

**The vegetation of the Ravensthorpe Range,
Western Australia:
I. Mt Short to South Coast Highway**



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by

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Department of
Environment and Conservation
Our environment, our future 



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Summary

The Biodiversity Inventory Program is an initiative of the South Coast Natural Resource Management Inc (South Coast NRM) which is being managed by the Department of Environment and Conservation (DEC). As part of the program, this project mapped 5,960 ha of vegetation in the northern sector of the Ravensthorpe Range as a pilot study between May & August 2007. The pilot project covered two areas of mainly Unallocated Crown Land in the northern sector of the Ravensthorpe Range. Area 1 included 5,360 ha between Mt Short and Carlingup Road and was surveyed by four Consultant Botanists (G. Craig, E. Hickman, A. Rick and E. Sandiford) assisted by a DEC Technical Officer (J. Newell). Area 2 included 600 ha between Carlingup Road and South Coast Hwy and was mapped both from data collected during previous surveys (Craig 2004, 2005) and concurrently with Area 1, by G. Craig.

The Ravensthorpe Range dominates the Ravensthorpe System of vegetation described by Beard (1973). Over 1300 native plant taxa have been recorded in this system of which 52 are endemic or almost endemic (Craig 2007). Eleven species are Declared Rare and a further 68 are listed as Priority taxa on DEC's *Declared Rare and Priority Flora list*. One vegetation community has been recommended for inclusion as 'Endangered' on DEC's Threatened Ecological Community database and three as Priority One communities. The range is included within the Fitzgerald Biosphere, a recognised 'hotspot' within one of Earth's 34 global biodiversity 'hotspots'.

This report provides:

- background information on the history, climate, geology, geomorphology and soils, and vegetation of the Ravensthorpe Range;
- details of the methodology used for vegetation mapping and recommendations for further mapping;
- a map at 1:10 000 scale with 50 vegetation units described.

A total of 400 taxa were recorded. A significant new population of the Declared Rare *Marianthus mollis* was located in a valley near of Mt Benson. Numerous occurrences were noted of the Declared Rare *Daviesia megacalyx* and Priority flora, including *Acacia bifaria*, *A. dicticha*, *A. durabilis*, *Allocasuarina hystricosa*, *Banksia laevigata*, *Beyeria* sp. A Ravensthorpe, *Boronia oxyantha* var. *brevicalyx*, *Dryandra corvijuga*, *D. foliosissima*, *Grevillea fulgens*, *Guichenotia anota*, *Micromyrtus navicularis*, *Pultenaea* sp. Kundip, *Siegfriedia darwinioides* and *Spyridium glaucum*. A new taxon with affinity to *Melaleuca coccinea* and *M. penicula* was found.

Two Threatened Ecological Communities currently listed as Priority One were found during the survey: (i) '*Banksia laevigata* – *Banksia lemmaniana* - proteaceous thicket' which equates to the *Banksia laevigata/Beaufortia orbifolia* (Blae/Borb) vegetation unit and covered 78 ha (1.3%) of the project area; and, (ii) 'heath on komatiite' which equates to the *Acacia ophiolithica* (Acop) vegetation unit and covered 6 ha (0.1%) of the project area.

The vegetation was in excellent condition with minimal invasion by weeds. One area that was dominated by *Dryandra* species was dead/dying and tested for dieback disease (*Phytophthora* spp.) with negative results; drought was believed to have caused the decline.

The majority (70%) of vegetation units were dominated by obligate seeder species. The lack of post-fire recovery of obligate seeders was of concern in a number of areas, particularly following a management burn in September 2006, and earlier burns in *Melaleuca* sp. Gorse dominated communities.

Recommendation

It is highly recommended that mapping of the vegetation of the Ravensthorpe Range and eventually the whole Ravensthorpe System continue.

Introduction

Background

South Coast Natural Resource Management Inc (South Coast NRM) is the regional group for natural resource management on the South Coast of Western Australia. Funding is provided by the Australian and Western Australian Governments through the joint National Action Plan for Salinity and Water Quality program and the Natural Heritage Trust.

The Department of Environment and Conservation (DEC) South Coast Region is managing the Biodiversity Inventory Program on behalf of South Coast NRM. One of the aims of the program is to improve vegetation mapping of areas of high species richness and endemism. The agency recognizes that vegetation mapping based on the techniques/scale used by Ken Newbey (1979) is needed across the region.

This program is focusing on the Ravensthorpe Range area for the current funding round (up until June 2008) and will later extend to other floristic hotspots (as described by Hopper and Gioia, 2004) dependant on funding. The program is initially focusing on the Ravensthorpe Range due to its high biodiversity and mineral wealth values.

Purpose of the survey

The aim of the Biodiversity Inventory Program is to produce a map of the vegetation units, based on plant associations, of the Ravensthorpe Range at a scale of 1:10,000. This would provide context for determining relative occurrence, extent and representation of vegetation units within the full study area for land-use and conservation planning.

Previous vegetation surveys (Craig & Chapman 1998, Craig 2004, Cockerton & Craig 2000) had found the Ravensthorpe Greenstone Belt difficult to map from aerial photo interpretation and that plant associations changed rapidly, often over distances of 200 m or less. Due to the complexity of the vegetation and funding limitations, it was decided that a pilot study should be carried out first in the northern Ravensthorpe Range to develop and trial a methodology for vegetation mapping that could be further used in a consistent and repeatable manner to map the remainder of the Ravensthorpe Range and other floristic hotspots in the South Coast Region. The vegetation map needed to include, but not be limited to:

- desktop aerial photography interpretation;
- ground truthing and field data collection; and
- proofing of digitised vegetation unit boundaries.

The survey area

The pilot project covers two areas: Area 1 includes 5,300 ha in the northern sector of the Ravensthorpe Range, between Mt Short in the north and Carlingup Road in the south, and Area 2 covering approximately 600 ha between Carlingup Road and South Coast Highway (Fig.1).

Four Consultant Botanists assisted by a Technical Officer provided by DEC surveyed Area 1. Area 2 was mapped from data collected during previous surveys for Traka Resources Ltd and Resource Mining Corporation Ltd (RMC) (Craig 2004, 2005) and as part of the current project, by G. Craig (Fig.1).

Land tenure

The project area is mainly Unallocated Crown Land, and includes a few reserves (Table 1), mainly in the vicinity of Mt Short, and road reserves managed by the Shire of Ravensthorpe. The relevant land managers granted permission to collect plant specimens.

Table 1. Land tenure within the Ravensthorpe Range project area

| Lot | Legend | Area (ha) | Owner |
|------------|-------------------------|----------------------|---|
| 1338 | Crown Allotment | 31.0 | STATE OF WA - Water and Rivers Commission |
| R 17880 | Reserve - Water | 747.5 | Vested: Water and Rivers Commission |
| R 36191 | Quarry site | 61.2 | Vested: Commissioner of Main Roads |
| R 37740 | Reserve - Radio Station | 0.4 | Electricity Corporation |

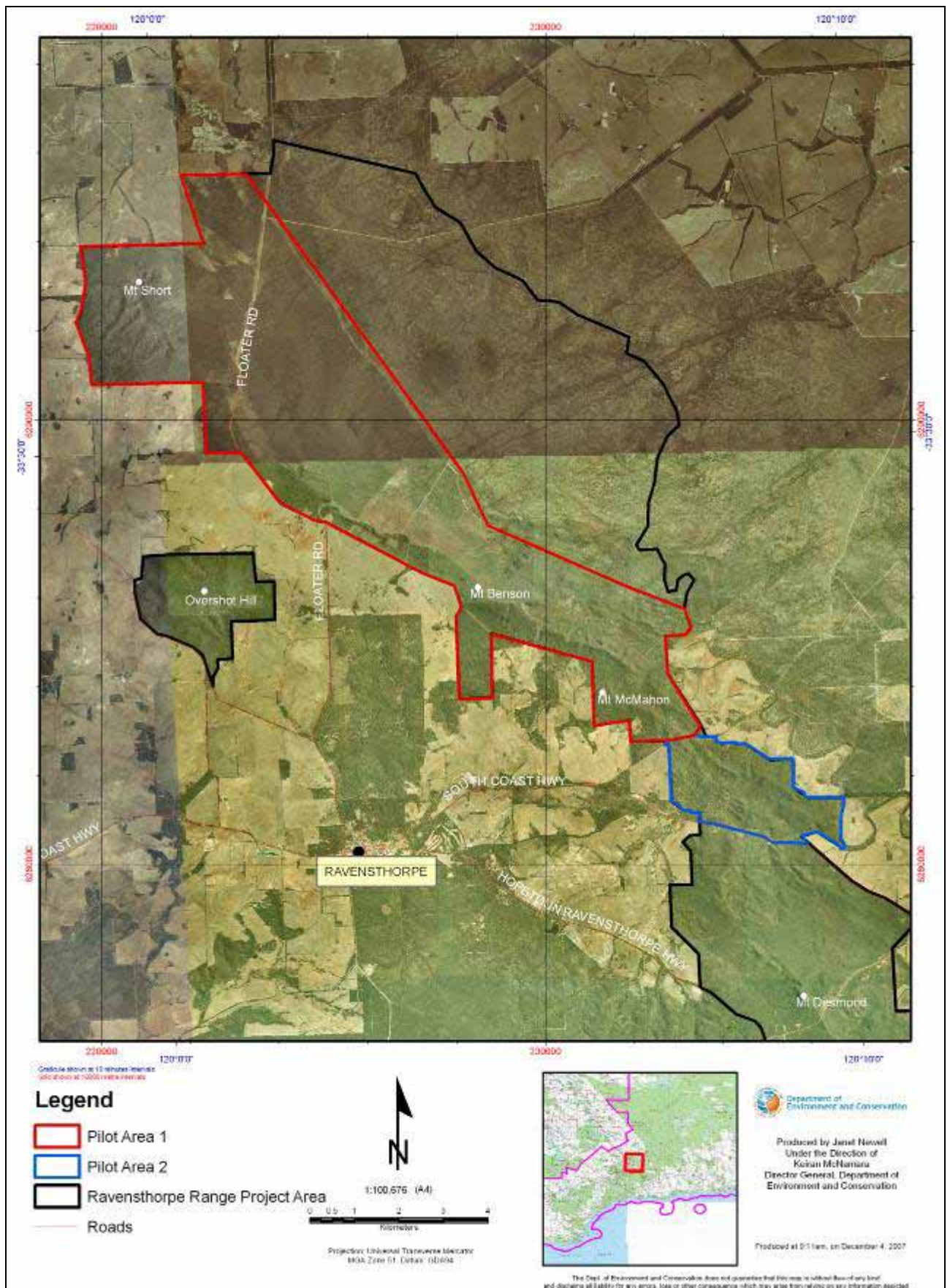


Figure 1. Location of project area in the northern sector of the Ravensthorpe Range

