	48.88	19.51	3474	1620	46.62	24.35
431 Shrublands; *Acacia rostellifera* open scrub	696	367	52.73	0	1.71	6.00	11.51	8.23	6047	4460	73.76	46.75
440 Shrublands; *Acacia ligulata* open scrub	1531	807	52.71	0	3.76	13.20	36.37	34.77	4209	2321	55.15	202.28
675 Shrublands; *Melaleuca* and *Hakea* mixed thicket	3148	240	7.62	79.42	7.73	3.93	6.07	2.18	51850	10992	21.20	328.05
Total area	**40737**	**6111.6**	**15.00**	**126.65**	**15.00**				**443575**	**124478**	**28.06**	**30224.1**

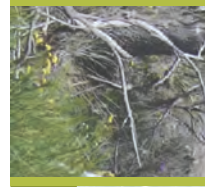
[1] **% Remaining** (current extent / original extent): the proportion of the original extent of this association remaining.

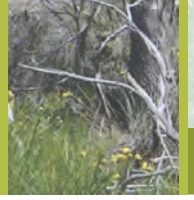
[2] **Original proportion of GRFVS area (%)** (original extent / total area): the proportion of the GRFVS area that was originally occupied by this association.

[3] **Current proportion of GRFVS vegetation (%)** (current extent / total current extent): the proportion of the total remaining vegetation in the GRFVS area occupied by this association.

[4] **Original proportion of WA extent in GRFVS (%)** (original GRFVS extent / original WA extent): the proportion of WA's extent of this association originally occurring within the GRFVS area.

[5] **Current proportion of WA extent in GRFVS (%)** (current GRFVS extent / current WA extent): the proportion of WA's extent of this association currently occurring within the GRFVS area.





Beard vegetation association 440 (Shrublands; *Acacia ligulata* scrub) originally occupied 3.76% of the pre-European extent of the GRFVS area, and 52.7% of the pre-European extent remains in the GRFVS area. Within WA approximately 55.15% of the original extent of this vegetation association remains.

Beard vegetation association 675 (Shrublands; *Melaleuca* and *Hakea* mixed thicket) originally occupied 7.7% of the pre-European extent of the GRFVS area, and 7.6% of the pre-European extent remains in the GRFVS area. Within WA approximately 21.2% of the original extent of this vegetation association remains.

Representation of Beard vegetation associations, both within the GRFVS area and WA, is discussed in section 4.2.

3.3 Floristic quadrats

The field surveys conducted during August and October 2008 assessed 81 of the 85 proposed quadrat sites. Most floristic quadrats were located close to the proposed locations. Logistical constraints prevented three sites from being surveyed.

Actual quadrat locations in relation to proposed quadrat locations are displayed on map 3 in appendix 5. The data collected from the quadrats is provided in appendix 6.

Table 3 indicates the number of quadrats sampled in each Beard vegetation association. The number of quadrats in each Beard vegetation association is approximately in proportion to the percent of the GRFVS area occupied by each association (eg 6% of the floristic quadrats were located in areas mapped as Beard vegetation association 371, which formerly occupied approximately 5.69% of the GRFVS area). There were no quadrats sampled from the one remnant mapped as Beard vegetation association 387 as the site was not easily accessible. Two quadrats were in areas not included in the 'vegetation extent' mapping (ie the areas were mapped as not having native vegetation), although native vegetation was clearly present.

The following vegetation communities identified during the survey differed from the broad scale Beard vegetation association descriptions:

- riparian areas, dominated by *Eucalyptus camaldulensis, Casuarina obesa* or *Melaleuca rhaphiophylla*;

Table 3: Quadrat locations in relation to Beard vegetation associations

Beard vegetation association	Number of quadrats	Proportion of quadrats (%)	Current proportion of GRFVS vegetation (%)
35 Shrublands; jam scrub with scattered York gum	5	6	8.98
129 Bare areas; drift sand	3	4	6.64
359 Shrublands; *Acacia* and *Banksia* scrub	44	54	50.35
371 Low forest; *Acacia rostellifera*	5	6	5.69
387 Shrublands; *Melaleuca cardiophylla* thicket	0	0	0.03
413 Shrublands; *Acacia neurophylla* thicket	5	6	5.17
431 Shrublands; *Acacia rostellifera* open scrub	4	5	6
440 Shrublands; *Acacia ligulata* open scrub	9	11	13.2
675 Shrublands; *Melaleuca* and *Hakea* mixed thicket	4	5	3.93
Not included in vegetation extent mapping	2	2	0
Totals	**81**	**100**	**100**

- estuarine areas dominated by samphire;
- foredune areas dominated by *Atriplex isatidea, Tetragonia decumbens* and *Spinifex longifolius*;
- *Frankenia pauciflora* dominated swale;
- *Ficinia nodosa* sedge dominated swale; and
- *Melaleuca cardiophylla* and *Diplolaena grandiflora* dominated shrublands on exposed limestone (not within areas mapped as Beard vegetation association 387).

These differing vegetation types are discussed in relation to statistical analysis in appendix 3.

3.3.1 Plant species

There were 469 voucher specimens collected during the survey. These were determined to represent 372 discrete species (299 native and 73 non-native), from approximately 81 families. Some specimens could only be determined to genus (10 species) or family (19 species) level, with seven specimens not identifiable to any level. The species list for each quadrat is included with the quadrat descriptions in appendix 6, and the complete species inventory is provided in appendix 7.

The most commonly represented families were Poaceae (41 species, including 22 introduced species, although some species could not be identified to genus/species level as they had no reproductive material), Asteraceae (36 species, including 11 introduced species), Myrtaceae (28 species), Papilionaceae (16 species, including 8 introduced species), Proteaceae (15 species) and Cyperaceae (14 species).

The most frequently recorded native species was *Acacia rostellifera*, occurring in 43 of the 81 sampled quadrats. Other common native species included *Austrostipa elegantissima* (in 37 quadrats), *Dioscorea hastifolia* (28 quadrats), *Acanthocarpus preissii* (26 quadrats), *Thysanotus manglesianus* (23 quadrats), *Desmocladus asper* (20 quadrats) and *Zygophyllum fruticulosum* (20 quadrats).

Introduced species (weeds) were also well represented in the quadrats, with 73 species recorded. Common species included bearded oat *Avena barbata* (in 42 quadrats), wild turnip *Brassica tournefortii* (37 quadrats), flat weed *Hypochaeris glabra* (36 quadrats) and annual veldt grass *Ehrharta longiflora* (33 quadrats). African boxthorn (*Lycium ferocissimum*) was recorded from 13 quadrats, but is far more common than is indicated by its occurrence in floristic quadrats.

Ten flora species of conservation significance were recorded from the quadrats, including two declared rare flora (R), one priority two (P2), five priority three (P3) and one priority four (P4) species:

- *Anthocercis intricata* (P3), recorded from two quadrats
- *Caladenia hoffmanii* (R), recorded from one quadrat
- *Diuris recurva* (P4), recorded from three quadrats
- *Eucalyptus blaxellii* (R), from one quadrat
- *Grevillea triloba* (P3), recorded from three quadrats
- *Hibbertia glomerosa* var. bistrata (P3), from one quadrat
- *Leucopogon* sp. Moresby Range (P3), from one quadrat
- *Thryptomene* sp. Moresby Range (P3) from two quadrats
- *Thryptomene stenophylla* (P2), from one quadrat.

DEC conservation codes and their definitions are in table A7.2 in appendix 7. In general, priority listed species are poorly known from few populations.

An additional three species were recorded at the extent of or beyond their usual range (range extension):

- *Hibbertia glomerosa* var. *bistrata* (range extension), which has previously been recorded from between Morawa and Mullewa.
- *Linum marginale* (range extremity), which has previously been recorded from Howatharra but the usual range is considerably south of the project area.
- *Drosera porrecta* (range extension). The collected specimen had no reproductive parts and was identified by comparing vegetative structure with all other *Drosera* species in the WA Herbarium reference collection. The only similar species was *Drosera porrecta*, which is known from as far north as Eneabba.

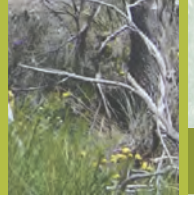


Table 4: Keighery (1994) bushland condition rating of quadrats

Condition	Degraded	Good	Very Good	Excellent	Pristine
Number of quadrats	7	19	35	19	1

3.3.2 Vegetation condition

Vegetation condition, assessed using the Keighery (1994) bushland condition rating methodology detailed in appendix 2, was recorded for each floristic quadrat. The results are shown on map 4 in appendix 5, and table 4. Representative photographs of each vegetation condition rating are included in appendix 2.

No surveyed floristic quadrats were considered to be in *completely degraded* condition as this rating would indicate minimal native vegetation.

Despite locating floristic quadrats in the least disturbed condition vegetation available for the vegetation type being assessed, there were more quadrats recorded from *degraded* or *good condition* vegetation than from *excellent* or *pristine* condition categories.

The *degraded* condition quadrats were at Buller (in the swale) or associated with riparian areas, including the discontinuous Rum Jungle drainage line. The only *pristine* condition quadrat was in the Wokatherra Gap outside the GRFVS area, where there was no evidence of disturbance. The Wokatherra Gap quadrat was surveyed to determine similarity with vegetation to the west of the Moresby Range, within the GRFVS area.

Weed cover is shown on map 5 in appendix 5, and table 5. Most quadrats were moderately weedy (5-25% cover); however, 11 had more than 50% weed cover. These quadrats were largely associated with riparian areas, but also included a grazed site near Moonyoonooka and a quadrat located in the swale at Buller.

3.4 Plant communities

3.4.1 Floristic groups from PATN© analysis

PATN© statistical analysis of collected floristic data produced a dendogram showing groups of floristic similarity, displayed in appendix 3. These initial floristic groups, as identified in the dendogram, are displayed hierarchically in figure 2.

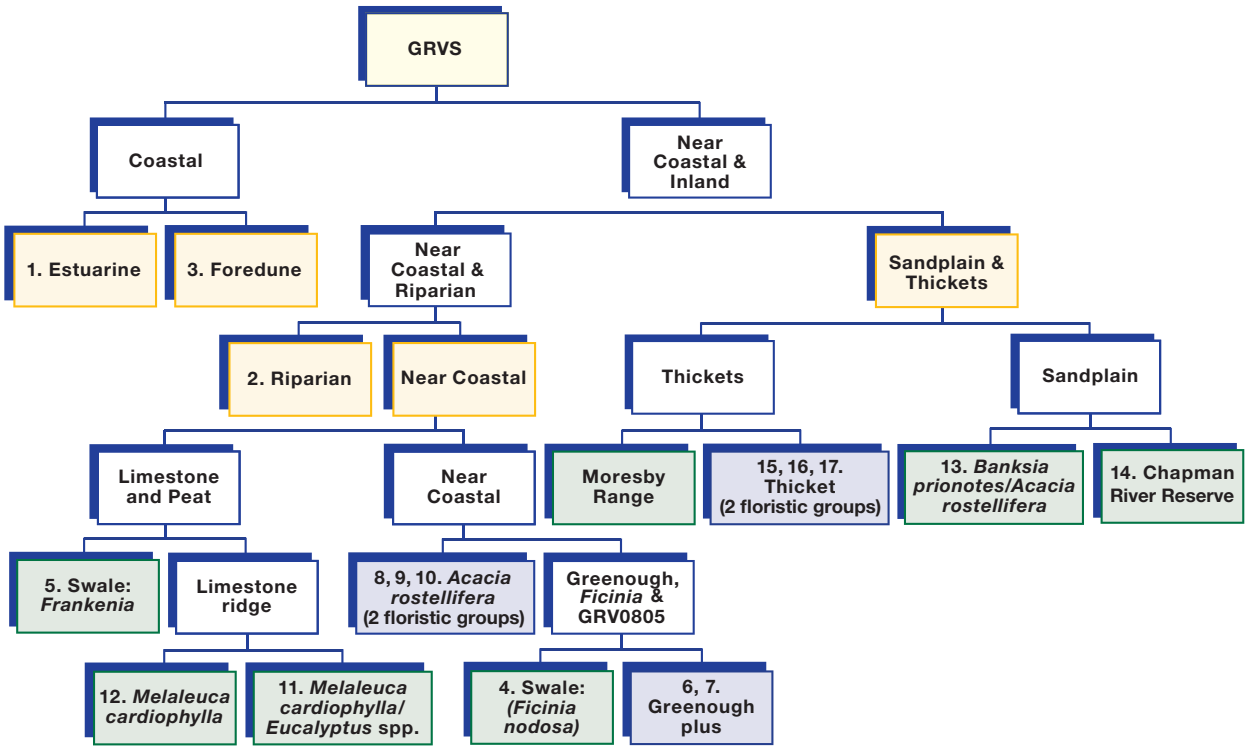
The names displayed on the hierarchy are descriptive only, to indicate a relationship between the quadrats that grouped together. The colour coding indicates different levels within the dendogram and hierarchy:

- white indicates a descriptive name only;
- orange indicates a supergroup, being the most similar floristic groups (and also include two floristic groups: estuarine and foredune);
- blue indicates broad floristic groups that are divided further in the dendogram, however these groups, based purely on floristic similarity, require further interpretation to translate into recognisable on-ground vegetation communities (discussed in appendix 3);
- green indicates a floristic group as identified from the floristic analysis; and
- the number before the name of the floristic group refers to the finalised plant community group number.

Table 5: Braun-Blanquet (1983) weed cover abundance of floristic quadrats

Weediness	R: (rare)	1:00 <5%	2 5-25%	3 25-50%	4 50-75%	5 >75%
Number of quadrats	12	13	33	12	6	5

Figure 2: Initial floristic group hierarchy, indicating final GRFVS plant community numbers



3.4.2 GRFVS plant communities

Using the PATN© analysis to determine broad floristic groups, then interpreting these groups using soil data, dominant species and vegetation structure to identify usable and recognisable groupings, the following plant communities have been identified. Each of these vegetation communities, denoted as the GRFVS plant communities, are described in detail in appendix 8, and the floristic quadrats, mapped as the GRFVS plant communities, are displayed on map 7. Each GRFVS plant community, as detailed in appendix 8, lists the NVIS structural formation name or names recorded during the survey (eg *Open Woodland* or *Woodland* for plant community 16) for the various strata within the community.

Table 6 outlines the methodology used to divide the floristic groups into the GRFVS plant communities. The Moresby Range shrublands were identified from the Wokatherra Gap quadrat. As this plant community is not within the GRFVS area, and is based on only one quadrat of a large and diverse area, it would be inappropriate to assign a community description. For further information, see the quadrat data for GRV0864 in appendix 6.

3.4.3 Changes to vegetation extent mapping

Areas where the vegetation extent mapping has changed is illustrated on map 8 in appendix 5. Some of the variation in vegetation extent mapping is due to the scale of the original mapping and recent clearing.

Some areas of native vegetation were not included in the vegetation extent mapping, and have been added for the plant community mapping. These include:

- samphire (estuarine areas, plant community 1), which are frequently not included in vegetation extent mapping;
- south of the Greenough River mouth;
- isolated vegetated areas within dune fields; and
- some foredune areas (plant community 3) were detected on the aerial imagery, although the full extent of this plant community is still likely to be underestimated. Most foredune areas are narrow or and sparsely vegetated.

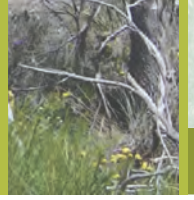


Table 6: Interpretation used to divide floristic groups into plant communities

Floristic supergroup	Floristic groups (and interpretation into plant communities)	Plant community
Estuarine	**Estuarine**	1 **Estuarine: *Casuarina obesa* / *Tecticornia* / *Sarcocornia* (Co/Te/Sa)**
Foredune	**Foredune**	3 **Foredune: *Atriplex isatidea* / *Spinifex longifolius* (Ati/Spl)**
Riparian	**Riparian**	2 **Riparian: *Eucalyptus camaldulensis* / *Casuarina obesa* / *Melaleuca rhaphiophylla* (Ec/Co/Mr)** Rum Jungle is included in this plant community
Near Coastal	**Swale: *Ficinia nodosa***	4 **Swale: *Ficinia nodosa* (Fin)**
	Swale: *Frankenia pauciflora*	5 **Swale: *Frankenia pauciflora* (Frp)**
	Greenough plus floristic group: two of the quadrats have been included in one of the *Acacia rostellifera* groups, the others are separated using dominant species and structure	6 **Coastal: *Thryptomene baeckeacea* (Thb)** GRV0849
		7 **Coastal: *Melaleuca cardiophylla* (cMc)** GRV0847
	Acacia rostellifera groups have largely been separated using vegetation structure	8 **Coastal: *Acacia rostellifera* low shrubland (cAr)** Includes GRV0805 and GRV0850 which were included in the Greenough plus group based on floristic analysis.
		9 **Coastal *Acacia rostellifera* / *Eucalyptus* spp. (Ar/Espp)**
		10 **Near Coastal: *Acacia rostellifera* shrubland (ncAr)**
	Limestone ridge: *Melaleuca cardiophylla /Eucalyptus* spp	11 **Limestone ridge: *Melaleuca cardiophylla* / *Eucalyptus* spp. (Mc/Espp)** Includes GRV0861 that was included in the limestone ridge Melaleuca cardiophylla group based on floristic analysis.
	Limestone ridge: *Melaleuca cardiophylla*	12 **Limestone ridge: *Melaleuca cardiophylla* (rMc)**
Sandplain and Thickets	**Sandplain** groups have been separated into two groups largely based on floristics, with some interpretation using soil and geography	13 **Sandplain: *Banksia prionotes* / *Acacia rostellifera* (Bp/Ar)** Includes GRV0976 from Chapman River Reserve
		14 **Chapman River Reserve: *Acacia rostellifera* / *Melaleuca* spp. (Ar/Mspp)** The remaining floristic quadrats on shallow soil.
	Thickets have been divided into groups based on dominant species, structure and soils (although the floristic groups are largely the same)	15 **Thicket: *Melaleuca* spp. / mixed spp. (Mspp/mx)** Occurs on sandstone soils of the foothills and lower slopes of the Moresby Range.
		16 **Woodland: *Acacia acuminata* / *A. tetragonophylla* / *Hakea preissii* (Aa/At/H)** Woodlands and shrublands on the loamy soils of the Northampton soil system.
		17 **Woodland: *Eucalyptus loxophleba* (El)** York gum woodlands of the Northampton system.
		Moresby Range shrublands Outside the GRFVS area.

Table 7: Changes to 2006 native vegetation extent mapping

Vegetation extent	Hectares	Per cent
GRFVS additional	102.19	1.65%
GRFVS excluded	135.83	2.20%
2006 extent	5938.97	96.15%

In total, approximately 6041.21 ha is included in the vegetation extent mapped for plant communities, which is approximately 70.39 ha less than the 2006 native vegetation extent mapping supplied for this project. In total, approximately 102.19 ha or 1.65% have been included as additional native vegetation, and 135.85 ha or 2.2% have been excluded, having been cleared or determined to not be native vegetation (table 7).

3.4.4 Plant community mapping

Maps of the GRFVS plant communities are included in appendix 5. Table 8 displays the extent (in hectares) and percent of native vegetation in the GRFVS area occupied by each GRFVS plant community.

The two swale plant communities (4 and 5) are the least extensive plant communities in the GRFVS area, with only one occurrence of each community recorded during the surveys, occupying respectively 0.01% and 0.08% of the native vegetation extent. Plant community 10 Near Coastal: Acacia rostellifera is the most frequently encountered community, occupying 36.63% of the native vegetation extent in the GRFVS area.

The implications of the plant community mapping are discussed in section 4.4.

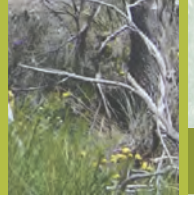


Table 8: Extent of GRFVS plant communities

GRFVS plant community	Description	Area (ha)	Proportion of GRFVS area mapped as native vegetation (%)
1	1 Estuarine: *Casuarina obesa / Tecticornia / Sarcocornia*	33.22	0.54
2	2 Riparian: *Eucalyptus camaldulensis / Casuarina obesa / Melaleuca rhaphiophylla*	388.36	6.30
3	3 Foredune: *Atriplex isatidea / Spinifex longifolius*	96.52	1.57
4	4 Swale: *Ficinia nodosa*	0.58	0.01
5	5 Swale: *Frankenia pauciflora*	4.78	0.08
6	6 Coastal: *Thryptomene baeckeacea*	11.08	0.18
7	7 Coastal: *Melaleuca cardiophylla*	62.71	1.02
8	8 Coastal: *Acacia rostellifera* low shrubland	546.26	8.86
9	9 Coastal: *Acacia rostellifera / Eucalyptus* spp.	12.47	0.20
10	10 Near Coastal: *Acacia rostellifera* shrubland	2258.87	36.63
11	11 Limestone ridge: *Melaleuca cardiophylla / Eucalyptus* spp.	19.95	0.32
12	12 Limestone ridge: *Melaleuca cardiophylla*	865.80	14.04
13	13 Sandplain: *Banksia prionotes / Acacia rostellifera*	754.39	12.23
14	14 Chapman River Reserve: *Acacia rostellifera / Melaleuca* spp.	47.50	0.77
15	15 Thicket: *Melaleuca* spp. / mixed spp.	469.57	7.61
16	16 Woodland: *Acacia acuminata / A. tetragonophylla / Hakea preissii*	452.11	7.33
17	17 Woodland: *Eucalyptus loxophleba*	17.06	0.28
Non native vegetation	**Area not occupied by native vegetation (e.g. planted vegetation)**	**125.57**	**2.04**
Total native vegetation	**Area occupied by native vegetation**	**6041.21**	**97.96**

4 Discussion

4.1 Native vegetation in the GRFVS area

Within the GRFVS area, 15% of the pre-European extent of native vegetation remains. Much of the remaining vegetation is disturbed, fragmented, and subject to ongoing threats and the impacts associated with climate change. Only 2% of the remaining native vegetation of the GRFVS area is within IUCN I-IV reserves. IUCN I-IV reserves are considered to be true conservation reserves (for further description of these categories see Dudley (2008)). All IUCN I-IV reserves in the GRFVS area are DEC-managed lands vested with the Conservation Commission of Western Australia.

The GRFVS project has identified and described plant communities occurring in the Geraldton region, focusing on areas where significant land use change or development is proposed or anticipated. Information collected through the GRFVS project will assist strategic regional planning for native vegetation protection, as well as assessment of proposals likely to impact on native vegetation.

4.1.1 Legislative and policy framework for native vegetation protection

WA environmental legislation

Native vegetation protection in Western Australia is legislated by the *Environmental Protection Act 1986* (Government of Western Australia) and the *Wildlife Conservation Act 1950* (Government of Western Australia). Specifically, the *Environmental Protection Act 1986* provides a legal basis to assess proposals that are likely to have an impact on the environment and to assess native vegetation clearing. The *Wildlife Conservation Act 1950* provides protection to species that are threatened or likely to become extinct without intervention.

National Strategy for Biodiversity Conservation

A number of strategies have also been developed to address biodiversity conservation, both nationally and within the state. The *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia 1996) is particularly relevant to native vegetation protection as it sets targets for the retention and protection of biodiversity at ecosystem, species and genetic levels. The strategy targets have been adopted in Western Australia and are used in the assessment of environmental impacts (EPA 2000, 2008).

EPA Position Statement 2

The EPA develops position and guidance statements to advise proponents on its view in regards to environmental matters in Western Australia. Due to the high clearing in the agricultural areas, the EPA published Position Statement 2 *Environmental Protection of Native Vegetation in Western Australia* to clarify its view of clearing in the Wheatbelt (including the Geraldton region), and also state its position on clearing in areas outside the focus area. Position Statement 2 states that *"…the EPA is of the view that it is unreasonable to expect to be able to continue to clear native vegetation from land within the agricultural area other than relatively small areas and where alternative mechanisms for protection biodiversity are addressed."* Therefore, according to EPA Position Statement 2, clearing in the GRFVS area would only be supported by the EPA where alternative mechanisms address biodiversity protection.

Importantly, EPA Position Statement 2 adopts two criteria from the *National Objectives and Targets for Biodiversity Conservation 2001-2005* (Environment Australia 2001) which are taken into consideration in the assessment of clearing proposals:

(i) 30% of the original extent of each vegetation type is regarded as the threshold level below which species loss appears to accelerate exponentially at an ecosystem level;

(ii) 10% of the original extent of each vegetation type is regarded as the level representing 'endangered'.

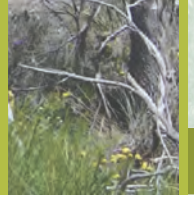
EPA Bulletin 891: Geraldton Region Plan

The stated objective of the EPA for native vegetation is to maintain the abundance, species diversity, geographic distribution and productivity of vegetation types and communities. In assessing the Geraldton Region Plan under section 16 of the *Environmental Protection Act 1986* (EPA Bulletin 891, 1998) the EPA supported the development of a remnant vegetation inventory in the Geraldton region and the conservation of regionally significant vegetation in both private and government ownership.