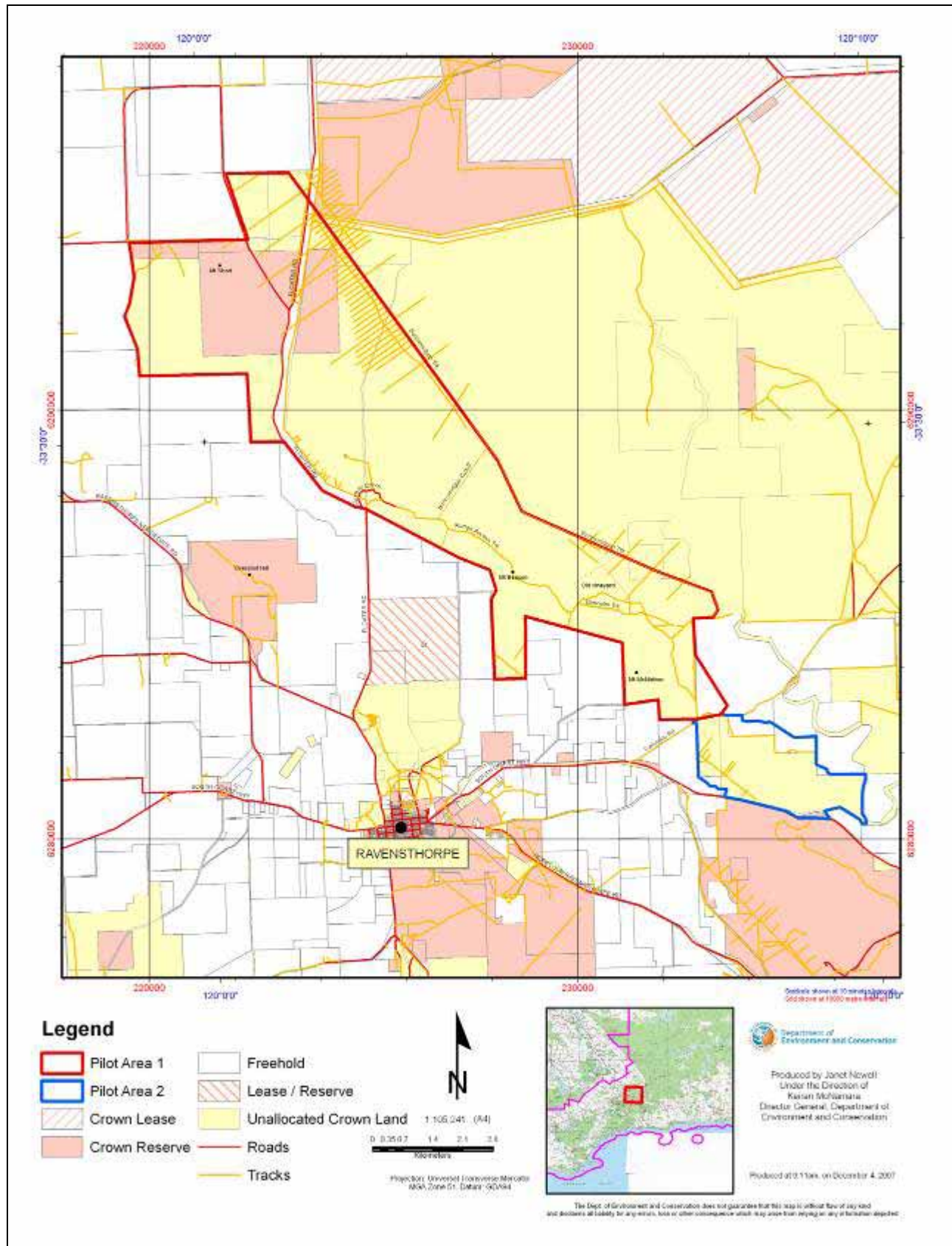


Figure 2. Land tenure and management tracks

Regional Setting

Historical

The Ravensthorpe district was first settled in 1868 for pastoral purposes, and it was not until 1892 that gold and copper deposits were opened up just north of Ravensthorpe. The principle copper and gold deposits of the Phillips River Goldfields extended in a belt from 4 km north of Ravensthorpe to 20 km south-east in the vicinity of the Kundip townsite.

In 1906, the growth of copper production gave the impetus for the Government to go ahead with a railway linking Hopetoun port with the mines and smelting works. The line opened in 1908 with permanent rail services continuing until 1931 then only sporadically until 1935, after which it was closed. Kundip station was placed close to the mines and a large Mines Department dam. A barracks building was provided for the flying gang's headquarters as well as toolsheds (Archer 1979). Evidence of these sites is still visible - mainly by the weeds, wire, bricks and other debris - on the mining leases. Today, the Railway Heritage Trail, a walking trail that follows the old railway route between Ravensthorpe and Hopetoun, provides a pleasant recreational experience for locals and tourists.

Mining activity tapered off during World War I (1914-1918), buildings were shifted as people moved away. In 1934, the Claude de Benarles Group opened up new workings at the Beryl mine, which resulted in 150 miners being employed in three shifts. Activity wound down again during World War II due to the reduction in manpower. In the late 1950s, when the Elverdton mine started up again, a number of houses were built for their workers. Today, only the foundations of a few buildings remain to indicate that 100 years ago, Kundip was once a bustling townsite with a baker, school, churches, hall, hotel, tinsmith, blacksmith and post office (Archer 1979; Goldfinch 2001). It now serves as a picnic area with historical information provided on sign boards.

Following the ensuing mining 'rush' in the early 1900s, some prospectors with farming experience from elsewhere decided to try farming on the rich red-brown loams surrounding the Ravensthorpe Range and the first crop was planted in 1902. Since then both mining and agriculture have provided the economic basis of life in the district. More recently conservation as a secondary industry including tourism and interpretation, research and management have brought people and some income to the district.

Within the project area, Loc 1243 (90 ha) which lies about 2 km east of Mt Benson, was cleared and a dam and vineyard installed by Colin and Merle Bennett in the 1970s; it has since reverted to Crown land. More recently, DEC negotiated the acquisition for the Crown uncleared portions of Locs 186, 187 and 190, and the south-west portion of Loc 267, which has been cleared but not cropped; native vegetation is currently regenerating.

Climate

Ravensthorpe lies in the 'dry mediterranean' bioclimatic region experiencing 5-6 dry months per year (Beard 1990). Winters are cool and damp while summers are warm to hot.

Daily maximum temperatures at Ravensthorpe average from 29°C in January to 16°C in July, and daily minimum temperatures average 14°C in January-February and 7°C in July-September (Table 2).

Temperatures have reached as high as 46°C in January-February and as low as -1.0 to 0.0°C between June and August.

Rainfall in Ravensthorpe is variable and unreliable, with an average annual rainfall of 426 mm. The highest annual rainfall recorded was 734 mm in 1951, while the lowest of 234 mm occurred in 1940. Generally, about two-thirds of the annual rain falls in the six months between May and October as a result of cold fronts

and occasional depressions. Summer rainfall comes mainly from thunderstorms associated with cyclones that have degenerated into rain-bearing depressions. Ravensthorpe's highest recorded daily rainfall was on 5 January 2007 with 113 mm and monthly highest in January 2000 (223 mm). There is significant summer rain in many years which provides moisture for vegetation to grow actively.

The Bureau of Meteorology considers that a drought event has occurred if the annual rainfall is within the first decile range (lowest 10%) for the average for that centre, which in Ravensthorpe means less than 303 mm. Drought years were recorded in 1907, 1910, 1928, 1935, 1936, 1940, 1954, 1957, 1972, 1994 and 2002.

The severity of drought will be influenced by the amount of soil moisture and surface evaporation. Average annual Class A Pan evaporation is about 1850 mm (SCRAP and SCRIPT 1997). Thus, potential evaporation is more than four times annual rainfall. Wind is usually present, averaging 12-16 km/hr by 3pm throughout the year.

Table 2. Monthly climate statistics for Ravensthorpe (BOM, 2007)

| | J | F | M | A | M | J | J | A | S | O | N | D | Ann. |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------------|
| Temperature (°C) (1962-2007) | | | | | | | | | | | | | |
| Ave. Max. | 29 | 28 | 27 | 24 | 20 | 17 | 16 | 17 | 20 | 22 | 25 | 27 | 23 |
| Highest | 45 | 46 | 42 | 38 | 34 | 26 | 26 | 30 | 33 | 38 | 42 | 43 | 46 |
| Lowest | 6 | 6 | 3 | 3 | 1 | -1 | -1 | 0 | 0 | 1 | 2 | 4 | -1 |
| Rainfall (mm) (1901-2007) | | | | | | | | | | | | | |
| Average | 25 | 25 | 31 | 34 | 44 | 44 | 47 | 45 | 41 | 38 | 30 | 22 | 426 |
| Highest | 223 | 179 | 118 | 145 | 127 | 118 | 130 | 137 | 145 | 121 | 189 | 140 | 735 |
| Lowest | 0 | 0 | 0 | 2 | 6 | 14 | 8 | 9 | 3 | 4 | 0 | 0 | 234 |
| Ave. no. rain days | 6 | 6 | 8 | 8 | 11 | 12 | 13 | 13 | 11 | 10 | 7 | 6 | 111 |
| Relative humidity (%) (1962-2007) | | | | | | | | | | | | | |
| Ave. 9am | 59 | 64 | 66 | 70 | 75 | 80 | 79 | 75 | 69 | 61 | 57 | 57 | 68 |
| Ave. 3pm | 46 | 47 | 49 | 51 | 56 | 60 | 59 | 55 | 52 | 48 | 47 | 44 | 51 |
| Wind speed (km/h) (1962-2007) | | | | | | | | | | | | | |
| Ave. 9am | 11 | 10 | 11 | 11 | 12 | 13 | 14 | 14 | 14 | 13 | 13 | 11 | 12 |
| Ave. 3pm | 14 | 14 | 12 | 12 | 13 | 16 | 16 | 16 | 16 | 15 | 16 | 15 | 15 |

Geology

The Ravensthorpe Range is a significant topographic landmark in the region with the notable high points being Mt Short (450 m), Mt Benson (404 m) and Mt McMahan (274 m). The Range and adjacent hilly country occur within the Ravensthorpe Greenstone Belt within the Archaean aged Yilgarn Craton (2600 to 3000 million years ago). The Greenstone Belt is a linear feature about 5 km wide and 60 km long which comprises a broad suite of different rock types. The name "greenstone" particularly refers to the fact that within this suite are mafic and ultramafic rocks of greenish-black colour, rich in rock forming ferromagnesium minerals. In contrast the Greenstone Belt is bounded by granite and gneiss that have light-colored quartz and feldspar rock forming minerals.

The Ravensthorpe Greenstone Belt comprises three tectonic units with associated formations (Witt 1997):

- A. Carlingup Terrane which includes most of the project area -
 - 1. Chester Formation (banded-iron formation - metamorphosed shale, siltstone and greywacke interbedded with chemical sedimentary rocks) on upper and east-facing slopes with gossanous limonite forming ridges along the range;
 - 2. Bandalup Ultramafics (komatiite – magnesium-rich) on lower, eastern slopes, particularly in the south-east sector;
 - 3. Maydon Basalt (metamorphosed basalt) in a narrow band parallel to Bonnymidgup track in the north;
- B. Ravensthorpe Terrane -
 - 4. Annabelle Volcanics on the lower, western slopes between Floater Rd and Carlingup Rd;
- C. Cocanarup greenstones -
 - 5. Metasedimentary rock (including quartz and feldspar) in the vicinity of Mt Short.

A complex but long period of predominately erosional history is primarily responsible for the formation of the current topography of the Ravensthorpe area. Tertiary aged (about 30 million years ago) and very resistant laterite cap-rock occupies most of the topographic high points along the ridges and peaks. Where the laterites have eroded off a relatively thin layer of regolith has formed over bedrock generally weathered to less than 30 m depth.

Geomorphology and Soils

Soils of the Ravensthorpe Range have not been systematically surveyed, although in cooperation with this project, Traka Resources Ltd prepared a map of the geomorphology (after Hocking et al. 2001) based on their own soil sampling and geological knowledge of the area.

A massive iron rich duricrust or capping has developed on the ridges and steep upper slopes of the Ravensthorpe Ranges with a thin layer of skeletal soil. Residual soils have developed on the lower slopes. Weathering of the erodable basalts, which are high in magnesium, has produced the fertile red loams which occur on the lower slopes and more even ground to depths of 1 - 2 m. Parallel to the Bonnymidgup Tracks, the land is relatively flat and residual quartz – feldspar rich sand derived from granite and gneiss occurs in this area which is underlain by granitic intrusions.

On the gentler slopes adjacent to the rock outcrops colluvium is common. It consists of poorly sorted rock fragments, gravel, sand and silt from different rock types. Iron-rich colluvium is derived from reworked duricrust and ferruginized rocks.

East-facing, lower slopes north of about the Bonnymidgup Cutoff and near Mt Short have a low gradient and comprise 'sheet flood' material. It is gradational between colluvial and alluvial areas and consists of well sorted reddish clay, silt and fine sand in extensive fans. Alluvium occupies the present day drainage channels and is made up of poorly sorted sediments ranging from clay through to boulders, although most of the material is sand to gravel sized.

Regional vegetation

Fitzgerald Biosphere

The Ravensthorpe Range lies in the eastern sector of the Fitzgerald Biosphere which is a part-tenured management concept recognised by UNESCO as well as State and Commonwealth governments. The concept includes a *core area* (the Fitzgerald River National Park (FRNP) 329,000 ha), a *buffer zone* (Crown land and some unvested reserves totalling 130,000 ha) and a *zone of cooperation* (private freehold farmland including 557,000 ha cleared and 160,000 ha uncleared). This Biosphere is one of only two in Western Australia (Bradby 1989, CALM 1991).

The Fitzgerald Biosphere project and DEC's *South Coast Region* management plan (CALM 1992) recognise the Ravensthorpe Range vegetation as an important linkage between the Fitzgerald River National Park and Crown land east of the Vermin Proof Fence which extends to the southern Goldfields. The corridor allows for the continuity of biological processes including floral and faunal succession following fire or other disturbance, emigration and immigration of less mobile animals dependent on natural vegetation and genetic processes. The long-term sustainability and viability of this corridor will largely depend on maintaining the vegetation in excellent condition.

Beard's Ravensthorpe System

Beard (1973) recognized vegetation systems based on a particular series of plant communities recurring in a catenary sequence or mosaic pattern linked to topographic, pedological and/or geological features. The Ravensthorpe System is associated with the outcrop of metalliferous, greenstone rocks around the town of Ravensthorpe.

The Ravensthorpe System is a subdivision of the South West Botanical Province and is within the Esperance Biogeographic Region (of the Interim Biogeographic Regionalisation of Australia (IBRA)). As well, it coincides with McQuoid's (2004) 'Greenstone Range' eco-zone, ie one of the 13 eco-zones of the South Coast Region based on landscape similarity and the distribution and configuration of vegetation systems.

Four vegetation systems surround the Ravensthorpe System, ie the Jerramungup, Oldfield, Esperance, and Qualup Systems (Fig. 3), which causes the vegetation of the greenstone belt to include a number of species typical of adjoining systems and a number of 'outlier' occurrences of taxa. It also makes it one of the most intense areas of plant diversity in the south-west of Western Australia.

Within the project area, Beard (1973) recognized six vegetation types (Fig. 3). The most extensive, occurring along the crest of the range, is 'Shrublands; *Dryandra quercifolia* and *Eucalyptus* spp. thicket', while the slopes are mapped as 'Shrublands; mallee scrub (*Eucalyptus cernua*)'.

Previous botanical studies

Publicly available biological studies which are relevant to this project are:

- vegetation of the Ravensthorpe area (Beard 1973);
- ecological relationships in vegetation near Mt Desmond, Ravensthorpe Range (Bennett 1987);
- biological survey of the Ravensthorpe Range by Chapman and Newbey (1995a);
- botanical studies of the Fitzgerald River National Park by Aplin and Newbey (1988b), Newbey and McQuoid (1997), and Chapman and Newbey (1995b) – the latter includes fauna studies;
- rare flora studies of the south coast by Robinson and Coates (1995), and Craig and Coates (2001).

Numerous vegetation, flora and fauna surveys have been carried out by mining companies as part of their compliance requirements for exploration and mining activities - these remain unpublished.

Concurrently with this project, a floristics survey of the Ravensthorpe Range is being funded by DEC under the *Biodiversity Conservation Initiative*. This quadrat-based survey has been contracted to a team from Western Botanical and extends from Mt Short to Kundip and includes conservation areas on Bandalup Hill.

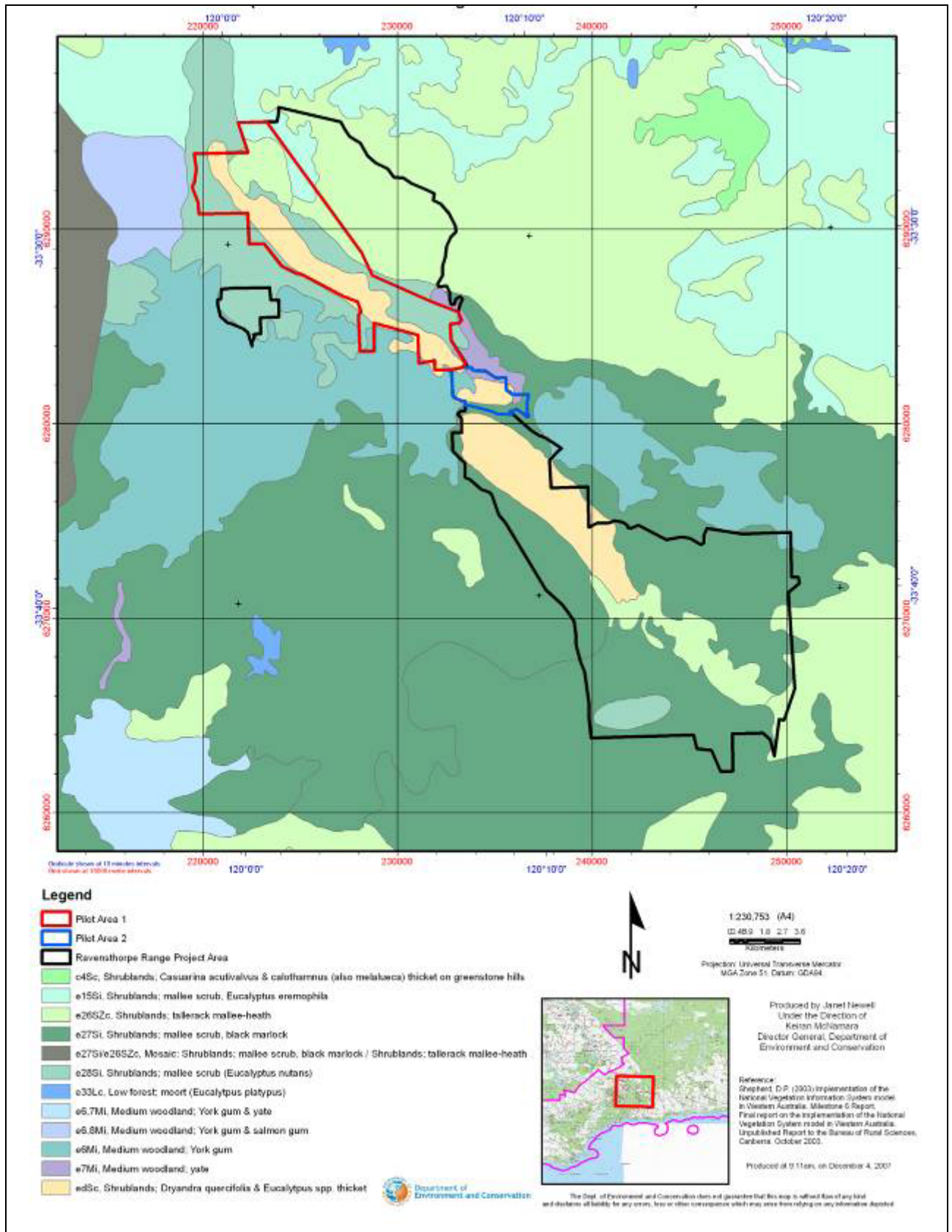


Figure 3. Pre-European vegetation, based on J.S. Beard's 'Vegetation of Western Australia'

Species Diversity and Endemism

The Fitzgerald Biosphere is recognised as being a ‘hotspot’ within one of Earth’s 34 global biodiversity ‘hotspots’. The south-west, which represents 5% of the continent, has 8000+ plant species or 40% of Australia’s higher plants (Saunders & Ingram 1995). Of these, 75% are endemic and more than 300 are threatened (Hopper 2002).

Research by Hopper and Gioia (unpub. data) has found that the Ravensthorpe region is one of the peak areas of species diversity in the south-west with about 340 species present per 30 km x 30 km. Isoflor maps by Hopper and Gioia (unpub. data) show the southern Ravensthorpe Range and surrounds as being one of the three areas of highest endemism in Western Australia (Mt Lesueur area and the Stirling Range being the other two), with more than 60 endemic species with a range of less than 30 km.

This high diversity and endemism has been confirmed by Craig (2007) who recorded over 1300 native taxa of which 52 are endemic or almost endemic to the Ravensthorpe System (Table 3).

Table 3. Summary of plant genera and taxa in Beard’s Ravensthorpe System (Craig, 2007)

| | | | |
|-------------------|-----|--|------|
| Families: lichens | 15 | Taxa: lichens | 26 |
| ferns | 3 | ferns | 6 |
| gymnosperms | 1 | gymnosperms | 4 |
| monocotyledons | 19 | monocotyledons | 220 |
| dicotyledons | 66 | dicotyledons | 1166 |
| TOTAL | 104 | TOTAL | 1422 |
| | | includes alien species | 99 |
| *Endemics: | | Ravensthorpe System (inc. Bandalup Hill) (E) | 36 |
| | | Almost confined to Ravensthorpe System (A) | 16 |

*Endemics: A = Almost confined to Beard’s Ravensthorpe System (80-99% of known populations)

E = Endemic to Ravensthorpe System (99-100% known populations)

Threatened Ecological Communities

English and Blythe (1997) proposed the Ravensthorpe System for inclusion in DEC’s Threatened Ecological Community (TEC) database, although at the time there was insufficient data to nominate any specific communities. Currently, four communities are listed on the database:

Endangered (needs official endorsement by Minister)

- *Eucalyptus purpurata* woodland on Bandalup Hill;

Priority One

- heath on komatiite on Bandalup Hill;
- *Melaleuca* sp. Kundip heath - very open mallee over *Melaleuca* sp. Kundip (GF Craig 6020) dense heath;
- *Banksia laevigata* – *B. lemanniana* – proteaceous thicket.

The Biodiversity Audit (CALM 2002) recognized five vegetation communities as being ecosystems at risk in the Ravensthorpe System:

1. proteaceous heath thickets of the Ravensthorpe Range laterite upland;
2. mallet woodlands of breakaway slopes of Ravensthorpe Range;
3. *Eucalyptus* spp on red loams on lower foothills of the eastern Ravensthorpe Range;
4. pale grey sand low ridge magnesite–*Eucalyptus purpurata* low forest on ridgetops and upper slopes;
5. unique mallee on magnesite ridges west of Bandalup Hill.

Declared Rare and Priority Flora

DEC maintains a Declared Rare and Priority Flora list under the provision of the Wildlife Conservation Act. The most recent list (Atkins 2006) identifies 11 Declared Rare flora and 68 Priority flora present in the Ravensthorpe System (Table 4, Craig 2007).