4.1.2 Conservation significance of native vegetation in the GRFVS area

EPA Guidance Statement 33 *Environmental Guidance for Planning and Development* (2008) lists the types of natural areas that the EPA considers are of high conservation significance and require a high level of protection in WA, including:

- state and regional conservation areas;
- areas where clearing would be at variance with the native vegetation clearing principles in schedule 5 of the *Environmental Protection Act 1986*;
- threatened ecological communities;
- significant flora and fauna;
- wetlands and buffers;
- rivers and foreshores;
- important landscapes and landforms;



- natural areas of heritage significance; and
- other natural areas, such as ecological linkages.

EPA Guidance Statement 33 also outlines criteria developed by government agencies and accepted by the EPA for the identification of regionally significant natural areas for a comprehensive, adequate and representative (CAR) system of conservation areas in Southwest Australia, including the Geraldton sandplain. These criteria were used in selecting natural areas for a regional system of conservation areas in the Perth metropolitan and Greater Bunbury region scheme areas. It is reasonable to expect that the following criteria should be taken into consideration when determining the conservation significance of GRFVS plant communities:

- representation of ecological communities;
- diversity;
- rarity;
- maintaining ecological processes or natural systems;
- scientific or evolutionary importance; and
- protection of wetland, streamline and estuarine fringing vegetation and coastal vegetation.

This report provides information on the representation of vegetation types in the GRFVS area, mapped at the regional scale by Beard (1976a) and at the local scale through the GRFVS project. The report also provides information on diversity, rarity, and vegetation condition, to assist in determining the conservation significance of native vegetation in the GRFVS area. A comprehensive analysis of the conservation significance of plant communities in the Geraldton region is expected to occur through phase 2 'Conservation and regional planning' of the GRFVS project.

In relation to the GRFVS plant communities documented in this report, some are uncommon or restricted in area, at least within the GRFVS area. It is difficult to discuss how widespread or common, in terms of area or proportion, these plant communities are outside the GRFVS area as the description only applies within the GRFVS area.

Unless there is a direct correlation between Beard vegetation associations and GRFVS plant communities, the plant communities cannot be discussed in terms of *remaining* vegetation extent as there is no historic information available. However, the current plant community extent (within the GRFVS area) does indicate the current extent of the plant community (ie in 2009), and provides information for future reference.

Vegetation condition

Within the GRFVS area, vegetation condition varies greatly. Although no floristic quadrats were recorded in areas where the vegetation condition is regarded as *completely degraded* (having virtually no native vegetation remaining, see appendix 2 for definitions), vegetation exists in all the Keighery (1994) rating scores, although the only quadrat recorded in *pristine* condition vegetation was outside the GRFVS area (GRV0864, in the Wokatherra Gap).

Many of the areas with high weed cover are associated with riparian areas, where weed cover is usually a result of a combination of fertile soil favouring weed colonisation, frequent or historic grazing (as riparian areas provide the best grazing land), and frequent disturbance from floods and stock trampling.

Recent regional drought conditions appear to have resulted in shrub and tree deaths and loss of vigour in some areas, mainly associated with plant community 13 sandplain: *Banksia prionotes / Acacia rostellifera*. However, the cause could not be definitively determined and some quadrats may have had their condition 'downgraded' as a result of drought rather than disturbance.

In general, most vegetation would be considered to be in *good* to *very good* condition, as in most areas there is weed invasion from previous and current land uses. Conservation priority should be given to vegetation in better condition, although there are other factors that influence how significant an area of native vegetation is, and how important it is to preserve it within the landscape (eg remnant size, landscape linkages, and rarity of species, ecosystems and vegetation types).

4.2 Beard vegetation associations in the GRFVS area

The Beard vegetation association boundaries supplied at the commencement of the GRFVS project have been modified during this assessment to more accurately reflect the smaller scale soil mapping, as detailed in appendix 1. It is recommended that these amended boundaries be adopted for assessments within the GRFVS area.

Descriptions of Beard vegetation associations occurring in the GRFVS area are provided in appendix 4. Interpretation of Beard vegetation associations within the GRFVS area should take the following into consideration:

- **Beard vegetation association 35** (Shrublands; jam scrub with scattered York gum) is usually readily recognisable as a vegetation type within the GRFVS area.
- **Beard vegetation association 129** (Bare areas; drift sand) contains mostly bare areas; however, there is vegetation located between and on the edges of the sandy areas. Within the GRFVS area, the vegetation is generally the same as found in the surrounding Beard vegetation associations 440 (Shrublands; *Acacia ligulata* open scrub) and 431 (Shrublands; *Acacia rostellifera* open scrub).
- **Beard vegetation association 359** (Shrublands; *Acacia* and *Banksia* scrub) is readily recognisable as *Acacia rostellifera* and *Banksia* prionotes dominated

shrublands, and the general description is applicable for most areas in the GRFVS area, although there are extensive areas where *Banksia prionotes* no longer occurs.

- **Beard vegetation association 371** (Low forest; *Acacia rostellifera*) is not readily recognisable as a unique vegetation type, and is difficult to differentiate from other *Acacia* dominated Beard vegetation associations in the GRFVS area.
- **Beard vegetation association 387** (Shrublands; *Melaleuca cardiophylla* thicket) is readily recognisable from its description, and occupies extensive areas of exposed limestone on ridges and escarpments. However, field surveys have indicated that vegetation matching the description of this association is more widespread than Beard vegetation association mapping indicates. *Melaleuca cardiophylla*-dominated vegetation is described from within the catenary sequence of other *Acacia*-dominated shrublands (Beard 1976a), and it is reasonable to assume that the scale of Beard vegetation association mapping is responsible for this perceived extent anomaly.
- **Beard vegetation association 413** (Shrublands; *Acacia neurophylla* thicket) is recognisable from its geographic location, occurring in the Buller catchment. However, as a species *Acacia neurophylla* was only occasionally observed during the field survey, and therefore this community is not readily recognisable by its species descriptor.
- **Beard vegetation association 440** (Shrublands; *Acacia ligulata* open scrub) is mapped as occurring in coastal areas north of Tarcoola Beach, although *Acacia ligulata* was not identified within the GRFVS area. Beard (1976a) states that 'at some stage north of Geraldton *A. rostellifera* is replaced in this habitat by the closely similar species *A. ligulata*'. Therefore it is concluded that this vegetation association is an amalgam of these two species, with *A. rostellifera* occurring in the GRFVS area. This vegetation association is not easily distinguished from other *Acacia rostellifera* dominated Beard vegetation associations.
- **Beard vegetation association 675** (Shrublands; *Melaleuca* and *Hakea* mixed thicket) occurs adjacent to the Moresby Range, on the eastern edge of the GRFVS area. The description of mixed thicket is ambiguous, however it is recognisable from its geographic location adjacent to the Moresby Range.

4.2.1 Representation of Beard vegetation associations

The representation of each of the Beard vegetation associations occurring in the GRFVS area is discussed below, in terms of extent and conservation significance in relation to the 10% and 30% thresholds applied at the state and GRFVS area levels. Table 2 shows pre-European and current extents of Beard vegetation associations in the GRFVS area.

The Beard vegetation associations are discussed in terms of the pre-European extent remaining and protected within WA and within the GRFVS area. It is important to consider the representation of vegetation types in terms of their total extent in WA, as well as their local extent within the GRFVS area. Consideration of 'local biodiversity' representation assists in the conservation of genetic, species and ecosystem diversity.

For the purposes of determining conservation priorities in the GRFVS area, Beard vegetation associations may be categorised according to the following:

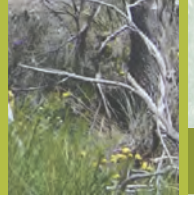
- *Regionally significant – endangered*: Beard vegetation associations that have less than 10% of their pre-European extent remaining in WA.
- *Regionally significant – vulnerable*: Beard vegetation associations that have more than 10% but less than 30% of their pre-European extent remaining in WA.
- *Locally significant*: Beard vegetation associations that have more than 30% of their pre-European extent remaining in WA. Beard vegetation associations that had more than 30% of the total (WA) extent originally occurring within the GRFVS area may be prioritised over other vegetation associations.

Regionally significant – endangered

Beard vegetation association 35 (Shrublands; jam scrub with scattered York gum) and **Beard vegetation association 371** (Low forest; *Acacia rostellifera*) are considered to have less than 10% of their pre-European extent remaining in WA. According to criteria established by the Commonwealth government and adopted in state policy, these vegetation types are regarded as 'endangered' ecosystems. Furthermore, these vegetation types are inadequately reserved within WA, with 0.355% of the original extent of Beard vegetation association 35 and 0.015% of the original extent of Beard vegetation association 371 within IUCN I-IV reserves.

Within the GRFVS area, Beard vegetation association 371 also has less than 10% (348 ha, equivalent to 2.95%) of its pre-European extent remaining, and none is within IUCN I-IV reserves. Beard vegetation association 35 has more than 10% but less than 30% (549 ha, equivalent to 18.83%) of its pre-European extent remaining in the GRFVS area, and 45.82 ha is within IUCN I-IV reserves (Oakajee Nature Reserve).

Beard vegetation association 371 originally occupied almost one-third (29%) of the GRFVS area, and was therefore one of the main vegetation types occurring in the area. Originally, almost one-third (30.43%) of WA's total extent of Beard vegetation association 371 was located within the GRFVS area, which highlights the significance of the area for representation of this vegetation type. The GRFVS area now contains 10.5% of the total remaining WA extent of Beard vegetation association 371.



The GRFVS area is less significant for its representation of Beard vegetation association 35. This vegetation type originally occupied 7.16% of the GRFVS area; however, only 1.58% of WA's total extent of this vegetation type originally occurred in the GRFVS area. The GRFVS area now contains 2.82% of WA's total remaining extent of this vegetation type.

Regionally significant – vulnerable

Beard vegetation association 359 (Shrublands; *Acacia* and *Banksia* scrub) and **Beard vegetation association 675** (Shrublands; *Melaleuca* and *Hakea* mixed thicket) have more than 10% but less than 30% of their pre-European extents remaining in WA. According to the criteria established by the Commonwealth government and adopted in state policy, these vegetation types have been cleared below the threshold at which species loss appears to accelerate exponentially at the ecosystem level. Furthermore, these vegetation types are inadequately reserved in WA, with only 0.003% of the current extent of Beard vegetation association 359 and 0.006% of the current extent of Beard vegetation association 675 within IUCN I-IV reserves.

Within the GRFVS area, Beard vegetation association 675 has less than 10% (240 ha, equivalent to 7.62%) of its pre-European extent remaining, with 79.42 ha in IUCN I-IV reserves (Oakajee and Wokatherra Nature Reserves). Beard vegetation association 359 has more than 10% but less than 30% (3077 ha, equivalent to 17.28%) of the pre-European extent remaining in the GRFVS area, with 1.41 ha within IUCN I-IV reserves (Wokatherra Nature Reserve).

Beard vegetation association 359 originally occupied almost half (43.71%) of the GRFVS area, and was therefore the main vegetation type occurring in the area. Originally, over one-third (40.02%) of WA's total extent of Beard vegetation association 359 was located within the GRFVS area, which highlights the significance of the area for representation of this vegetation type. The GRFVS area now contains 36.78% of the total remaining WA extent of Beard vegetation association 359, which also highlights the importance of the area for conservation of this vegetation type.

The GRFVS area is not so significant for representation of Beard vegetation association 675. This vegetation type originally occupied 7.73% of the GRFVS area, however only 6.07% of WA's total extent of this vegetation type originally occurred in the GRFVS area. The GRFVS area now contains 2.18% of WA's total remaining extent of this vegetation type. Beard vegetation association 675 is also considered to be synonymous with the P1 priority ecological community 'Plant assemblages of the Moresby Range' (DEC 2009b).

Locally significant

Beard vegetation associations 129 (Bare areas; drift sand), **387** (Shrublands; *Melaleuca cardiophylla* thicket), **413** (Shrublands; *Acacia neurophylla* thicket), *431* (Shrublands; *Acacia rostellifera* open scrub), and *440* (Shrublands; **Acacia ligulata** open scrub) have more than 30% of the pre-European extent of native vegetation remaining in WA. Most of these vegetation types are inadequately reserved, as Beard vegetation association 387 has 2.643%, 413 has 0.701%, 431 has 0.773%, 440 has 4.806%, and 129 has 0.049% of the current extent of native vegetation within IUCN I-IV reserves.

In terms of national and state policy criteria for representation, these vegetation types are not considered to be high conservation priorities for WA. However, the extent to which they have been cleared also needs to be considered at the local level. Within the GRFVS area, Beard vegetation association 387 has less than 10% (1.6 ha, equivalent to 1.37%) of the pre-European extent remaining, with none within IUCN I-IV reserves. Beard vegetation association 413 has more than 10% but less than 30% (316 ha, equivalent to 18.61%) of the pre-European extent remaining, and none within IUCN I-IV reserves in the GRFVS area.