Table 4. Number of Declared Rare and Priority Flora in the Ravensthorpe System (Atkins 2006, Craig 2007)

| | No. of taxa |
|---------------|-------------|
| Declared Rare | 11 |
| Priority 1 | 15 |
| Priority 2 | 13 |
| Priority 3 | 22 |
| Priority 4 | 18 |
| TOTAL | 79 |

Methods

Field work

Mt Short to Carlingup Road

Four consultant botanists, experienced in the South Coast flora, and one technical officer provided by DEC Albany surveyed the area between Mt Short and Carlingup Rd (5,360 ha). Between May and August 2007 three trips lasting 5 days each were made to this area – the botanists spending 295 hrs in the field. Sarah Barrett (Flora Conservation Officer, DEC Albany) assisted for one day and Rodger Walker (Officer, Ravensthorpe Agricultural Initiative Network) for a half day. The weather was mostly fine and warm (16°-25°C max) with light to moderate breezes, except during the final week there were intermittent showers and cold winds (14°-16°C max).



Plate 1. The project team - (from left) Gillian Craig, Ellen Hickman, Libby Sandiford, Janet Newell (Technical Officer) and Anne Rick

Digital orthophotos, satellite imagery, stereo pairs of aerial photos and maps of geology, geomorphology and fire history were used in planning, field work and mapping (see Appendix 1).

Prior to conducting the field work, orthophotos (1:10 000 scale) were used to plan field traverses to include as much vegetation variation as possible. The botanists walked traverses through areas approximately 400 m wide over the range in a 40°/320° direction. Along each traverse, vegetation boundaries were marked as waypoints on the GPS using GDA94 or the compatible-WGS84 datum. However, it was found that some areas, such as the lateritic soils on the upper slopes, were consistently mappable from aerial photo interpretation. Thereafter, surveys concentrated on more complicated areas such as the lower slopes and valleys (Fig.4).

The vegetation unit boundaries were based on changes in species composition, rather than just vegetation structure. Within each vegetation unit, common plant species and vegetation structure, based on a modified Muir classification (Appendix 2), were recorded. Species were recorded if more than five plants were observed in the vegetation unit.

Each vegetation unit that was traversed was allocated a ‘shape number’ by the botanist. The botanist’s first initial was used to denote the shape, eg A22 refers to Anne Rick’s shape no.22. These numbers were to refer to the GIS polygon of the vegetation unit, and to be used as a common code for all datasets. Ultimately each mapped unit was assigned a representative polygon number.

The technical officer went with a different botanist each day and collected landform, rock, surface fragment and soil data (Appendices 3 & 4). The format used was the same as used by the Banded Ironstone Formations project (Gibson et. al. & Western Botanical, in prep.). Digital photographs, with the direction and GPS location, were taken (Appendix 5).

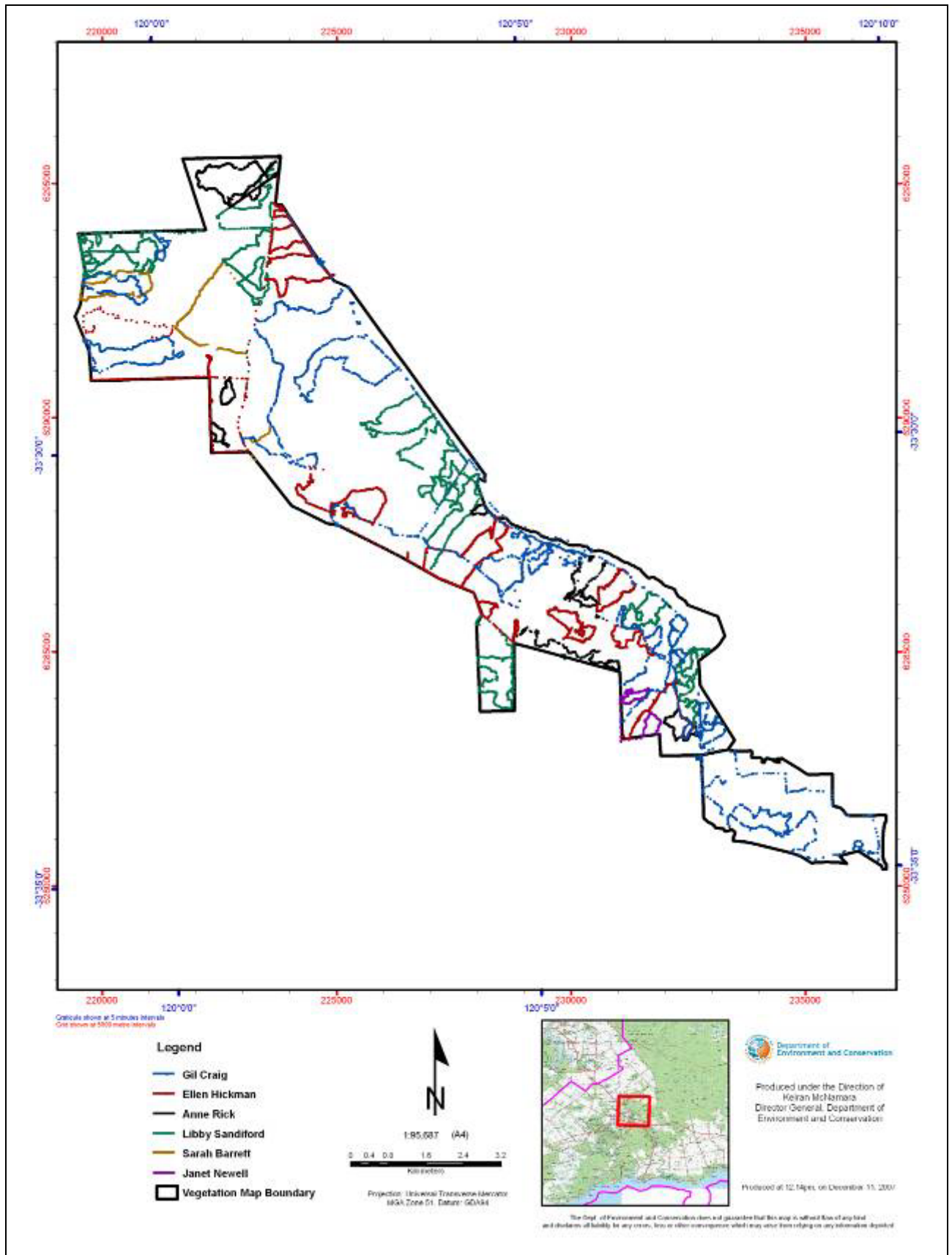


Figure 4. Tracks of botanists in the project area

Areas of recent burns, eg the areas east and west of Floater Road burnt in September 2006, were largely interpreted from the orthophotos, Quickbird satellite imagery and stereo-pairs of aerial photos. In addition, some vegetation types were distinctive on different types of imagery, for example:

- the *Dryandra cirsioides* unit was mainly mapped from aerial photography;
- the *Dryandra foliossima* unit was also mainly mapped from the Quickbird imagery as it showed as a distinctive shiny, pale green;
- the *Eucalyptus clivicola* and *E. salmonophloia* units were clearly defined on Quickbird imagery.

Carlingup Road to South Coast Hwy

The survey area between Carlingup Rd and South Coast Hwy (600 ha) had previously been surveyed in the south-east sector by Craig (2004, 2005) for threatened flora along traverses 400 m apart. Notes were taken during these surveys on vegetation and flora. Consequently, approximately 360 ha was mapped using previously collected data and aerial photo interpretation. One day was spent in the field by G. Craig ground-truthing the remaining area.

Plant identification

Plant specimens were verified using the Ravensthorpe and Perth herbaria; nomenclature follows that of the Perth Herbarium. Assistance with some taxa was provided by specialist botanists, notably Russell Barrett (*Lepidosperma*) and Malcolm French (*Eucalyptus*). Specimens of special interest will be lodged in the Perth herbarium.

The genus *Lepidosperma* is currently under revision so definitive names for our collections were not available. Russell Barrett kindly grouped our specimens and provided some of his current phrase names, however the divisions within the groups are not finalized. It was found that specimens which the botanists referred to as *Tetraria capillaris* is very similar to *Lepidosperma* sp. Saltbush Hill (KR Newbey 4118), consequently it is not certain which taxon was occurring in field observations.

Difficulties were also found in determining the differences between *Acacia fragilis*, *A. fragilis* 'Ravensthorpe variant', *A. triptycha* and *A. uncinella*. This is recognized by Bruce Maslin as a complex group which requires further taxonomic work.



Plate 2. Plant identification at the Ravensthorpe Regional Herbarium

Analysis of data

Tracks and waypoints were downloaded from the GPS units using OziExplorer® and GPS Utility® software. Tracks were saved as .plt files and waypoints as both .wpt and .txt files (UTM/UPS and hddd.ddddd°), the latter allows importing of data into Excel® spreadsheets.

Plant species were recorded in a MAX V3 data table, a software program developed by DEC's Western Australian herbarium which links datasets to the Census of Western Australian Plants master list. The vegetation unit and 'shape number' were entered into the database.

Excel spreadsheets were used to record: 1) landform, rock, surface fragment and soil data; 2) Muir classification; and, 3) photograph number, photographer, direction and GPS location (eg Appendices 2, 4 & 5). The ‘shape number’ was common to all datasets, including GIS polygons, and used to link them.

To assist in clarifying the vegetation groups, multivariate analysis was used to produce dendrograms that grouped sites on the basis of species similarity. The output was too large to visualise in one dendrogram, so the data was split into units which were associated with different landforms/soils, eg slopes, laterite, greenstone (Fig.5). This was first conducted by Ted Griffin using the first week’s data of species composition versus shape number from two botanists using PATN® software (Belbin 1987). After the second field trip, dendrograms were produced by Neil Gibson (DEC Woodvale) ran PRIMER® software using the data of all four botanists. Shapes with only a few species recorded were excluded in the PRIMER® analysis as they skewed the data.

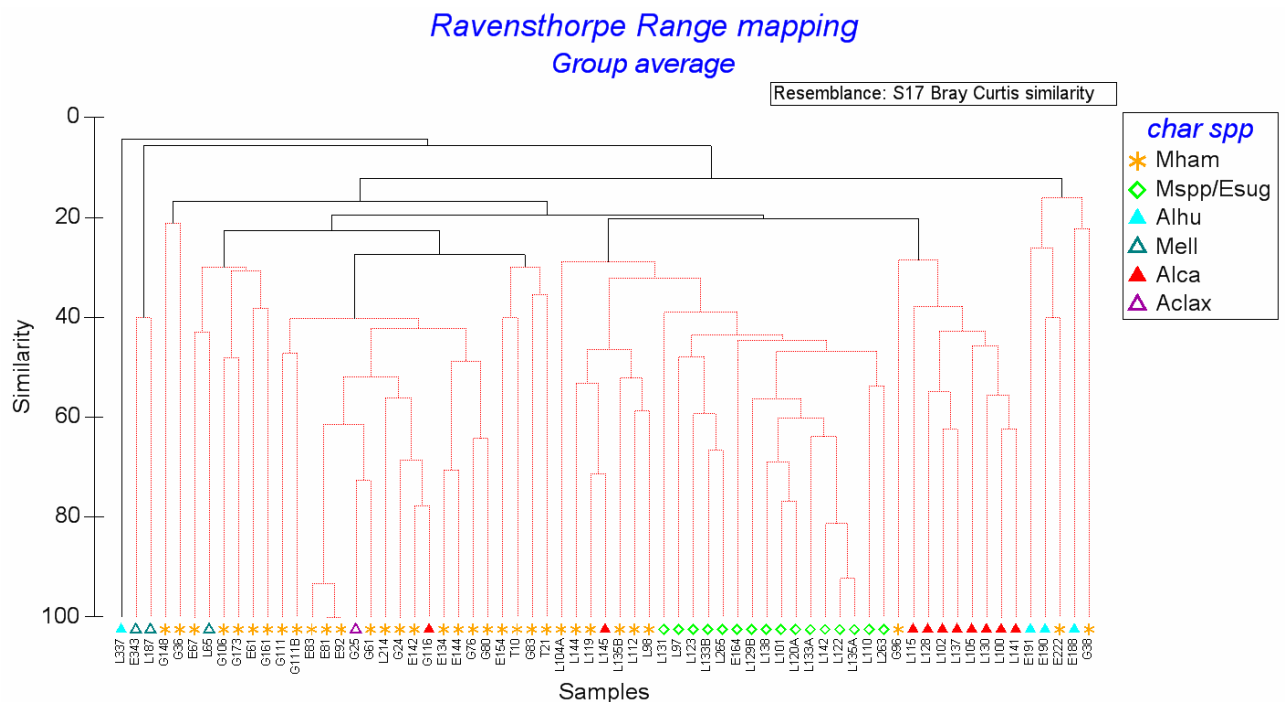


Figure 5. Example of dendrogram output from PRIMER® analysis of vegetation types found on granites

Map production

Linework

Between each field survey, GPS locations of vegetation boundaries were overlaid on orthophotos in OziExplorer® and printed out at 1:5000 scale. The initial linework for the vegetation map was drawn by each botanist for the area that they had surveyed onto plastic overlays over printed 1:5000 scale (A2 size) orthophotos and Quickbird satellite imagery. Some revisions then had to be made to make sure that the vegetation unit boundaries joined between each botanist’s areas.

Once the map boundaries were joined, it was found that either 1) a single polygon could have many ‘shape numbers’ from the same botanist, or 2) all four botanists could have one or more shape numbers within the same polygon. It was decided that for a particular polygon, there should be only one shape number per person. Botanists then handled their data differently, by either 1) choosing a ‘shape number’ that had the best species representation for that vegetation unit, or 2) combining the species list for all the ‘shape numbers’ in that polygon.

Digitising

The initial line work of the vegetation map that had been drawn onto plastic overlays (1:5000) by each of the botanists was digitised by Phil Tasker (Picket Resources). These plastic overlays were of various sizes and showed the vegetation boundaries, vegetation unit codes, shape numbers, roads and major tracks, and GDA94 datum coordinates. Each polygon of the vegetation map was attributed a vegetation unit code (veg_id) and shape numbers (bot_id).

Due to time constraints, Phil Tasker started to digitize the southern section of the vegetation map prior to the field work and PRIMER® analyses of the vegetation units in the northern section being completed. Consequently, some of the original vegetation unit codes and shape numbers had to be changed after initial digitising which caused unnecessary duplication of work for the digitizer.

After the vegetation map was initially digitised 1:10 000 scale proofs were given to the botanists on which they finalised the linework, vegetation unit codes and shape numbers. The final maps were provided to DEC as ArcGIS shapefiles (.shp).

Data Management

It was originally planned that DEC staff, including Deon Utber and Janet Newell, would integrate all of the MAX data tables and Excel spreadsheets into an Access database which would be linked to the vegetation map in ArcMap. Unfortunately due to confusion of the shape numbers, time constraints, technical difficulties and lack of expertise this has not been possible. However, such a database is planned to be completed before conducting more mapping of the Range.

The vegetation map was compared to the geomorphology (Traka Resources, unpub), geology (Ravensthorpe 1:250000, 1977) and fire regimes (DEC, unpub) by overlaying them with the vegetation map in ArcMap. The area, both in hectares and as a percentage of the total project area, of each vegetation unit in relation to the various attributes in the overlaid maps was calculated. This information, along with the data from the various databases (Table 5) was imported into the report form and then formatted to provide a summary for each vegetation unit.

Table 5. Vegetation unit datasets linked to the ArcMap

| Dataset Name | Type of data included |
|---------------------|---|
| SPECIES_* | vegetation unit, list of taxa in each shape number (MAX3 dataset) |
| Life form vs taxon | life form of each taxon |
| VEGUNIT_incNewbey | vegetation unit code, vegetation unit name |
| Rock_soil | landform, rock, surface fragments, soil type, soil colour, %litter cover, % bare ground |
| Muir classification | Muir classification |
| PHOTOS_* | photographs, GPS location, direction |
| Geomorphology | geomorphology units (Traka Resources Ltd) |
| Geology | geology – Ravensthorpe 1: 250 000 (1977) |
| Fire regime | fire history (DEC database) |

Results

Vegetation Units

Fifty vegetation units are described which were closely associated with landform, soil type and underlying terrain. Geological formations and species affinities have been used to group the vegetation units into broad categories, ie Chester formation, Bandalup ultramafics, granites, or drainage lines (Table 7); some of these groups are tentative, particularly where a vegetation unit covers less than 1% of the project area. Further sub-groupings have been made according to geomorphology and position in the landscape. As more of the Ravensthorpe Range is mapped, it should be possible to obtain a better understanding of the preferred habitat for each plant association.

A description of each vegetation unit is provided later in this section, with the information for each attribute being derived from a particular dataset as shown in Fig.6. A number of vegetation unit ‘mosaics’ have been mapped where individual units were too small to map separately; these are not described.

Beard’s vegetation system

Although comparisons between the 50 vegetation units in this project and Beard’s (1973) six vegetation types is desirable, the authors consider that it would be premature to lump vegetation units into larger, related complexes at this stage. Such an exercise should be carried out once all of the Ravensthorpe Range has been mapped. It is possible however, to say that the *Eucalyptus falcata*/ *E. pleurocarpa* complex would most closely relate to Beard’s ‘Shrublands; *Dryandra quercifolia* and *Eucalyptus* spp. thicket’.

Species diversity

The project area was highly diverse with 400 taxa recorded, with a rapid turnover of species across the landscape. The highest diversity was recorded in the large, heterogeneous *Eucalyptus falcata*/ *E. pleurocarpa* (*Efal/Eple*) complex. The least diverse unit was the *Eucalyptus platypus* low forest which often had no other species present.

Declared Rare and Priority Flora

Two Declared Rare species were noted, ie a significant new population of *Marianthus mollis* located in a valley north of Mt Benson, and *Daviesia megacalyx* scattered in the north and central sectors of the project area. Numerous populations of Priority flora, including *Acacia bifaria*, *A. dicticha*, *A. durabilis*, *Allocasuarina hystricosa*, *Banksia laevigata*, *Beyeria* sp. A Ravensthorpe, *Boronia oxyantha* var. *brevicalyx*, *Dryandra corvijuga*, *D. foliosissima*, *Grevillea fulgens*, *Guichenotia anota*, *Micromyrtus navicularis*, *Pultenaea* sp. Kundip, *Siegfriedia darwinioides* and *Spyridium glaucum* were found. A new taxon with affinity to *Melaleuca coccinea* and *M. penicula* was found.

Threatened Ecological Communities

Two Threatened Ecological Communities currently listed as Priority One were found during the survey:

- (i) ‘*Banksia laevigata* – *Banksia lemmaniana* - proteaceous thicket’ which equates to the *Banksia laevigata*/ *Beaufortia orbifolia* (*Blae/Borb*) vegetation unit and covered 78 ha (1.3%) of the project area; and,
- (ii) ‘heath on komatiite’ equates to the *Acacia ophiolithica* (*Acop*) vegetation unit and covered 6 ha (0.1%) of the project area.

Health

The vegetation was in excellent condition with minimal invasion by weeds. One area that was dominated by *Dryandra* species was dead/dying and tested for dieback disease (*Phytophthora* spp.) with negative results; drought was believed to have caused the decline (M.Grant, pers.comm.).

During the survey it became evident that the majority (70%) of vegetation units in the northern Ravensthorpe Range were dominated by obligate seeder species (Table 6). This includes the *Eucalyptus megacornuta*, *E. gardneri* subsp. *ravensthorpensis*, *E. cernua*, *E. clivicola*, *E. depauperata*, *E. extensa*, *E. platypus*, *E. dielsii*, *E. salubris*, *Melaleuca* sp. Gorse, *M. acuminata*, *M. cucullata*, *M. pauperiflora*, *M. thapsina* and *M. undulata*

dominated vegetation units, plus the large *E. falcata*/*E. pleurocarpa* complex (including the *Banksia laevigata*/*Beaufortia orbifolia*, *Dryandra cirsioides* and *D. foliosissima* units) and *Banksia media* that is characterized by proteaceous species.

The lack of post-fire recovery of obligate seeder species was of concern in a number of areas, particularly following a management burn in September 2006, and earlier burns in *Melaleuca* sp. Gorse dominated communities.

Table 6. Vegetation units dominated by obligate seeder species

| Vegetation Units | Area (ha) | % of project area |
|-----------------------------------|-------------|-------------------|
| Mallet dominated units: | | |
| Ecer | 98 | 1.6% |
| Ecli | 313 | 5.2% |
| Edep/Epil | 126 | 2.1% |
| Edie | 49 | 0.8% |
| Eext | 32 | 0.5% |
| Egar | 223 | 3.7% |
| Emeg | 61 | 1.0% |
| Epla | 102 | 1.7% |
| Esab | 5 | 0.1% |
| Total | 1010 | 16.9% |
| Melaleuca dominated units: | | |
| Ecer/Macu | 7 | 0.1% |
| Edep/Epil/Mspp | 156 | 2.6% |
| Eind/Mpau | 91 | 1.5% |
| Eflo/Mcuc | 11 | 0.2% |
| Eflo/Mgor | 19 | 0.3% |
| Eole/Mcuc | 18 | 0.3% |
| Eole/Mpau | 29 | 0.5% |
| Epla/Mcuc | 14 | 0.2% |
| Macu | 30 | 0.5% |
| Mallee/Mund | 4 | 0.1% |
| Mtha | 38 | 0.6% |
| Total | 418 | 7.0% |
| Proteaceous mallee-heaths: | | |
| Blae/Borb | 78 | 1.3% |
| Dcir | 373 | 6.2% |
| Dfol | 101 | 1.7% |
| Efal | 75 | 1.3% |
| Efal/Eple | 1994 | 33.4% |
| Eunc/Bmed | 106 | 1.8% |
| Mosaic_Blae/Borb_and_Efal/Eple | 5 | 0.1% |
| Total | 2732 | 45.8% |
| Grand total | 4160 | 69.7% |

Figure 6. Attributes used for the description of vegetation units

1. *Eucalyptus megacornuta* (Emeg)



Unit area: total area of vegetation unit in project area (ha)

% Project area: unit area (ha)/ project area (5970 ha) x 100

Sampling: number of polygons which had common species recorded, although more polygons may occur on the map

Muir classification: A modified classification of vegetation structure (Appendix 2); determined as mode of botanists' records for polygons sampled

Species are included in the following list if:

≥ 10 polygons sampled then ≥ 10% occurrence of species;

6-9 polygons sampled then ≥ 20% occurrence of species;

5 polygons sampled then ≥ 40% occurrence of species;

< 5 polygons sampled then all species recorded.

A full list of species for each vegetation unit is provided in Appendix 6.

The following definitions were used to describe the life form of each plant species. Life forms were ascribed using field observations primarily, or Paczkowska and Chapman (2000) or Chapman and Newbey (1995) secondarily.

Tree: a plant over 2 m high with a single stem and a usually open-branching habit. Branching may occur a short distance above ground level.

Mallet: a small to medium-sized tree, usually of steep-branching habit and with a conspicuously dense, terminal crown. The base of the trunk is sometimes fluted.

Mallee: a multi-stemmed plant from ground level, usually less than 10 m in height. Mallee forms are produced when several stems of similar size grow from a lignotuber into a mature plant.