Beard vegetation associations 129, 431 and 440 have more than 30% of the pre-European extent remaining, both in WA and the GRFVS area; however, none is within IUCN I-IV reserves in the GRFVS area. In terms of national and state policy criteria, these vegetation types, mapped at the Beard vegetation association scale, are not considered to be high conservation priorities. However, the GRFVS plant communities mapped at a finer scale in these Beard associations may be considered to have high conservation significance. The GRFVS plant communities, including their relationship (spatial and floristic) to Beard vegetation associations, are discussed in section 4.3.

Originally, the GRFVS area was occupied by 2.49% of Beard vegetation associations 129, 0.29% of 387, 4.17% of 413, 1.71% of 431, and 3.76% of 440. Although none of these vegetation types were originally widespread in the GRFVS area, the area is considered significant in terms of the state's representation of Beard vegetation associations 413 and 440. Originally, almost half (48.88%) of WA's total extent of Beard vegetation association 413 was located in the GRFVS area, and now 19.51% of the total remaining WA extent of this vegetation type is contained in the GRFVS area. Similarly, over one-third (36.37%) of WA's total extent of Beard vegetation association 440 was located in the GRFVS area, and now 34.77% of the total remaining WA extent of this vegetation type is contained in the GRFVS area.

The GRFVS area is not considered to be significant in terms of the state's representation of Beard vegetation associations 129, 387 and 431. Originally, 1.07% of WA's total extent of Beard vegetation association 129, 0.79% of 387, and 11.51% of 431 occurred in the GRFVS area. The GRFVS area now contains 0.67% of WA's total remaining extent of Beard vegetation association 129, 0.01% of 387, and 8.23% of 431.

4.3 Identifying and describing GRFVS plant communities

The GRFVS does not aim to replace the Beard vegetation association mapping, but provides more detail about the vegetation of the GRFVS area to permit reasonable planning decisions to be made. To this end, a new set of supplemental plant communities (the GRFVS plant communities) have been developed using collected floristic quadrat data, statistical analysis and interpretation. These have been described earlier in this report, and will be discussed in further detail in section 4.4.

4.3.1 Determining GRFVS plant communities

Determining GRFVS plant communities was a multi-stage process, that began with desktop interpretation of existing mapping (Beard vegetation associations and soil mapping), and continued with field verification of the validity of the vegetation types and the mapping boundaries.

Desktop and field survey

It was apparent that the scale, and, at times the mapped boundaries of the Beard vegetation association data, was insufficient to describe the vegetation of the GRFVS area. This was particularly the case in relation to important but small scale vegetation types including riparian and foredune areas, limestone communities, and variation in vegetation structure.

The next stage in determining GRFVS plant communities was to undertake a floristic survey, recording all species within 10 m x 10 m floristic quadrats, vegetation community descriptions and environmental attributes of the quadrat locations.

Statistical analysis and interpretation

Although some plant species could not be determined to species level, mostly because of the absence of diagnostic reproductive material, PATN© statistical analysis was undertaken to group the floristic quadrats into floristic groups. Broadly, the resulting hierarchy represented the plant communities of the GRFVS area; however, some floristic groups required interpretation, and rearrangement, to represent the observed on-ground plant communities. Having recognisable on-ground plant communities is vital because the objectives for the project included production of mappable plant communities that adequately describe the vegetation of the GRFVS area, to enable sound environmental planning including recognising significant plant communities.

Following discussion with the GRFVS project steering committee, the 15 floristic groups identified using the statistical analysis have been interpreted and modified to form 17 GRFVS plant communities, detailed in various sections of this report and described in appendix 8. An additional group from the Moresby Range (Wokatherra Gap) was separated by statistical analysis. As discussed in section 2.3 this quadrat was not within the GRFVS area, therefore it has not been examined further in this report.

4.3.2 Relevance of GRFVS plant communities

The GRFVS plant communities are only applicable to the GRFVS project area. The GRFVS plant communities may also be relevant to areas outside the GRFVS area; however, care would be required with community interpretation and extrapolation, particularly in relation to rarity and commonality of various communities.

Adoption of the GRFVS plant communities by the DEC, EPA, other state authorities and local governments will not replace the requirement for detailed site-specific flora and vegetation surveys, including those required for environmental impact assessments, clearing permits or rezoning applications.

4.3.3 GRFVS plant community mapping

All plant communities were recognisable as on-ground vegetation units; however, some of these require interpretation and there are some potential mapping issues, detailed in section 2.7.2, and shown in table 9.

4.3.4 Difficulties with recognising plant communities

The majority of the plant communities determined from this project were all recognisable in the field, and could be immediately identified without confusion. The exceptions which required interpretation were:

- An area of *Melaleuca huegelii / Acacia rostellifera* shrubland near Glendinning Road, Tarcoola Beach (mapped by ATA Environmental 2008), which was determined in the field to be most similar to plant community 8 Coastal *Acacia rostellifera* low shrubland, based on the presence of understorey species. A floristic quadrat was not established in this area; however, this site was visited during the community mapping survey and nine perennial and six identifiable annual (weed) species were recorded. PATN© analysis, using species identified from an approximate 10 m x 10 m area, indicated that this community was floristically most similar to plant community 8. The plant community description has been broadened to include this variant.
- Areas of low heath at Karloo and Utakarra dominated by *Melaleuca* spp. recorded by Ecoscape (2007). These initially appeared to be a new community but on closer examination were determined to be part of plant community 13 (Sandplain: *Banksia prionotes / Acacia rostellifera*) as the species present constituted the understorey species of this plant community. It is likely that the shallow soil of this area, which included limestone outcropping, limited the presence of the

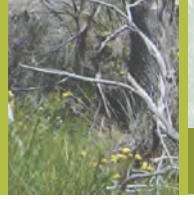


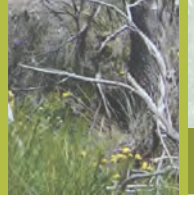
Table 9: Anticipated potential mapping issues

GRFVS plant community	Discrete or merging: boundary accuracy	Other potential mapping issues
1 Estuarine: ***Casuarina obesa* / *Tecticornia* / *Sarcocornia*** (Co/Te/Sa)	Discrete; boundary accuracy c.20 m	Often occupies areas not included in 'vegetation extent' mapping; potential for saline areas that are not estuarine to be this plant community
2 Riparian: ***Eucalyptus camaldulensis* / *Casuarina obesa* / *Melaleuca rhaphiophylla*** (Ec/Co/Mr)	Discrete; boundary accuracy c.20 m	Fringe or pockets of *Acacia rostellifera* vegetation common but usually too narrow to be mapped separately
3 Foredune: ***Atriplex isatidea* / *Spinifex longifolius*** (Ati/Spl)	Merges with plant community 8: boundary accuracy 20-50 m	Often occupies areas not included within 'vegetation extent' mapping
4 Swale: ***Ficinia nodosa*** (Fin)	Discrete; boundary accuracy c.20 m	Most occurrences of *Ficinia nodosa* have less than 2% ground cover and cannot be mapped as a community
5 Swale: ***Frankenia pauciflora*** (Frp)	Discrete; boundary accuracy c.20 m	
6 Coastal: ***Thryptomene baeckeacea*** (Thb)	Merges with plant community 8: boundary accuracy 20-50 m	
7 Coastal: ***Melaleuca cardiophylla*** (cMc)	Discrete; boundary accuracy c.20 m	Mosaic community (usually with community 10).
8 Coastal: ***Acacia rostellifera*** low shrubland (cAr)	Merges with plant communities 3 and 10; boundary accuracy 20-50 m	Broad boundary with plant community 10; uncommon variant dominated by *Melaleuca huegelii*
9 Coastal: ***Acacia rostellifera* / *Eucalyptus*** spp. (Ar/Espp)	Discrete; boundary accuracy c.20 m	Dominant mallee (*E. oraria*) has same foliage colour as *A. rostellifera*, and may be difficult to differentiate from a distance; a few isolated mallees may occur in adjacent areas
10 Near Coastal: ***Acacia rostellifera*** shrubland (ncAr)	Merges with plant community 8: boundary accuracy 20-50 m	Broad boundary with plant community 8; variant community co-dominated by *Alyxia buxifolia* and *Pittosporum ligustrifolium* near Greenough River; plant community 10 is often a result of disturbance but some elements of previous community remaining may make interpretation difficult
11 Limestone ridge: ***Melaleuca cardiophylla* / *Eucalyptus*** spp. (Mc/Espp)	Discrete; boundary accuracy c.20 m	Although these communities are structurally distinct, the scale of plant community 11 may make these communities difficult to map as separate units; isolated mallees within plant community 12 should not be interpreted as plant community 11
12 Limestone ridge: ***Melaleuca cardiophylla*** (rMc)	Discrete; boundary accuracy c20 m	
13 Sandplain: ***Banksia prionotes* / *Acacia rostellifera*** (Bp/Ar)	Merges with plant community 14 in Chapman River Reserve: boundary accuracy c20 m	Uncommon community variants include low heath and *Allocasuarina huegeliana* woodland; degradation of this community leads to it becoming plant community 10
14 Chapman River Reserve: ***Acacia rostellifera* / *Melaleuca*** spp. (Ar/Mspp)	Merges with plant community 13; boundary accuracy c20 m	Unable to accurately map extent due to recent fire prior to survey
15 Thicket: ***Melaleuca*** spp / mixed spp. (Mspp/mx)	Discrete; boundary accuracy c20 m	Degraded examples of this community become plant community 16, but may be difficult to interpret between these communities
16 Woodland: ***Acacia acuminata* / *A. tetragonophylla* / *Hakea preissii*** (Aa/At/Hp)	Discrete; boundary accuracy c20 m	Less degraded examples include *Acacia acuminata* but more degraded examples are almost entirely *Acacia tetragonophylla* or more commonly *Hakea preissii*
17 Woodland: ***Eucalyptus loxophleba*** (El)	Discrete; boundary accuracy c20 m	

overstorey species and restricted the development of all species to form a low heath community rather than a taller shrubland.

- Small areas dominated by *Melaleuca lanceolata*. Anecdotal and historical records indicate a *M. lanceolata* dominated community occurred within the GRFVS area, near the road to the Greenough River mouth (O'Connor 2001), and near the mouth of the Chapman River (Jenna Brooker, pers. comm.). Four areas were identified where this community had previously existed; however, only small areas dissected by roads remained (two were along Brand Highway between Devlin Pool Road and Greenough River Road, and at Point Moore and Cathedral Avenue, illustrated in figure 3). None were of sufficient size to map as separate communities and have been included in the adjacent plant community descriptions in appendix 8. A few individual *M. lanceolata* were also located in the Chapman River Reserve adjacent to the Spalding Park playing fields; however, their scattered nature indicated that these were unlikely to have formed a community in the past.
- Areas of disturbance, where some elements of the previous community remained but had largely been replaced by *Acacia rostellifera*. This was most apparent on yellow sandplain soils, where occasional *Banksia prionotes* or other typical sandplain species occurred sparsely within otherwise degraded areas. In this case, where herbaceous species no longer occurred or were sparsely distributed within the community (except *Acanthocarpus preissii*, *Austrostipa elegantissima*, *Pimelea microcephala*, *Rhagodia* spp. and *Stylobasium spathulatum*), the community was assessed as being plant community 10 (Near Coastal: *Acacia rostellifera* shrubland). The description of this community includes reference to its often disturbed nature.
- Areas close to the Greenough River dominated by *Acacia rostellifera*, *Alyxia buxifolia* and *Pittosporum ligustrifolium* have been assessed as being associated with plant community 10 (Near Coastal: *Acacia rostellifera* shrubland).
- Chapman River Reserve where a recent fire on the eastern side of the park made the determination of the plant community 14 (Chapman River Reserve: *Acacia rostellifera / Melaleuca* spp.) boundary difficult to interpret. It is possible that this community occupies a larger area than is mapped.
- Within Oakajee Nature Reserve, adjacent to the southern edge, is a patch of samphire. Analysis of this area determined it to be a variant of plant community

Figure 3: Areas dominated by Melaleuca lanceolata that are too small to be mapped as a plant community



1 (Estuarine: *Casuarina obesa / Tecticornia / Sarcocornia*). This area within Oakajee Nature Reserve does not match the 'estuarine' description of plant community 1; however, it forms a very small proportion of this community. As the majority of the occurrences for this plant community are well suited to the descriptive name of 'estuarine', the decision was made not to change the community name. Had similar areas occurred more frequently within this plant community, it would have necessitated a name change to 'saltmarsh'.

4.3.5 Historical plant communities

Plant communities that were known from historical records, that were searched for and not found, were:

- *Verticordia chrysantha* recorded from Chapman River Reserve (McCotter and Ecoscape 1993). Although this plant community was not found and is presumed to no longer exist in the park, it is assumed to have been a former variant within plant community 13 (Sandplain: *Banksia prionotes / Acacia rostellifera*) and is noted in the description in appendix 8. As the area of its formerly reported occurrence had been recently burnt, it is also possible that it may have been a variant within plant community 14 (Chapman River Reserve: *Acacia rostellifera / Melaleuca* spp.); however, this could not be determined.
- *Themeda triandra* grasslands were previously recorded from the Greenough Alluvial Flats (O'Connor 2001), of which a small area is included in the GRFVS area. It is possible that this community may still exist in the area but may not have been mapped as native vegetation. If it does occur within the GRFVS area, it would be a discrete plant community and would require a community description to be developed.
- York gum (*Eucalyptus loxophleba*) woodland with *Acacia rostellifera* and *Themeda triandra* understorey, formerly known from the Greenough Alluvial Flats. O'Connor (2001) suggested that this community has probably been completely cleared. Although the description of this community does not completely match that of a *critically endangered* threatened ecological community from the Greenough River Flats (42: *Acacia rostellifera* low forest with scattered *Eucalyptus camaldulensis* on Greenough Alluvial Flats), there is a degree of similarity to the description of the 'back flats' that indicate that the York Gum woodland is included. This community has been nominated for a change in conservation status to *Presumed Totally Destroyed* (Catherine Page, DEC *pers. comm.*) as all previously known occurrences are completely degraded. This change in status is currently awaiting endorsement from the Western Australian Minister for the Environment.

Despite attempts to survey the complete range of vegetation, there is the potential that other discrete plant communities may also occur within the GRFVS area.

4.4 GRFVS plant communities

This section discusses each GRFVS plant community in terms of its occurrence in the GRFVS area, spatial and floristic relationship to Beard vegetation associations, conservation significance (rarity, representation, diversity, and presence of wetland, streamline/estuarine fringing or coastal vegetation), and vegetation condition and threats.

4.4.1 Plant community 1 Estuarine: *Casuarina obesa / Tecticornia / Sarcocornia*

Description and occurrence

Plant community 1 is dominated by Casuarina obesa and samphire, and occurs in estuarine areas on wet saline alluvial soil at river mouths and along saline river edges close to the coast. Plant community 1 is most extensive at the mouth of Chapman River and Rudds Gully near Devlin Pool. It also occurs along the edge of Greenough River near the river mouth, and in small areas near the mouths of other rivers. Plant community 1 is considered to be equivalent to vegetation unit 6 'river fringe' defined through the SWALE project for the area south of Greenough River (Tauss 2002).

Relationship to Beard vegetation associations

Plant community 1 is located in parts of Beard vegetation associations 371 and 431 within the GRFVS area. Floristically, plant community 1 does not correspond to any particular Beard vegetation association, due to the plant community being restricted to estuarine areas which are present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 1 occupies 33.22 ha or 0.54% of the native vegetation of the GRFVS area, and is one of the most restricted GRFVS plant communities.

Representation

None of the mapped extent of plant community 1 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 1 was identified from two quadrats in the GRFVS area (GRV0859 and 60), where up to eight native species were recorded. A variant of plant community 1 occurs on Oakajee Nature Reserve, and would be described as 'saltmarsh' rather than estuarine. A narrow area of Melaleuca lanceolata occurs upslope of plant community 1 along Brand Highway, Rudds Gully.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 1 contains estuarine fringing vegetation.

Vegetation condition and threats

Plant community 1 is not threatened by clearing, grazing or weed invasion. However, it may be threatened by hydrological change, including changes in salinity, watertable rise and changes in river flows.

4.4.2 Plant community 2 Riparian: *Eucalyptus camaldulensis / Casuarina obesa / Melaleuca rhaphiophylla*

Description and occurrence

Plant community 2 is dominated by *Eucalyptus camaldulensis* subsp. *obtusa, Casuarina obesa* and *Melaleuca rhaphiophylla*, and occurs in riparian areas along drainage lines until merging with an estuarine plant community (plant community 1). Plant community 2 occurs along all rivers and streams in the GRFVS area, and includes the area informally known as 'Rum Jungle'. *Eucalyptus camaldulensis* and *Casuarina obesa* occur along the length of the rivers, whereas *Melaleuca rhaphiophylla* only occurs in the fresher and wetter reaches of the rivers. *Acacia rostellifera* often occurs at the top of river banks, or in raised areas within the drainage lines associated with this plant community. Saline areas of plant community 2 are similar to plant community 1.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 2 traverses Beard vegetation associations 35, 359, 371, 413 and 675. Floristically, plant community 2 does not correspond to any Beard vegetation association within the GRFVS area, due to the plant community being restricted to riparian areas which are present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 2 occupies 388.36 ha or 6.3% of the native vegetation of the GRFVS area.

Representation

None of the mapped extent of plant community 2 occurs within IUCN I-IV reserves in the GRFVS area, but it occurs in Chapman River Reserve. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 2 was identified from 10 quadrats in the GRFVS area (GRV0806, 07, 08, 09, 15, 24, 45, 71, 72 and 80), where a range of 3-11 native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 2 contains streamline fringing vegetation.

Vegetation condition and threats

Within the GRFVS area, this plant community is largely in degraded or good condition, usually as a result of weed invasion and grazing. It is anticipated that the condition would be similar through much of the potential range of the plant community as much of the area is within the agricultural zone. The main threats to this plant community within the GRFVS area are grazing, weed invasion, stock trampling, fire, clearing and increasing salinity, and it is likely that these threats are common throughout the potential area in which this plant community may occur. Although most representatives of this plant community are degraded (weedy and often grazed), the plant community is important to maintain ecological function and linkages in the landscape.

4.4.3 Plant community 3 Foredune: *Atriplex isatidea / Spinifex longifolius*

Description and occurrence

Plant community 3 is dominated by *Atriplex isatidea* and *Spinifex longifolius*, and occurs on foredunes along the coast. *Atriplex isatidea* is only found on foredunes, whereas other species in this plant community also occur in the low coastal shrubland (plant community 8) behind the primary dunes. Plant community 3 is considered to be equivalent to vegetation unit 1 'foredune' defined through the SWALE project for the area south of Greenough River (Tauss 2002).

Relationship to Beard vegetation associations

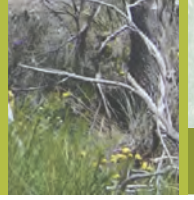
Within the GRFVS area, plant community 3 is located within parts of Beard vegetation associations 129, 371, 431 and 440 (ie the coastal vegetation types). Floristically, plant community 3 does not specifically correspond to any of these Beard vegetation associations, but is included in the broader descriptions used by Beard (1976a). The plant community is restricted to foredune areas, which are present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 3 occupies 96.52 ha or 1.57% of the native vegetation of the GRFVS area; however, it is likely to be more widespread as it occupies areas not included in native vegetation extent mapping.

Representation

None of the mapped extent of plant community 3 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.



Diversity

Plant community 3 was identified from two quadrats in the GRFVS area (GRV0804 and 26), where up to five native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 3 contains coastal vegetation.

Vegetation condition and threats

Plant community 3 is widespread along the coast. However, most occurrences are threatened by urban development, storm erosion, and the impacts of recreational vehicle use along beaches.

4.4.4 Plant community 4 Swale: *Ficinia nodosa*

Description and occurrence

Plant community 4 is dominated by *Ficinia nodosa*, and occurs in a small pocket in the deflation basin swale behind an advancing dune field. The only occurrence of this plant community is south of the Oakajee River mouth, although as a species *Ficinia nodosa* is sparsely scattered throughout the shallow sand areas behind advancing dunes between Drummonds Cove and the Oakajee River.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 4 is located within Beard vegetation association 129. Floristically, plant community 4 does not specifically correspond to this Beard vegetation association, but is included in the broader description used by Beard (1976a). The plant community has a localised occurrence present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 4 occupies 0.58 ha or 0.01% of the native vegetation of the GRFVS area, and is the most restricted of all the GRFVS plant communities. While it is possible that this is a successional stage, and not a long-lived community, it is rare as a *community* (although not rare as a species) in the GRFVS area. Despite intensive searches during the field surveys, only one example of this plant community was located. It has been observed as a plant community elsewhere in Western Australia by the surveyor, most notably near Port Gregory, but has not been commonly observed in any area nor covering any great extent. Further surveys would be required to determine its regional and statewide significance.

Representation

None of the mapped extent of plant community 4 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 4 was identified from one quadrat (GRV0814) where four native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 4 contains coastal vegetation.

Vegetation condition and threats

In the GRFVS area, plant community 4 is primarily threatened by degradation from recreational vehicle use and potentially by clearing for the Oakajee Port and Rail development. Elsewhere in Western Australia the main threats are likely to be hydrological change as the community is often associated with damp areas, including deeper dune swales.

4.4.5 Plant community 5 Swale: *Frankenia pauciflora*

Description and occurrence

Plant community 5 is dominated by *Frankenia pauciflora* and occurs in a single peat-soil swale in the coastal dunes of the Buller locality.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 5 is located within Beard vegetation association 359. Floristically, plant community 5 does not correspond to any particular Beard vegetation association within the GRFVS area, due to the plant community having a localised occurrence present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 5 occupies 4.78 ha or 0.08% of the native vegetation of the GRFVS area, and is the second most restricted GRFVS plant community. Elsewhere in Western Australia this community is associated with areas close to salt lakes or near the shore. The GRFVS occurrence appears to be unique in its association with a peat-soil dune swale rather than salt lake or coastal areas; however, further surveys would be required to determine its regional and statewide significance.

Representation

None of the mapped extent of plant community 5 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 5 was identified from two quadrats in the GRFVS area (GRV0818 and 58), where up to seven native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 5 contains coastal vegetation.

Vegetation condition and threats

Within the GRFVS area, the land occupied by this plant community is privately owned, with multiple owners, and is threatened by grazing and trampling (by domestic and feral animals), rubbish dumping, vehicle use, and perhaps by water use and increasing salinity. Future threats include land development in the Buller Locality. Outside the GRFVS area, this plant community is likely to be similarly threatened, with hydrological change (increasing watertable and higher salinity) being the most serious threat.

4.4.6 Plant community 6 Coastal: *Thryptomene baeckeacea*

Description and occurrence

Plant community 6 is dominated by *Thryptomene baeckeacea* and occurs in a portion of the coastal dunes south of Greenough River. Floristically, plant community 6 is similar to plant communities 7 and 8, which occur nearby. Plant community 6 is considered to be equivalent to vegetation unit 4 '*Thryptomene baeckeacea* closed heath' defined through the SWALE project for the area south of Greenough River (Tauss 2002).

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 6 is located within Beard vegetation association 431. Floristically, plant community 6 does not specifically correspond to this Beard vegetation association, but it is included in the broader description used by Beard (1976a). The plant community has a localised occurrence present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 6 occupies 11.08 ha or 0.18% of the native vegetation of the GRFVS area, and is the third most restricted GRFVS plant community. There is only one representative of this plant community in the GRFVS area, which indicates local conservation significance. Further survey is required to determine its regional and statewide significance.

Whilst this plant community is not directly comparable to any Beard vegetation associations, Beard (1976a) described and photographed similar areas in Edel Land that appear to correspond with Beard vegetation association 1100 (Hummock grassland; dwarf shrub steppe; mixed ericoid shrubs and spinifex). Such areas have been observed on Peron Peninsula by the assessor.

Representation

None of the mapped extent of plant community 6 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 6 was identified from one quadrat (GRV0849) where 13 native species were recorded. The plant community was observed to reach greater height in protected swales than on exposed dunes.

Vegetation condition and threats

Plant community 6 may be threatened by future development (clearing), and by recreational vehicle use in the GRFVS area.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 6 contains coastal vegetation.

4.4.7 Plant community 7 Coastal: *Melaleuca cardiophylla*

Description and occurrence

Plant community 7 is dominated by *Melaleuca cardiophylla*, and occurs south of the Greenough River on shallow coastal sands with little or no exposed limestone, usually in a mosaic associated with plant communities 8 and 10. Floristically, plant community 7 is similar to plant communities 6 and 8. Plant community 7 is considered to be equivalent to vegetation unit 8 'closed scrub *Melaleuca cardiophylla*' defined through the SWALE project for the area south of Greenough River (Tauss 2002).

Relationship to Beard vegetation associations

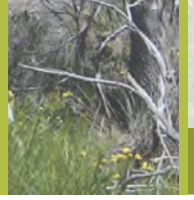
Within the GRFVS area, plant community 7 is located within Beard vegetation association 431. Floristically, plant community 7 does not specifically correspond to this Beard vegetation association, but it is included in the broader description used by Beard (1976a). The plant community has a localised occurrence present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 7 occupies 62.71 ha or 1.02% of the native vegetation of the GRFVS area.