Tall shrub: a plant over 2 m tall, usually with more than one main branch below 1.3 m

Mid shrub: a shrub between 1 and 2 m in height

Low shrub: a shrub between 0.5 and 1 m in height

Dwarf shrub: a shrub less than 0.5 m in height

Sedge/sedge-like: a plant of the family Cyperaceae, Restionaceae or Juncaceae

Grass/herb: a plant which is non-woody or woody at the base only, the above ground stems usually being ephemeral

Landform: Information collected by Technical Officer (eg Appendix 3); not comprehensive for all polygons

Geology: Geology was determined from overlay of the vegetation units on a digital 1:250 000 Ravensthorpe geological map (1977)

Geomorphology: determined for the area between Mt Short and Carlingup Road from a digital map prepared by Traka Resources Ltd (unpub.). Generally, only areas greater than 1 ha or more than 80% for a geology/geomorphological type were included in descriptions.

Surface fragments: Information collected by Technical Officer (eg Appendix 3); not comprehensive for all polygons.

Soil: Information collected by Technical Officer (eg Appendix 3); not comprehensive for all polygons.

% Cover leaf litter: Information collected by Technical Officer (eg Appendix 3); not comprehensive for all polygons.

% Cover bare ground: Information collected by Technical Officer (eg Appendix 3); not comprehensive for all polygons.

Fire regime: determined from fire histories digitally mapped by DEC from satellite imagery. Information on regeneration strategy species is by botanists' field observations.

Notes: general field observations by botanists.

Photo: information includes photo number, direction, location (polygon no) & GPS location, and photographer.

Table 7. Vegetation units grouped according to landscape position

| 1. Chester formation | | | |
|---|----------------|--|---------------------------------|
| 1.1 Metamorphosed sedimentary rock and colluvium | | | |
| | | | %vegetation unit/ total area |
| Crests, upper- & mid slopes | | | |
| 1. | Emeg | <i>Eucalyptus megacornuta</i> | 1 |
| 2. | Egar | <i>Eucalyptus gardneri</i> subsp. <i>ravensthorpensis</i> | 4 |
| 3. | Ecli | <i>Eucalyptus clivicola</i> | 5 |
| Mid- & lower slopes | | | |
| 4. | Eflo/Ephe | <i>Eucalyptus flocktoniae/ E. phenax</i> | 4 |
| 5. | Mallee/Mspp | <i>Eucalyptus species/ Melaleuca species</i> | 2 |
| 6. | Mallee/Mund | <i>Eucalyptus species/ Melaleuca undulata</i> | 0 |
| 7. | Eflo/Mcuc | <i>Eucalyptus flocktoniae/ Melaleuca cucullata</i> | 0 |
| 8. | Eext | <i>Eucalyptus extensa</i> | 1 |
| 9. | Mham | <i>Melaleuca hamata</i> | 1 |
| 10. | Mell | <i>Melaleuca elliptica</i> | 0 |
| Valleys | | | |
| 11. | Esal | <i>Eucalyptus salmonophloia</i> | 3 |
| 12. | Ecer | <i>Eucalyptus cernua</i> | 2 |
| 13. | Ecer/Macu | <i>Eucalyptus cernua/ Melaleuca acuminata</i> | 0 |
| 14. | Macu | <i>Melaleuca acuminata</i> | 0 |
| 1.2 Colluvium & laterite | | | |
| Slopes | | | |
| 15. | Efal/Eple | <i>Eucalyptus falcata/ E. pleurocarpa</i> | 33 |
| 16. | Efal | <i>Eucalyptus falcata</i> | 1 |
| 17. | Efal/Alca | <i>Eucalyptus falcata/ Allocasuarina campestris</i> | 1 |
| 18. | Blae/Borb | <i>Banksia laevigata/ Beaufortia orbifolia</i> | 1 |
| 19. | Mtha | <i>Melaleuca thapsina</i> | 1 |
| 20. | Dcir | <i>Dryandra cirsioides</i> | 6 |
| 21. | Dfol | <i>Dryandra foliosissima</i> | 2 |
| 22. | Eunc/Espp | <i>Eucalyptus uncinata/ Eucalyptus species</i> | 8 |
| 23. | Eunc/Bmed | <i>Eucalyptus uncinata/ Banksia media</i> | 2 |
| 24. | Alac | <i>Allocasuarina acutivalvis</i> | 0 |
| 25. | Alsp | <i>Allocasuarina spinosissima</i> | 0 |
| Lower slopes & drainages | | | |
| 26. | Edep/Epil/Mspp | <i>Eucalyptus depauperata/ E. pileata/ Melaleuca species</i> | 3 |
| 27. | Edep/Epil | <i>Eucalyptus depauperata/ E. pileata</i> | 2 |
| 28. | Espo | <i>Eucalyptus sporadica</i> | 0 |

2. Bandalup Ultramafics

2.1 Serpentinite & komatiite

| | | | |
|-----|-----------|--|---|
| 29. | Eind/Mpau | <i>Eucalyptus indurata/ Melaleuca pauperiflora</i> | 2 |
| 30. | Eind | <i>Eucalyptus indurata</i> | 0 |
| 31. | Eflo/Mgor | <i>Eucalyptus flocktoniae/ Melaleuca</i> sp. Gorse | 0 |
| 32. | Eole | <i>Eucalyptus oleosa</i> subsp. <i>corvina</i> | 1 |
| 33. | Eole/Mcuc | <i>Eucalyptus oleosa</i> subsp. <i>corvina/ Melaleuca cucullata</i> | 0 |
| 34. | Eole/Mpau | <i>Eucalyptus oleosa</i> subsp. <i>corvina/ Melaleuca pauperiflora</i> | 0 |
| 35. | Epro | <i>Eucalyptus proxima</i> | 0 |
| 36. | Mcli | <i>Melaleuca cliffortioides</i> | 0 |
| 37. | Acop | <i>Acacia ophiolithica</i> | 0 |
| 38. | Alscba | <i>Allocasuarina hystricosa</i> | 0 |
| 39. | Alsc | <i>Allocasuarina scleroclada</i> | 0 |

3. Granites

3.1 Quartz diorite

| | | | |
|-----|----------------|---|---|
| 40. | Alca | <i>Allocasuarina campestris</i> | 0 |
| 41. | Alhu | <i>Allocasuarina huegeliana</i> | 0 |
| 42. | Eplu/Esug/Mspp | <i>Eucalyptus pluricaulis/ E. suggrandis/ Melaleuca</i> species | 0 |

3.2 Kaolinized, deep weathered rock over granite

| | | | |
|-----|-----------|---|---|
| 43. | Epla | <i>Eucalyptus platypus</i> | 2 |
| 44. | Epla/Mcuc | <i>Eucalyptus platypus/ Melaleuca cucullata</i> | 0 |
| 45. | Edie | <i>Eucalyptus dielsii</i> | 1 |
| 46. | Esab | <i>Eucalyptus salubris</i> | 0 |

4. Drainage

4.1 Alluvium

| | | | |
|-----|----------|--------------------------------|---|
| 47. | Acac | <i>Acacia acuminata</i> | 0 |
| 48. | Eocc | <i>Eucalyptus occidentalis</i> | 0 |
| 49. | Mcut | <i>Melaleuca cuticularis</i> | 0 |
| 50. | ck_shrub | creekline with mixed shrubs | 0 |

1. *Eucalyptus megacornuta* (Emeg)

Unit area: 61.5 ha

% Project area: 1.03%

Sampling: 28 polygons

Muir classification: Low Forest, Heath, Open Dwarf Scrub C and D

The following common species were recorded:

Mallets: *Eucalyptus megacornuta*, *Eucalyptus gardneri* subsp. *ravensthorpensis*, *Eucalyptus lehmanii*

Tall shrubs: *Beaufortia orbifolia*, *Hakea laurina*, *Melaleuca thapsina*

Mid shrubs: *Exocarpos aphyllus*, *Gastrolobium parviflorum* forma 'broad', *Grevillea patentiloba* subsp. *platypoda*, *Hakea obtuse*, *Hovea acanthoclada*, *Isopogon polycephalus*, *Persoonia teretifolia*, *Phebalium tuberosum*, *Rhadinotamnus rudis* subsp. *amblycarpus*, *Trymalium elachophyllum*

Low shrubs: *Boronia oxyantha* var. *brevicalyx*, *Lasiopetalum compactum*, *Marianthus mollis*, *Siegfriedia darwinioides*, *Spyridium glaucum*

Landform: Crest and upper slopes, breakaways

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (23.0 ha); Metamorphosed sedimentary rock - As (22.2 ha); Cemented ironstone gravel and laterite - Cz1 (6.3 ha)

Geomorphology: Exposed, weathered rock with thin layer of skeletal soil on steep slopes - X (11.6 ha); Colluvium, ferruginous gravel and duricrust on proximal slopes - Cf(10.0 ha); Colluvium, scree derived from different rock types on gentle slopes - C (7.8 ha)

Surface fragments: Slightly rocky to rocky weathered laterised outcrops, very few to many weathered laterised and quartz small pebbles to stones

Soil: Soft light brown to red brown clayey sand to loam

% Cover leaf litter: >30% **% Cover bare ground:** >30%

Fire regime: 2000 (6.1 ha); 2001 (0.05 ha)

Eucalyptus megacornuta is an obligate seeder.

Notes: *Emeg* is usually found on gossanous, rocky outcrops on the crests and upper slopes east of Mt Benson. The unit is defined by the presence of *Eucalyptus megacornuta* and has a very variable understorey.



Photo no: P1000187
Date: 08-May-07
Photo direction: SE
Location: (G9) GDA94 S33.52674 E120.08156
Photographer: J Newell

2. *Eucalyptus gardneri* subsp. *ravensthorpensis* (Egar)

Unit area: 222.9 ha **% Project area:** 3.7% **Sampling:** 33 polygons

Muir classification: Low Forest, Open Low Scrub, Open Dwarf Scrub C and D

The following common species were recorded:

Mallets: *Eucalyptus gardneri* subsp. *ravensthorpensis*

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*

Tall shrubs: *Melaleuca hamata*

Mid shrubs: *Beyeria brevifolia* var. *brevifolia*, *Daviesia nematophylla*, *Exocarpos aphyllus*, *Gastrolobium parviflorum* forma 'broad', *Grevillea patentiloba* subsp. *platypoda*, *Hovea acanthoclada*, *Phebalium tuberculosum*

Low shrubs: *Boronia oxyantha* var. *brevicalyx*, *Dodonaea pinifolia*, *Lasiopetalum compactum*, *Platysace maxwellii*, *Siegfriedia darwinioides*

Dwarf shrubs: *Acacia erinacea*, *Acacia glaucoptera* forma 'spreading', *Boronia inornata*

Sedges: *Lepidosperma* sp. *Ravensthorpe* (GF Craig 5188)

Landform: Upper- to mid- slope

Geology: Metamorphosed sedimentary rock - As (124.3 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (56.0); Cemented ironstone gravel and laterite - Cz1 (16.6 ha); Serpentinite - Au (14.0 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (34.1 ha); Colluvium, ferruginous gravel and duricrust on proximal slopes - Cf(29.1 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (12.2 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (6.0 ha)

Surface fragments: Few to abundant sedimentary, weathered laterised and quartz small pebbles to cobbles

Soil: Firm yellow brown and red brown sandy loam and clay loam

% Cover leaf litter: >10% **% Cover bare ground:** >30%

Fire regime: 1977 (0.03 ha); 1982 (0.07 ha); 1999 (4.6 ha); 2000 (2.8 ha)

This vegetation unit is dominated by *Eucalyptus gardneri* subsp. *ravensthorpensis*, an obligate seeder.

Notes: Egar grades from low forest to more open woodland with a sparse understorey. North of Carlingup Road, it is usually upslope of *Eflo/Ephe* or *Ecer* on east-facing aspects and occasionally upslope of *Ecli* on western slopes. Between Carlingup Rd and South Coast Hwy it is frequent on both east- and west-facing, upper slopes.