Representation

None of the mapped extent of plant community 7 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.



Diversity

Plant community 7 was recorded from one quadrat in the GRFVS area (GRV0847) where 15 native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 7 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

Plant community 7 may be threatened by future development (clearing), and is currently threatened by weed invasion, grazing by feral animals, fire and recreational vehicle use.

4.4.8 Plant community 8 Coastal: *Acacia rostellifera* low shrubland

Description and occurrence

Plant community 8 is dominated by *Acacia rostellifera* and occurs along the entire coastline of the GRFVS area. The plant community occurs close to the coast, from behind the foredunes to various distances inland but generally on primary dunes. Floristically, this plant community is similar to other coastal and near coastal GRFVS plant communities, and can be differentiated by the generally low stature (<2m high) of the dominant species (*Acacia rostellifera*) and the frequent occurrence of *Myoporum insulare*, *Olearia axillaris*, *Carpobrotus virescens*, *Scaevola crassifolia* and *Spinifex longifolius*, which are generally not found further inland. In areas without the presence of these characteristic species, the vegetation is more likely to be plant community 10. Plant community 8 is considered to be equivalent to vegetation unit 2 'closed heath to scrub on seaward slopes' defined through the SWALE project for the area south of Greenough River (Tauss 2002).

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 8 is located within Beard vegetation associations 129, 371, 431 and 440 (ie the coastal vegetation types). Floristically, plant community 8 does not correspond to any of these Beard vegetation associations in particular, but is included in the broader descriptions used by Beard (1976a).

Rarity

Plant community 8 occupies 546.26 ha or 8.86% of the native vegetation of the GRFVS area.

Representation

None of the mapped extent of plant community 8 occurs within IUCN I-IV reserves in the GRFVS area. It is widespread outside the GRFVS area, and is not dissimilar to the vegetation found on the equivalent landform at least as far south as Perth, but is not directly comparable with any one or small group of Beard vegetation associations. Therefore there is no information available in relation to previous or current extent of *Acacia rostellifera* low shrubland.

Diversity

Plant community 8 was recorded from six quadrats in the GRFVS area (GRV0801, 03, 05, 16, 46 and 50), where a range of 5-14 native species were recorded. A variant of this community, dominated by *Melaleuca huegelii*, occurs near the southern end of Tarcoola Beach. Another variant within this plant community includes small areas of *Melaleuca lanceolata*.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 8 contains coastal vegetation.

Vegetation condition and threats

Plant community 8 is threatened by future development (clearing for housing) as it occurs close to the coast. Other threats include weed invasion, grazing, fire and recreational vehicle use, with higher potential for threatening process to occur in areas closer to human habitation.

4.4.9 Plant community 9 Coastal: *Acacia rostellifera / Eucalyptus* spp.

Description and occurrence

Plant community 9 is dominated by *Acacia rostellifera* and *Eucalyptus oraria* and *E. obtusiflora*, and occurs on coastal sand. Floristically, plant community 9 is similar to other *Acacia rostellifera* communities, but is differentiated on structure, being dominated by mallee eucalypts. Plant community 9 was observed between Tarcoola Beach and Greenough River, where it is restricted to two small areas.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 9 is located within Beard vegetation associations 371 and 431. Floristically, plant community 9 does not correspond to any particular Beard vegetation association within the GRFVS area, due to the plant community having localised occurrences present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 9 occupies 12.47 ha or 0.2% of the native vegetation of the GRFVS area, and is the fourth most restricted GRFVS plant community. Despite extensive survey, this plant community has only been found in one part of the GRFVS area, between Tarcoola Beach and Greenough River. The two mallee species in this plant community (*Eucalyptus obtusiflora* and *E. oraria*) are sparsely distributed through the vegetation surrounding the most southern occurrence, but were not observed

elsewhere in the coastal area. There are no other reported observations of vegetation matching this description from nearby coastal areas. The plant community is unlikely to be abundant in the region, and may be unique. However, a more widespread survey would be required to confirm this.

Eucalyptus oraria, which is one of the mallee species associated with plant community 9, is a definitive species in Beard vegetation association 1107 (Open low woodland; *Eucalyptus oraria*) in the Shark Bay area.

Representation

None of the mapped extent of plant community 9 occurs within IUCN I-IV reserves in the GRFVS area. As this plant community does not correspond with any Beard vegetation associations, there is no information in relation to this plant community's distribution outside the GRFVS area.

Diversity

Plant community 9 was recorded from one quadrat in the GRFVS area (GRV0828) where 11 native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 9 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

The current threats are clearing, fire, weed invasion, rubbish dumping and recreational vehicle use.

4.4.10 Plant community 10 Near Coastal: Acacia rostellifera shrubland

Description and occurrence

Plant community 10 is usually dominated by *Acacia rostellifera*. *Acacia xanthina*, *Alyxia buxifolia* or *Chamelaucium uncinatum* may be dominant or co-dominant species in this plant community. Plant community 10 occurs on taller secondary dunes, and on exposed limestone and sandplain soils to the east as a result of disturbance to other plant communities. On the sandplain soils, the plant community may have formerly included *Banksia prionotes* but has since been reduced to a simpler community dominated by *Acacia rostellifera*. Plant community 10 merges with plant community 8 closer to the coast, and plant community 13 on the sandplain to the east.

Plant community 10 is considered to be equivalent to vegetation unit 3 'closed *Acacia rostellifera* scrub' defined through the SWALE project for the area south of Greenough River (Tauss 2002).

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 10 is located within Beard vegetation associations 129, 359, 371, 413, 431 and 440. Floristically, plant community 10 does not correspond to any of these Beard vegetation associations in particular, but it is included in the broader descriptions used by Beard (1976a).

Rarity

Plant community 10 occupies 2258.86 ha or 36.63% of the native vegetation of the GRFVS area, and is the most widespread of the GRFVS plant communities.

Representation

None of the mapped extent of of plant community 10 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 10 was recorded from 14 quadrats in the GRFVS area (GRV0802, 12, 17, 19, 30, 31, 32, 48, 51, 52, 54, 57, 73 and 74), where a range of 2-18 native species were recorded. One of the quadrat sites, close to Greenough River, had surface soil consisting of a significant proportion of snail shells. *Acacia rostellifera* is a colonising species, which explains why it dominates in disturbed areas.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 10 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

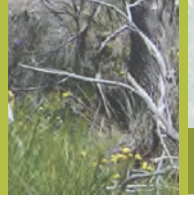
GRV0857 was considered to be a particularly good example of plant community 10 but could not be rated higher than very good condition due to the presence of the very aggressive weed *Lycium ferocissimum* throughout the vegetation. Plant community 10 is threatened by development (clearing), grazing, fire, weed invasion and recreational vehicle use.

4.4.11 Plant community 11 Limestone ridge: *Melaleuca cardiophylla / Eucalyptus* spp.

Description and extent

Description and occurrence

Plant community 11 is dominated by *Melaleuca cardiophylla* and *Eucalyptus* species, and occurs on limestone ridges and slopes between Mount Tarcoola and Rudds Gully, and on the limestone scarp between the Oakajee and Buller rivers. Floristically, plant community



11 is similar to plant community 12, but is structurally different due to the presence of mallees including *E. obtusiflora* and *E. oraria*, which in places form dense stands, and *E. zopherophloia*.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 11 is located within Beard vegetation associations 359 and 387. Floristically, plant community 11 is related to Beard vegetation association 387. The plant community also has a localised occurrence in Beard vegetation association 359, which is present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 11 occupies 19.95 ha or 0.32% of the native vegetation of the GRFVS area, and is one of the most restricted GRFVS plant communities. Plant community 11 is also known to occur south of the GRFVS area, where it may be more common. On occasion, the mallees in this community also occur as scattered individuals within plant community 12. Although the most common mallee species found in this plant community are *Eucalyptus obtusiflora* and *E. oraria*, the Priority 4 species *E. zopherophloia* was also recorded. An additional survey may also be required to determine the local distribution of *Eucalyptus zopherophloia* and preserve areas of its occurrence.

Representation

None of the mapped extent of of plant community 11 occurs within IUCN I-IV reserves in the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 11 was recorded from two quadrats in the GRFVS area (GRV0827 and 61), where up to 15 native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 11 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

Plant community 11 is threatened by clearing, weed invasion and grazing. The best representative of plant community 11 is north of the Buller River on the limestone scarp, which may be threatened with clearing associated with the Oakajee industrial development.

4.4.12 Plant community 12 Limestone Ridge: *Melaleuca cardiophylla*

Description and occurrence

Plant community 12 is dominated by *Melaleuca cardiophylla*, and occurs from the Buller Locality northwards, high on the first and second ridges from the coast where there is exposed limestone capping, and on the limestone ridges of Mount Tarcoola and south-east through Rudds Gully and Jandanol Park. This plant community would have been the most common plant community on exposed Tamala limestone ridges, but some areas have been reduced to a simpler community dominated by *Acacia rostellifera*. Plant community 12 can be differentiated from plant community 7 due to the characteristic limestone capping, and its characteristic species including *Diplolaena grandiflora* and *Grevillea argyrophylla*.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 12 is located within areas mapped as, and is floristically related to, Beard vegetation association 387. The plant community often occupies narrow bands on limestone ridgetops, which are present at a finer scale than Beard vegetation associations were mapped.

Rarity

Plant community 12 occupies 865.8 ha or 14.04% of the native vegetation of the GRFVS area, and is one of the more widespread GRFVS plant communities.

Representation

None of the mapped extent of plant community 12 occurs in IUCN I-IV reserves within the GRFVS area. Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 12 was recorded from nine quadrats in the GRFVS area (GRV0813, 20, 21, 29, 43, 56, 66, 67 and 68), where a range of 11-23 native species were recorded. Floristic quadrat GRV0867, near the southern edge of the GRFVS area, had lower-height vegetation than other representatives of plant community 12 (Limestone ridge: *Melaleuca cardiophylla*), generally less than 1.2 m high, and was dominated by *Melaleuca campanae* (canopy cover of 50% of the area), with *Melaleuca cardiophylla* occasionally emergent to 2 m high, but with only 2% canopy cover. Sedges and herbs also contributed to ground cover in this quadrat (30-70% canopy cover), which was uncommon for this vegetation type.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 12 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

Many areas of this plant community are grazed, and in most cases this has led to a low cover of shrub species and a high weed cover. The greatest threat to this plant community is clearing for urban development, especially as it occurs on the limestone scarp with uninterrupted views towards the coast in areas close to current development, and in the Oakajee in areas associated with the port and rail development. Other threats to this plant community are grazing, weed invasion and fire.

4.4.13 Plant community 13 Sandplain: *Banksia prionotes / Acacia rostellifera*

Description and occurrence

Plant community 13 is dominated by *Banksia prionotes* and *Acacia rostellifera*, and occurs on sandplain soils inland from the coast. Characteristic species are *Grevillea candelabroides*, *Melaleuca depressa*, *Hibbertia* spp., *Conostylis* spp. and sedges and rushes. Floristically, this plant community is most similar to plant community 14, which occurs on the more rocky soils close to Chapman River. Most of Chapman River Reserve is occupied by plant community 13, although frequent fire appears to have reduced the numbers of *B. prionotes* and there are large portions of the area where this characteristic species does not occur. Other characteristic species indicate the presence of plant community 13 in Chapman River Reserve.

Relationship to Beard vegetation associations

Plant community 13 is analogous with, but not completely inclusive of, Beard vegetation association 359. Within the GRFVS area, Beard vegetation association 359 occupies 3077 ha, however the GRFVS project only recorded 754.39 ha of this area as having *Banksia prionotes*-dominated vegetation (or similar plant community, as described in appendix 8). Therefore only approximately 24.52% of Beard vegetation association 359 corresponds with plant community 13 within the GRFVS area.

Rarity

Plant community 13 occupies 754.39 ha or 12.23% of the native vegetation of the GRFVS area, and is one of the more widespread GRFVS plant communities. It is considered that Beard vegetation association 359 and its constituent GRFVS plant community 13 have conservation significance.

Representation

Only 1.25 ha of Beard vegetation association 359 is within IUCN I-IV reserves (DEC 2007), and none of this area is mapped as plant community 13. Banksia prionotes occurs as a dominant or common species on many areas of the Geraldton Sandplain; however further surveys including floristic analysis would be required to determine if there is any degree of similarity between these areas and GRFVS plant community 13, and thereby provide additional regional information on extent and reservation status of this plant community.

Diversity

Plant community 13 was recorded from 13 quadrats in the GRFVS area (GRV0822, 33, 34, 35, 36, 37, 38, 62, 65, 69, 70, 75 and 76), where a range of 4-30 native species were recorded. In degraded areas, plant community 13 is replaced by the less species-rich plant community 10, although there may be a few of the characteristic sandplain species remaining. A variant of plant community 13 is a low heath, which occurs on shallow soil within the sandplain. Another uncommon variant of the plant community is dominated by *Allocasuarina huegeliana*.

Floristic quadrat GRV0875 in Karloo is not the usual vegetation for this area, which is generally *Acacia rostellifera* shrubland. There are patches of *Banksia prionotes / Acacia rostellifera* vegetation scattered through the area. Vegetation south of the railway corridor previously mapped by Ecoscape (2007) as mixed heath in excellent condition, has been included in plant community 13. No floristic quadrats were recorded for this area; however the vegetation is described as a low heath variant in the community description in appendix 8.

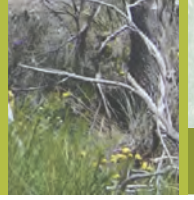
Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 13 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

The largest threat to this plant community is clearing for development, as it occurs in the Glenfield and Waggrakine structure plan areas and the buffer area north of the Oakajee port and rail development. Other significant threats include grazing, weed invasion, potential for soil-borne diseases (eg *Phytophthora* and other species) and fire. *Banksia prionotes* appears to be in decline in the GRFVS area. It is suspected that this is due to prolonged drought and it being near the northern (rainfall) limit of its distribution. Hence, reduced rainfall due to climate change may be a threat to this plant community.

The vegetation of the Glenfield and Waggrakine area is largely GRFVS plant community 13, with the *excellent* condition portions being the best condition and best representation of this vegetation identified during the GRFVS survey. The vegetation appeared to be healthier, less disturbed and more diverse (having more plant



species) than similar vegetation in the Chapman River Reserve, where fire and human disturbance, including rubbish dumping, have probably contributed to the decline in vegetation condition.

4.4.14 Plant community 14 Chapman River Reserve: **Acacia rostellifera / Melaleuca** spp.

Description and occurrence

Plant community 14 is dominated by *Acacia rostellifera* and *Melaleuca* species, and occurs on the slightly rocky (limestone) or shallow soils close to the river in Chapman River Reserve. It is most similar to plant community 13, but includes elements of plant community 12 (on the western side of Chapman River) and plant community 15 (on the eastern side of the river).

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 14 is located within Beard vegetation association 359. Floristically, plant community 14 does not specifically correspond to this Beard vegetation association, but it is included in the broader description used by Beard (1976a). The plant community has a localised occurrence present at a finer scale than Beard vegetation associations were mapped. Its localised occurrence is probably due to underlying geology and to its position downstream from thicket communities.

Rarity

Plant community 14 occupies 47.5 ha or 0.77% of the native vegetation of the GRFVS area, although the extent may be up to 30 ha larger due to a recent fire that made boundary interpretation difficult. Plant community 14 is one of the most restricted GRFVS plant communities, as it only occurs in the Chapman River Reserve. Due to its extremely local occurrence, this plant community must be considered to have high conservation significance as a unique community.

Representation

None of the mapped extent of plant community 14 occurs within IUCN I-IV reserves in the GRFVS area; however the entire plant community occurs in Chapman River Reserve.

Diversity

Plant community 14 was recorded from 4 quadrats in the GRFVS area (GRV0877, 78, 79 and 81), where a range of 19-31 native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 14 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

The threats to plant community 14 are fire, weeds, human disturbance and drought.

4.4.15 Plant community 15 Thicket: *Melaleuca* spp. / mixed spp.

Description and occurrence

Plant community 15 is often dominated by one of a number of *Melaleuca* species, including *M. megacephala, M. concreta*, *M. coronicarpa* and *M. fulgens* subsp. *steedmanii*, but is usually a mixed thicket consisting of many species. It occurs on the footslopes and isolated mesas to the west of the Moresby Range, and includes the steep slopes of the Oakajee and Buller rivers to the east of the North West Coastal Highway.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 15 is located within Beard vegetation associations 35, 413 and 675. Floristically, plant community 15 largely corresponds with Beard vegetation associations 413 and 675. Significant numbers of declared rare flora and priority-listed species were recorded in this plant community during the floristic survey. Plant community 15 may also include the 'natural value' ecosystem 'Moresby Ranges communities with rare plants' (Australian Natural Resources Atlas 2009) and the P1 priority ecological community 'Plant assemblages of the Moresby Range system' (DEC 2009a).

Rarity

Plant community 15 occupies 469.57 ha or 7.61% of the native vegetation of the GRFVS area, and is one of the more widespread GRFVS plant communities. The low mallee *Eucalyptus blaxellii*, a declared rare flora species, is an occasional component of this community.

Representation

Oakajee and Wokatherra nature reserves contain areas mapped as plant community 15 (approximately 103.00 ha and 1.84 ha, respectively). Information is not available to determine the distribution of this plant community outside the GRFVS area.

Diversity

Plant community 15 was recorded from eight quadrats in the GRFVS area (GRV0810, 25, 39, 40, 41, 53, 55 and 63), where a range of 21-48 native species were recorded. Quadrat GRV0825, located near North West Coastal Highway in Oakajee, exhibited the greatest species richness (48 native species) of all quadrats recorded through the GRFVS.

Where grazing has occurred, the more palatable species have been removed and *Acacia tetragonophylla*, *Hakea preissii* and other hard leaved or prickly species remain, and the vegetation is less dense. Plant community 16 is characterised by areas where only the unpalatable species remain.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 15 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

Plant community 15 is often grazed but is unlikely to be affected by further clearing as it occurs on rocky slopes that are not suitable for cultivation, and little is within areas associated with urban or industrial development (except in the Wokatherra Gap, which is within the main infrastructure corridor for the Oakajee port and rail development). The main threats are likely to be grazing, weed invasion and fire.

There are several representatives in *excellent* condition within the GRFVS area, including the areas associated with floristic quadrats GRV0810, 25, 39, 40 and (especially) 55, and these areas have high conservation significance. There are also areas associated with creeklines that are fenced. These may have conservation significance due to their likely excellent condition and their value as landscape linkages.

4.4.16 Plant community 16 Woodland: *Acacia acuminata / Acacia tetragonophylla / Hakea preissii*

Description and occurrence

Plant community 16 is dominated by *Acacia acuminata*, *A. tetragonophylla* and *Hakea preissii*, and occurs on loamy soils of the Northampton soil system, in the Buller and Oakajee catchments. The three listed characteristic species may not all be present, with the two less palatable species (*Acacia tetragonophylla* and *Hakea preissii*) dominating in grazed areas. Plant community 16 is dominated by tree and tall shrub species, climbers, grasses and herbs, with few low or mid-shrubs. Floristically, it is most similar to plant communities 15 and 17, but is differentiated by vegetation structure and dominant species.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 16 is located within Beard vegetation associations 35, 413 and 675. Floristically, plant community 16 correlates largely with Beard vegetation association 35. It includes areas of other Beard vegetation associations that have largely been degraded due to grazing, leaving *Acacia tetragonophylla* and *Hakea preissii* as the dominant species.

Rarity

Plant community 16 occupies 452.11 ha or 7.33% of the native vegetation of the GRFVS area, and is one of the more widespread GRFVS plant communities. Similar plant communities are common throughout Western Australia, although *Acacia tetragonophylla* is not present in the wetter and cooler areas (WA Herbarium and DEC 2009). However, because these species usually grow on loamy soil that is highly regarded for agriculture, this plant community and its equivalents elsewhere are generally degraded by grazing and weed invasion, as was observed in the GRFVS area.

Representation

Oakajee Nature Reserve contains approximately 14.35 ha of plant community 16. Only 655.85 ha of the most equivalent Beard vegetation association (35) are within DEC estate in Western Australia.

Diversity

Plant community 16 was recorded from three quadrats in the GRFVS area (GRV0811, 23 and 44), where a range of 22-34 native species were recorded. Occassionally *Eucalyptus loxophleba* trees occur within this plant community.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 16 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

Most of the extent of this plant community has been grazed, and therefore areas in good or better condition are of conservation significance; however very little was observed in the GRFVS area. The area associated with GRV0844 is an exception, which, although grazed, was in *very good* condition. The main threats are grazing, weed invasion, fire and clearing.

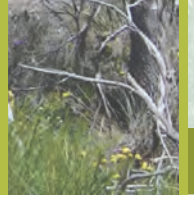
4.4.17 Plant community 17 Woodland: *Eucalyptus loxophleba*

Description and occurrence

Plant community 17 is dominated by *Eucalyptus loxophleba* and occurs largely in the Oakajee catchment. It is separated from plant community 16 by dominant species and lifeform, but occurs on the same soil system. Occasionally it occurs on soil-filled pockets on rocky slopes that are otherwise plant community 15.

Relationship to Beard vegetation associations

Within the GRFVS area, plant community 17 is located within and is floristically related to Beard vegetation association 35.



Rarity

Plant community 17 occupies 17.06 ha or 0.28% of the native vegetation of the GRFVS area, and is one of the most restricted GRFVS plant communities.

Representation

Although plant community 17 is restricted in the GRFVS area, from previous studies of this vegetation type, it appears to be very common outside it. Further survey is required to determine its regional significance.

Diversity

Plant community 17 was recorded from one quadrat in the GRFVS area (GRV0842), where 21 native species were recorded.

Wetland, streamline/estuarine fringing or coastal vegetation

Plant community 17 does not contain typical wetland, streamline or estuarine fringing or coastal vegetation.

Vegetation condition and threats

Although this plant community is most similar to Beard vegetation association 35, it occupies only a small proportion of its extent in the GRFVS area. The plant community, or ones similar to it, are common throughout much of the southwest of Western Australia, although they, too, are largely degraded by grazing and weed invasion. The best representative of this plant community was in the Oakajee Nature Reserve (approximately 4.38 ha), but all other observations of it were weedy and degraded. Therefore, any occurrence of this plant community that is in good or better condition is of conservation significance.

4.5 Flora species

4.5.1 Threatened species

Ten flora species of conservation significance, including two rare species, were recorded from the quadrats sampled within the GRFVS area (listed in section 3.3.1). Rare flora report forms will be submitted to DEC with additional details when the voucher specimens are submitted to the Western Australian Herbarium.

Significantly, two rare, one P3 and one P4 flora species were recorded from one floristic quadrat, determined to be GRFVS plant community 15. The P3 species *Thryptomene* sp. Moresby Range was a dominant species in this quadrat, covering 10% of the area. The site appears to have been lightly, but not intentionally, grazed by livestock.

4.5.2 Range extensions and extremities

Three recorded species, listed in section 3.3.1, are range extensions or on the edge (extremity) of their known range, including one P3 species. Complete records of occurrences of threatened flora species have not been examined as they are not easily accessible, but the P3 species (*Hibbertia glomerosa* var. *bistrata*) is known from between Mullewa and Morawa, approximately 100 km east of Geraldton, therefore this range extension may be significant.

4.5.3 Weeds

A total of 73 weed species were recorded during the floristic quadrat survey, seven of which are rated as *high* risk by the Environmental Weed Strategy for Western Australia (CALM 1999), but none of which are listed as declared plants requiring control (DAFWA 2009). Weeds that are *high* risk are those that have the ability to invade bushland that is in *good* to *excellent* condition, have a wide current or potential distribution, and have the ability to change the structure, composition and function of ecosystems, often forming monocultures (CALM 1999).

The seven high risk weeds are *Brassica tournefortii* (wild turnip), *Bromus diandrus* (brome grass), *Cenchrus ciliaris* (buffel grass), *Ehrharta calycina* (perennial veldt grass), *Euphorbia terracina* (Geraldton carnation weed), *Lupinus cosentinii* (Sandplain lupin) and *Lycium ferocissimum* (African boxthorn). While it is impractical to consider broad-scale weed control of any of these species, they should be considered priorities for localised control.

5 Conclusions

5.1 Summary of GRFVS findings

The desktop assessment determined that, within the GRFVS area (40,737 ha), there are nine Beard vegetation associations, seven soil systems and 52 soil subsystems. Approximately 6,112 ha of native vegetation remains within 625 discrete remnants, equivalent to approximately 15% of the original extent of native vegetation in the GRFVS area.

The field assessment determined that approximately 6,041.21 ha of native vegetation currently exists in the GRFVS area. Some areas previously mapped as native vegetation have been cleared or do not contain native vegetation (eg planted vegetation), so these areas have been removed from the native vegetation extent dataset for the GRFVS area. Other areas of native vegetation had been overlooked in previous mapping, so these areas have been added to the native vegetation extent dataset for the GRFVS area.