Photo no: DSCN1921
Date: 21-Oct-05
Location: (T11D)
Photographer: GF Craig

3. *Eucalyptus clivicola* (Ecli)

Unit area: 313.2 ha

% Project area: 5.25%

Sampling: 62 polygons

Muir classification: Low Forest, Open Scrub, Open Low Scrub, Open Dwarf Scrub D

The following common species were recorded:

Mallets: *Eucalyptus clivicola*, *Eucalyptus platypus*

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*

Tall shrubs: *Melaleuca hamata*

Mid shrubs: *Acacia fragilis*, *Beyeria brevifolia* var. *brevifolia*, *Exocarpos aphyllus*, *Gastrolobium parviflorum* forma 'broad', *Phebalium tuberosum*, *Rhadinothamnus rudis* subsp. *amblycarpus*

Low shrubs: *Boronia oxyantha* var. *brevicalyx*, *Platysace maxwellii*, *Siegfriedia darwinioides*, *Spyridium glaucum*

Landform: Crest, upper to lower slope and flat.

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (150.9 ha); Cemented ironstone gravel and laterite - Czl (56.3 ha); Quartz diorite - Agt (50.5 ha); Metamorphosed sedimentary rock - As (21.0 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (117.0 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (71.5 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (55.0 ha); Colluvium, ferruginous gravel and duricrust on proximal slopes – Cf (20.9 ha); Exposed, weathered rock with thin layer of skeletal soil on steep slopes - X (18.7 ha)

Surface fragments: None to rocky weathered laterised or sedimentary outcrops with very few to very abundant sedimentary, weathered laterised and quartz small pebbles to boulders

Soil: Soft yellow, brown and red brown sandy loam to clay loam

% Cover leaf litter: >70%

% Cover bare ground: >70%

Fire regime: 2006 (11.9 ha); 2003 (9.3 ha); 2001 (1.2 ha); 2000 (11.8 ha); 1993 (0.3 ha); 1982 (2.7 ha)

This vegetation unit is dominated by *Eucalyptus clivicola*, an obligate seeder.

Notes: *Ecli* usually forms a low forest with a sparse shrub understorey. It is predominantly found on west to south-west facing slopes between Carlingup Road and Mt Benson.



Photo no: DSCN6656 Date: 11_MAY_07
Location: (E127) GDA94 S33.55014 E120.1118
Photographer: EJ Hickman



Photo no: IMG4167 Date: 25-Jun-07
Location: (A78/EE119/G66) GDA94 S33.54901 E120.10504
Photographer: J Newell

4. *Eucalyptus flocktoniae*/ *E. phenax* (Eflo/Ephe)

Unit area: 267.8 ha

% Project area: 4.5%

Sampling: 67 polygons

Muir classification: Tree Mallee, Open Scrub, Low Scrub, Open Dwarf Scrub C and D

The following common species were recorded:

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus phenax* subsp. *phenax*, *Eucalyptus calycogona* subsp. *calycogona*, *Eucalyptus suggrandis* subsp. *suggrandis*

Tall shrubs: *Melaleuca hamata*, *Melaleuca pauperiflora* subsp. *pauperiflora*

Mid shrubs: *Exocarpus aphyllus*, *Beyeria brevifolia* var. *brevifolia*, *Daviesia nematophylla*, *Dodonaea concinna*, *Gastrolobium parviflorum* forma 'broad', *Hakea verrucosa*, *Melaleuca* sp. *Gorse* (AS George 7224), *Phebalium tuberculatum*, *Senna artemisioides* subsp. *x artemisioides*

Low shrubs: *Boronia inornata*, *Dodonaea pinifolia*, *Lasiopetalum compactum*, *Platysace maxwellii*

Dwarf shrubs: *Acacia erinacea*, *Acacia glaucoptera* forma 'spreading', *Acacia ingrata*, *Acacia pusilla*, *Eremophila densifolia*, *Grevillea huegelii*

Landform: Upper to lower slopes and flat

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (109.2 ha); Metamorphosed sedimentary rock - As (107.8 ha); Cemented ironstone gravel and laterite - Czl (25.3 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (109.5 ha); Colluvium, scree derived from different rock types on gentle slopes - C (57.8 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (15.5 ha); Residual soil derived from ultramafic rock - Ru (18.4 ha); Colluvium, ferruginous gravel and duricrust on proximal slopes – Cf (10.9 ha)

Surface fragments: Common to abundant granite, weathered laterised and quartz small pebbles to cobbles

Soil: Hard light to red brown clay loam or clay loam sandy

% Cover leaf litter: >30% **% Cover bare ground:** >30%

Fire regime: 2006 (9.8 ha); 2004 (6.0 ha); 2003 (0.6 ha); 2000 (4.0 ha); 1999 (7.6 ha); 1982 (1.5 ha); 1977 (6.0 ha)

Notes: Usually *Eflo/Ephe* is a tall mallee community with a sparse shrub understorey. North of Carlingup Road, this unit is common on north-east facing slopes, whereas between Carlingup Road and South Coast Highway, it is more usually found on south-west facing slopes. It may form mosaics with *Eflo/Mgor*.



Photo no: IMG_2114 Date: 11-May-07
Location: (L189) WGS84 S33.5553 E120.E12034
Photographer: EM Sandiford

5. Eucalyptus species/ Melaleuca species (Mallee/Mspp)**Unit area:** 127.2 ha**% Project area:** 2.13%**Sampling:** 29 polygons**Muir classification:** Open Shrub Mallee, Open Scrub, Heath, Dwarf Scrub C, Open Dwarf Scrub D, Very Open Sedges

The following common species were recorded:

Mallet/Mallee: *Eucalyptus pileata***Mallees:** *Eucalyptus depauperata*, *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus incrassata*, *Eucalyptus phaenophylla* subsp. *phaenophylla*, *Eucalyptus phenax* subsp. *phenax*, *Eucalyptus pleurocarpa*, *Eucalyptus pluricaulis* subsp. *pluricaulis*, *Eucalyptus suggrandis* subsp. *suggrandis*, *Eucalyptus uncinata***Tall shrubs:** *Hakea laurina*, *Melaleuca hamata*, *Melaleuca lateriflora* subsp. *lateriflora*, *Melaleuca undulata*, *Santalum acuminatum*, *Templetonia retusa***Mid shrubs:** *Acacia sulcata* var. *platyphylla*, *Daviesia nematophylla*, *Exocarpos aphyllus*, *Gastrolobium parviflorum* forma 'broad', *Grevillea pectinata*, *Hakea commutata*, *Hakea verrucosa*, *Melaleuca cliffortioides*, *Melaleuca glaberrima*, *Melaleuca rigidifolia*, *Melaleuca* sp. *Gorse* (AS George 7224), *Phebalium tuberculatum*, *Senna artemisioides* subsp. *x artemisioides***Low shrubs:** *Baeckea corynophylla*, *Dodonaea pinifolia*, *Hibbertia psilocarpa*, *Hibbertia pungens*, *Hybanthus floribundus* subsp. *adpressus*, *Platysace maxwellii*, *Siegfriedia darwinioides***Dwarf shrubs:** *Acacia erinacea*, *Acacia glaucoptera* forma 'spreading', *Acacia ingrata*, *Acacia pusilla*, *Daviesia anceps*, *Pultenaea purpurea***Sedges/sedge-like:** *Gahnia ancistrophylla*, *Gahnia aristata***Landform:** Ridge, upper to lower slope and flat**Geology:** Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (57.2 ha); Deep-weathered rock, kaolinized - Czo/Agb (22.4 ha); Pelitic metasediments - Alp (10.5 ha); Metamorphosed sedimentary rock - As (11.7 ha)**Geomorphology:** Sheetwash, low gradient slope, sheet flood, distal slope - W (68.4 ha); Colluvium, scree derived from different rock types on gentle slopes - C (16.6 ha)**Surface fragments:** Few to abundant sedimentary or weathered laterised medium pebbles to cobbles**Soil:** Surface crust red brown loam or clay loam**% Cover leaf litter:** 30-70% **% Cover bare ground:** 30-70%**Fire regime:** 2006 (21.8); 2004 (3.2 ha); 2000 (0.3 ha); 1999 (3.9 ha); 1995 (0.3 ha); 1993 (10.1 ha); 1982 (3.7 ha); 1977 (1.7 ha)**Notes:** *Mallee/Mspp* is a mallee heath community with a diversity of mallee-form eucalypts and *Melaleuca* species within the shrub layer, none of which are dominant. It is closely related to, and often interspersed with, *Mallee/Mund* and *Eplu/Esug/Mspp*.

Photo no: P1000214 Date: 09-May-07
 Photo direction: S
 Location: (G20) AGD66 S33.536034 E120.116622
 Photographer: J Newell

6. *Eucalyptus species/ Melaleuca undulata (Mallee/Mund)*

Unit area: 4.4 ha

% Project area: 0.08%

Sampling: 5 polygons

Muir classification: Very Open Shrub Mallee, Heath, Open Dwarf Scrub D, Very Open Sedges

The following common species were recorded:

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus phenax* subsp. *phenax*, *Eucalyptus suggrandis* subsp. *suggrandis*

Tall shrubs: *Melaleuca hamata*, *Melaleuca undulata*

Mid shrubs: *Hakea commutata*

Landform: Flat

Geology: Metamorphosed sedimentary rock - As (1.3 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (1.4 ha); Cemented ironstone gravel and laterite - Cz1 (1.0 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (2.4 ha); Residual soil derived from ultramafic rock - Ru (1.3 ha)

Surface fragments: Very few to common granite or ultramafic large pebbles

Soil: Surface crust light brown clay loam sandy

% Cover leaf litter: >70%

% Cover bare ground: 30-70%

Fire regime: 2001 (0.3 ha)

Melaleuca undulata is an obligate seeder.

Notes: *Mallee/Mund* has a mid-dense to dense shrub layer dominated by *Melaleuca undulata* with emergent mallees. This unit was included to conform with other units where there is a distinctive *Melaleuca* understorey. It forms a mosaic with *Mallee/Mspp* on the lowest slopes.



Photo no: P1000235 Date: 10-May-07
Photo direction: W
Location: (L95)
WGS 84 S33.54547 E120.07879
Photographer: J Newell

7. *Eucalyptus flocktoniae/ Melaleuca cucullata (Eflo/Mcuc)*

Unit area: 11.2 ha **% Project area:** 0.19% **Sampling:** 3 polygons

Muir classification: Very Open Shrub Mallee, Thicket, Open Low Scrub, Open Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus phenax* subsp. *phenax*

Tall shrubs: *Melaleuca cucullata*, *Melaleuca eleuterostachya*, *Melaleuca pauperiflora* subsp. *pauperiflora*

Mid shrubs: *Dodonaea concinna*, *Exocarpos aphyllus*, *Hakea commutata*, *Hakea verrucosa*, *Senna artemisioides* subsp. *x artemisioides*

Low shrubs: *Boronia inornata*, *Boronia inconspicua*, *Dodonaea pinifolia*

Dwarf shrubs: *Acacia bifaria*, *Acacia erinacea*, *Acacia ingrata*, *Acacia pusilla*, *Eremophila densifolia*, *Grevillea huegelii*, *Pultenaea purpurea*

Landform: not recorded

Geology: Metamorphosed sedimentary rock - As (5.4 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (5.0 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (5.3 ha); Residual, quartzofeldspathic sand commonly over granite rock - Rg (5.1 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 2004 (0.9 ha); 1982 (1.2 ha)

Notes: This unit has relatively low species diversity and is distinguished by a dense *Melaleuca cucullata* stratum.

No photo available.