Beard vegetation association mapping has traditionally been used as baseline information for determining conservation priorities throughout Western Australia, as it provides broad-scale vegetation descriptions and mapping, as well as historical context for vegetation extents. However, Beard vegetation mapping does not provide adequate information at a local scale. The GRFVS plant communities have been developed in response to this need.

5.2 Conservation significance of Beard vegetation associations

The GRFVS plant communities developed through this project provide more detailed and accurate descriptions of the vegetation types within the GRFVS area than Beard vegetation associations mapped at a broad scale. Some GRFVS plant communities closely correspond with Beard vegetation associations. However, the descriptions of the Beard vegetation associations and scale of mapping does not adequately describe some of the vegetation types, represent the range of vegetation types within the area, or provide accurate delineation of vegetation boundaries. Hence, conservation significance should be considered both in terms of Beard vegetation associations and GRFVS plant communities.

Regionally significant – endangered

Beard vegetation association 35 (Shrublands; jam scrub with scattered York gum) and Beard vegetation association 371 (Low forest; *Acacia rostellifera*) have less than 10% of their pre-European extent remaining in WA.

Beard vegetation association 35 corresponds well to GRFVS **plant community 16** (Woodland: *Acacia acuminata / Acacia tetragonophylla / Hakea preissii*) and **plant community 17** (Woodland: *Eucalyptus loxophleba*).

Beard vegetation association 371 does not correspond to any particular community, instead the description of the community can be applied over a larger area that includes GRFVS **plant community 8** (Coastal: *Acacia rostellifera* low shrubland) and **plant community 10** (Near Coastal: *Acacia rostellifera* shrubland). Beard vegetation association 371 therefore requires interpretation using GRFVS plant community mapping to determine conservation significance.

Regionally significant – vulnerable

Beard vegetation association 359 (Shrublands; *Acacia* and *Banksia* scrub) and Beard vegetation association 675 (Shrublands; *Melaleuca* and *Hakea* mixed thicket) have more than 10% but less than 30% of their pre-European extent remaining in WA.

Beard vegetation association 359 corresponds well to GRFVS **plant community 13** (Sandplain: *Banksia prionotes / Acacia rostellifera*) and **plant community 14** (Chapman River Reserve: *Acacia rostellifera / Melaleuca* spp.). Plant community 13 occupies approximately 25% of the spatial extent of Beard vegetation association 359 within the GRFVS area. Plant community 14 appears to be a localised occurrence due to the underlying soils in Chapman River Reserve.

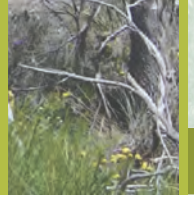
Beard vegetation association 675 corresponds well to GRFVS **plant community 15** (Thicket: *Melaleuca* spp. / mixed spp.) and is equivalent to the P1 priority ecological community 'Plant assemblages of the Moresby range system'.

Locally significant

Beard vegetation association 129 (Bare areas; drift sand), Beard vegetation association 387 (Shrublands; *Melaleuca cardiophylla* thicket), Beard vegetation association 413 (Shrublands; *Acacia neurophylla* and A. species thicket), Beard vegetation association 431 (Shrublands; *Acacia rostellifera* open scrub) and Beard vegetation association 440 (Shrublands; *Acacia ligulata* open scrub) have more than 30% of their pre-European extent remaining in WA.

Beard vegetation association 129 does not correspond to any particular community; instead the description of the community can be applied over a larger area that includes GRFVS **plant community 3** (Foredune: *Atriplex isatidea / Spinifex longifolius*), **plant community 8** (Coastal: *Acacia rostellifera* low shrubland) and **plant community 10** (Near Coastal: *Acacia rostellifera* shrubland). Beard vegetation association 129 therefore requires interpretation using GRFVS plant community mapping to determine conservation significance.

Beard vegetation association 387 is identified as a *rare and endangered* vegetation association in the Native Vegetation Management Plan Northern Agricultural Region. Beard vegetation association 387 is considered to be the equivalent of GRFVS **plant community 11** (Limestone ridge: *Melaleuca cardiophylla / Eucalyptus* spp.) and **plant community 12** (Limestone ridge:



Melaleuca cardiophylla). Plant community 12 occupies 14.04% of the GRFVS area, and is the second most widespread plant community. Therefore, Beard vegetation association 387 may not be regarded as an *endangered* community within the GRFVS area, although there is none in secure tenure. However, plant community 11, which has only 19.95 ha in the GRFVS area, should be considered to have local conservation significance.

Beard vegetation association 413 corresponds well to GRFVS plant community 15 (Thicket: *Melaleuca* spp. / mixed spp.). Beard vegetation association 413 is identified as a *last stand* vegetation association in the Native Vegetation Management Plan Northern Agricultural Region. Further survey and scrutiny is required prior to the definition of *last stand* being adopted for this Beard vegetation association in the GRFVS area.

Beard vegetation association 431 does not correspond to any particular community, instead the description of the community can be applied over a larger area that includes GRFVS **plant community 3** (Foredune: *Atriplex isatidea / Spinifex longifolius*), **plant community 6** (Coastal: *Thryptomene baeckeacea*), **plant community 7** (Coastal: *Melaleuca cardiophylla*), **plant community 8** (Coastal: *Acacia rostellifera* low shrubland) and **plant community 10** (Near Coastal: *Acacia rostellifera* shrubland). Beard vegetation association 431 therefore requires interpretation using GRFVS plant community mapping to determine conservation significance.

Beard vegetation association 440 does not correspond to any particular community, instead the description of the community can be applied over a larger area that includes GRFVS **plant community 3** (Foredune: *Atriplex isatidea / Spinifex longifolius*), **plant community 8** (Coastal: *Acacia rostellifera* low shrubland) and **plant community 10** (Near Coastal: *Acacia rostellifera* shrubland). Beard vegetation association 440 therefore requires interpretation using GRFVS plant community mapping to determine conservation significance.

5.3 Conservation significance of GRFVS plant communities

Several of the GRFVS plant communities identified from this project are geographically restricted, and are therefore naturally rare or uncommon. The proposed phase two of this project will involve the identification of priority conservation areas. Plant communities that are restricted in extent in the Geraldton region are currently considered to be regionally significant. Further investigation outside the survey area may establish alternate levels of significance for plant communities.

The GRFVS plant communities are discussed in order of conservation significance, based on current extent:

- **Plant community 5** (Swale: *Frankenia pauciflora*) appears to be the rarest and most threatened plant community in the GRFVS area, being geographically restricted, threatened by grazing and potential future development and perhaps salinisation. Also given its size and disturbed nature, it may not be a sustainable community. It is recommended that further surveys outside the GRFVS area be undertaken to determine the regional distribution and significance of this community.
- **Plant community 4** (Swale: *Ficinia nodosa*) is likewise very restricted within the GRFVS area with only a single 0.58 ha occurrence, and further survey outside of the GRFVS area would be required to determine its regional distribution and conservation significance.

Other plant communities that are restricted in distribution that should be investigated outside the GRFVS area to determine their conservation significance are:

- **Plant community 6** (Coastal: *Thryptomene baeckeacea*), which is restricted to an 11.08 ha area south of the Greenough River within the GRFVS area. Survey of a wider area should be undertaken to determine regional significance and distribution.
- **Plant community 7** (Coastal: *Melaleuca cardiophylla*), occupying 62.71 ha, is also restricted in its distribution within the GRFVS area, and would require survey of a wider area to determine regional significance.
- **Plant community 9** (Coastal: *Acacia rostellifera / Eucalyptus* spp.) occurs in small pockets between Tarcoola Beach and the Greenough River, occupying 12.47 ha. This plant community should be considered to have conservation significance as it is distinctive and restricted to this area.
- **Plant community 11** (Limestone ridge: *Melaleuca cardiophylla / Eucalyptus* spp.) occupies 19.95 ha in the GRFVS area. The areas south of Mount Tarcoola are more degraded than those to the north on the Oakajee scarp. As a consequence the areas to the north of the Oakajee River should be considered to have conservation significance.
- **Plant community 15** (Thicket: *Melaleuca* spp. / mixed spp.) occupies 469.57 ha. It includes the area which matches the description of the 'natural value' ecosystem 'Moresby Ranges' (Australian Natural Resources Atlas 2009) and the P1 priority ecological community 'Plant assemblages of the Moresby Range system' (DEC 2009a). Consequently, this area is considered to have conservation significance.

The following plant communities are also considered to have conservation significance because, although they have a greater natural extent, they are largely degraded or threatened:

- **Plant community 1** (Estuarine: *Casuarina obesa / Tecticornia / Sarcocornia*), which is geographically restricted.
- **Plant community 2** (Riparian: *Eucalyptus camaldulensis / Casuarina obesa / Melaleuca rhaphiophylla*), which is restricted to river channels

and river banks (including the former river channel at Rum Jungle). This plant community is generally degraded, with the best condition observed being good.

- **Plant community 3** (Foredune: *Atriplex isatidea / Spinifex longifolius*) is geographically restricted to the primary dune, and is threatened in areas associated with close proximity to areas of urbanisation, but is widespread in distribution and has an important role in dune stabilisation.
- **Plant community 12** (Limestone Ridge: *Melaleuca cardiophylla*) occupies 865.8 ha; however most areas are grazed and degraded. The areas north and south of the Oakajee River, associated with sampled quadrats GRV0813, GRV0820 and GRV0821, are classified as being in very good and excellent condition, and were in the best condition observed for this community.
- **Plant community 13** (Sandplain: *Banksia prionotes / Acacia rostellifera*) occupies 754.39 ha, however much of this area is degraded. The better representatives of this plant community occur in the Glenfield and Waggrakine areas. A low heath variant of this plant community occurs in Karloo and Utakarra.
- **Plant community 14** (Chapman River Reserve: *Acacia rostellifera /Melaleuca* spp.), which is restricted to shallow soils close to the Chapman River in the Chapman River Reserve. It is not currently considered to be under threat from development as the entire area is contained within an existing reserve.
- **Plant community 16** (Woodland: *Acacia acuminata / A. tetragonophylla / Hakea preissii*) is restricted to the Northampton soil system within the GRFVS area, where it is generally threatened by agricultural activities and associated with high levels of weed infestation. It is likely to be widely distributed outside this area, however representatives in very good condition or better, both within and outside the GRFVS area, are uncommon.
- **Plant community 17** (Woodland: *Eucalyptus loxophleba*) is restricted within the GRFVS area, and, where not represented within the conservation estate, is generally grazed and degraded. Outside the GRFVS area it is more widespread. Therefore, areas of this plant community in poor condition within the GRFVS area are not considered to be of high conservation significance.

GRFVS **plant community 8** (Coastal: *Acacia rostellifera* low shrubland) and **plant community 10** (Near Coastal: *Acacia rostellifera* shrubland) are more widespread in the GRFVS area; however better condition representatives have local conservation significance.

5.4 Plant species conservation

From the 81 floristic quadrats sampled, 376 species were identified. Ten flora species of conservation significance, including two declared rare flora taxa, were identified from 10 quadrats. Three species were recorded at the extreme range of their known extent or were range extensions.

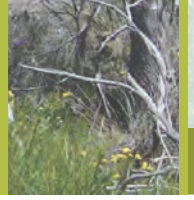
Five of the eight quadrats assessed as being GRFVS plant community 15 (Thicket: *Melaleuca* spp. / mixed spp.) had flora species of conservation significance. Significantly, one quadrat contained two declared rare flora and two priority species, and another contained two priority species. Only one of the quadrats with flora of conservation significance is within the conservation estate. As there are a number of threatened flora species associated with this plant community, it is recommended that isolated hilltops to the west of the Moresby Range are surveyed for threatened flora and fenced to exclude from grazing.

5.5 Future implementation of GRFVS

All data collected through the GRFVS, including floristic quadrat data, GIS shapefiles and voucher specimens, will be made available for use by others in the future. This will allow state government agencies, local governments, land owners and developers to make informed decisions in relation to setting conservation priorities for native vegetation in the GRFVS area.

The EPA supported the proposal in the Geraldton Region Plan to compile an inventory of, and to conserve, regionally significant remnant vegetation across the Geraldton region, which encompasses the local governments of Northampton, Chapman Valley, Geraldton-Greenough, Mullewa and Irwin. Phase one of the GRFVS has been completed for the area generally covered by the Greater Geraldton Structure Plan (ie portions of the City of Geraldton-Greenough and the Shire of Chapman Valley).

Further consideration should be given to implementation of phase two (conservation and regional planning) and phase three (further regional flora and vegetation surveys) of the GRFVS. This includes the preparation of a conservation plan to assist regional strategic planning, and extension of the GRFVS project to other parts of the Geraldton region experiencing development pressure.



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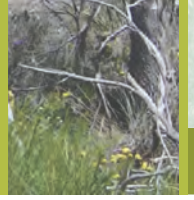

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