8. *Eucalyptus extensa* (Eext)

Unit area: 32.2 ha

% Project area: 0.54%

Sampling: 14 polygons

Muir classification: Low Forest, Low Scrub, Open Dwarf Scrub D

The following common species were recorded:

Mallets: *Eucalyptus extensa*, *Eucalyptus cernua*

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*

Tall shrubs: *Melaleuca cucullata*, *Melaleuca pauperiflora* subsp. *pauperiflora*, *Melaleuca acuminata* subsp. *acuminata*, *Melaleuca* sp. *Gorse* (A.S. George 7224), *Melaleuca torquata*, *Melaleuca undulata*

Mid shrubs: *Dodonaea concinna*, *Exocarpos aphyllus*, *Hakea commutata*

Low shrubs: *Acacia binata*

Dwarf shrubs: *Acacia erinacea*, *Acacia glaucoptera* forma 'spreading'

Landform: Mid slope and flat

Geology: Metamorphosed sedimentary rock - As (14.9 ha); Quartz diorite - Agt (6.6 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (4.3 ha)

Geomorphology: Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (6.1 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (3.9 ha); Residual ferruginous duricrust forming ridges and capping - Rfi (3.9 ha); Residual, quartzofeldspathic sand commonly over granite rock - Rg (3.4 ha)

Surface fragments: Very few ultramafic and quartz medium pebbles, and common weathered laterised medium pebbles

Soil: Soft light brown clay loam sandy, and firm yellow clay loam

% Cover leaf litter: >70%

% Cover bare ground: 30-70%

Fire regime: 2004 (0.5 ha); 2000 (0.4 ha); 1993 (0.2 ha); 1982 (0.1 ha);

This vegetation unit is dominated by *Eucalyptus extensa*, an obligate seeder.

Notes: A low forest community dominated by *Eucalyptus extensa* with a sparse understorey.



Photo no: DSCN4234 Date: 10-May-07
Photo direction: SE
Location: (G48) GDA94 S33.551594 E120.107602
Photographer: GF Craig

9. *Melaleuca hamata* (Mham)

Unit area: 45.1 ha

% Project area: 0.76%

Sampling: 34 polygons

Muir classification: Dense Thicket, Heath, Low Heath C, Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*

Tall shrubs: *Allocasuarina campestris*, *Melaleuca hamata*, *Santalum acuminatum*

Mid shrubs: *Calothamnus quadrifidus*, *Gastrolobium parviflorum* forma 'broad', *Hakea verrucosa*, *Grevillea patentiloba* subsp. *platypoda*, *Hakea verrucosa*, *Kunzea cincinnata*, *Phebalium tuberculatum*

Low shrubs: *Acacia sulcata* var. *platyphylla*, *Baeckea corynophylla*, *Dodonaea pinifolia*, *Hybanthus floribundus* subsp. *adpressus*, *Lasiopetalum compactum*, *Leucopogon hamulosus*, *Philotheca gardneri* subsp. *Ravensthorpe* (G.F. Craig 6902), *Platysace maxwellii*

Dwarf shrubs: *Hibbertia gracilipes*, *Hibbertia pungens*

Landform: Upper to lower slope and flat

Geology: Metamorphosed sedimentary rock - As (20.6 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (20.0 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (23.5 ha); Residual soil derived from ultramafic rock - Ru (6.9 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (4.7 ha)

Surface fragments: Few to many sedimentary and granite medium pebbles to cobbles

Soil: Soft light brown to brown sandy loam to clay loam

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2004 (1.2 ha); 2000 (0.1 ha); 1999 (6.5 ha); 1982 (0.5 ha); 1977 (0.9 ha)

Notes: A heterogeneous group, which varies from being a monotypic *Melaleuca hamata* thicket to a mixed species shrubland - there is possibly more than one vegetation unit included here. In areas where granite is exposed or close to the surface, *Melaleuca hamata* tends to form mosaics with other vegetation types, notably *Alca* and *Eplu/Esug/Mspp*.



Photo no: DSCN6620 Date: 10_MAY_07
Photo direction: E
Location: (E081) GDA94 S33.53789 E120.09679
Photographer: EJ Hickman

10. *Melaleuca elliptica* (Mell)

Unit area: 1.3 ha

% Project area: 0.02%

Sampling: 2 polygons

Muir classification: Dense Thicket, Open Dwarf Scrub D

The following common species were recorded:

Tall shrubs: *Melaleuca elliptica*

Mid shrubs: *Hakea verrucosa*

Low shrubs: *Dodonaea pinifolia*, *Hybanthus floribundus* subsp. *adpressus*

Landform: Drainage lines and lower slopes

Geology: Metamorphosed sedimentary rock - As (0.7 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (0.4 ha); Pelitic metasediments - Alp (0.2 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (0.5 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (0.8 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded

% Cover bare ground: not recorded

Fire regime: 2006 (0.19)

Notes: *Mell* occurs as both a monotypic thicket and a mixed shrub thicket.



Regeneration following September 2006 burn

Photo no: DSCN4382 Date: 28-Jun-07
Photo direction: SE
Location: GDA94 S33.47785 E120.00134
Photographer: GF Craig

11. *Eucalyptus salmonophloia* (Esal)

Unit area: 181.8 ha **% Project area:** 3.05% **Sampling:** 5 polygons

Muir classification: Low Woodland, Open Scrub, Open Dwarf Scrub C and D

The following common species were recorded:

Trees: *Eucalyptus salmonophloia*

Mallees: *Eucalyptus phenax subsp. phenax*

Mid shrubs: *Senna artemisioides subsp. filifolia*, *Senna artemisioides subsp. x artemisioides*

Low shrubs: *Lasiopetalum compactum*, *Olearia muelleri*

Dwarf shrubs: *Acacia erinacea*, *Acacia glaucoptera forma 'spreading'*, *Grevillea huegelii*

Landform: lower slopes and flats of broad valleys

Geology: Metamorphosed sedimentary rock - As (98.0 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (25.6 ha); Serpentinite - Au (21.4 ha); Quartz diorite - Agt (16.9 ha); Cemented ironstone gravel and laterite - Czl (8.4 ha)

Geomorphology: Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (3.8 ha)

Surface fragments: not recorded

Soil: Red-brown loam

% Cover leaf litter: not recorded

% Cover bare ground: not recorded

Fire regime: 2003 (0.04 ha)

Notes: Low woodlands of *Eucalyptus salmonophloia* with a scattered shrub understorey are usually present in the base of broad valleys although not restricted to them. Occasionally *Esal* grows on slopes, particularly between Carlingup Road and South Coast Highway.



Photo no: DSCN4321 Date: 19-Jun-07
Photo direction: S
Location: GDA94 S33.57146 E120.13486
Photographer: GF Craig

12. *Eucalyptus cernua* (Ecer)

Unit area: 97.6 ha **% Project area:** 1.6% **Sampling:** 20 polygons

Muir classification: Low Forest, Open Low Scrub, Open Dwarf Scrub

The following common species were recorded:

Trees/Mallets: *Eucalyptus cernua*, *Eucalyptus clivicola*, *Eucalyptus extensa*, *Eucalyptus gardneri* subsp. *ravensthorpensis*

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*

Tall shrubs: *Melaleuca acuminata* subsp. *acuminata*, *Melaleuca hamata*

Mid shrubs: *Exocarpus aphyllus*, *Gastrolobium parviflorum* forma 'broad', *Hakea verrucosa*, *Melaleuca* sp. *Gorse* (A.S. George 7224), *Senna artemisioides* subsp. *x artemisioides*

Low shrubs: *Dodonaea pinifolia*, *Platysace maxwellii*, *Siegfriedia darwinioides*

Dwarf shrubs: *Acacia glaucoptera* forma 'spreading', *Acacia erinacea*, *Acacia pusilla*, *Grevillea huegelii*

Landform: Lower slopes and drainage lines

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (41.6 ha); Metamorphosed sedimentary rock - As (32.6 ha); Serpentinite - Au (11.2 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (30.0 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (31.7 ha); Colluvium, scree derived from different rock types on gentle slopes - C (27.0 ha);

Surface fragments: Common to many sedimentary and weathered laterised medium to large pebbles

Soil: Brown soft sandy loam and firm clay loam

% Cover leaf litter: >70% **% Cover bare ground:** 30-70%

Fire regime: 2004 (7.7 ha); 2003 (0.2 ha); 2000 (0.3ha); 1999 (5.6 ha); 1990 (1.2 ha); 1982 (3.0 ha); 1977 (6.6 ha)

This vegetation unit is dominated by *Eucalyptus cernua*, an obligate seeder.

Notes: *Ecer* forms a low forest with a very open understorey.



Photo no: DSCN6628 Date: 10_MAY_07
Photo direction: SW
Location: (E87) GDA94 S33.53693 E120.09425
Photographer: EJ Hickman

13. *Eucalyptus cernua*/*Melaleuca acuminata* (Ecer/Macu)

Unit area: 7.3 ha **% Project area:** 0.12% **Sampling:** 4 polygons

Muir classification: Low Forest, Thicket

The following common species were recorded:

Mallets: *Eucalyptus cernua*

Tall shrubs: *Melaleuca acuminata* subsp. *acuminata*

Mid shrubs: *Gastrolobium parviflorum* forma 'broad', *Senna artemisioides* subsp. *x artemisioides*

Landform: Lower slopes and drainage lines

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (4.3 ha); Fine-grained mafic rock - Ab (1.1 ha); Serpentinite - Au (1.2 ha);

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (7.0 ha)

Surface fragments: not recorded

Soil: Brown loam

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 1999 (0.7 ha); 1977 (0.01 ha)

This vegetation unit is characterised by *Eucalyptus cernua*, an obligate seeder. The post-fire response of *Melaleuca acuminata* is uncertain.

Notes: This unit is dominated by a *Melaleuca acuminata* thicket with an overstorey of *Eucalyptus cernua*.

No photo available.

14. *Melaleuca acuminata* (Macu)

Unit area: 29.6 ha **% Project area:** 0.50% **Sampling:** 7 polygons

Muir classification: Thicket, Low Scrub, Dwarf Scrub C

The following common species were recorded:

Mallets: *Eucalyptus cernua*

Tall shrubs: *Melaleuca acuminata* subsp. *acuminata*, *Melaleuca thapsina*, *Santalum acuminatum*

Mid shrubs: *Phebalium tuberosum*

Landform: Lower slopes and drainage lines

Geology: Metamorphosed sedimentary rock - As (15.2 ha); Serpentinite - Au (7.2 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (3.1 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 2003 (0.32 ha)

Notes: *Macu* usually varies from being a dense thicket to a more open tall shrubland dominated by *Melaleuca acuminata* with a sparse understorey and no overstorey. It is found along the lower slopes adjacent to drainage lines and has affinity with the *Ecer/Macu* and *Eocc* unit.

It is possible that the records for *Melaleuca thapsina* in the above list are misidentifications, it is more likely that *M. hamata* is present.



Photo no: IMGP4054 Date: 11/05/2007
Photo direction: NW
Location: (A75) GDA94 S33.5529 E120.11588
Photographer: AM Rick

15. *Eucalyptus falcata/ E. pleurocarpa (Efal/Eple)*

The *Eucalyptus falcata/ E. pleurocarpa* vegetation unit is a large, heterogeneous complex that includes a number of plant associations that were mapped as separate units when large areas could be identified, ie *Dcir*, *Dfol*, *Blae/Borb* and others with close affinity, ie *Efal*, *Efal/Alca* and *Mtha*. There may be further discrete units within this complex that have not been identified. The mallee heath is quite variable in species composition, being a function of soil depth and fire history. Clear boundaries could not be defined in a number of localities, particularly in areas of recent fire (September 2006), so a number of mosaics with *Efal/Eple* are shown on the map, ie with *Blae/Borb*, *Efal*, and *Eunc/Espp*.

Unit area: 1994.1 ha **% Project area:** 33.4% **Sampling:** 69 polygons

Muir classification: Open Shrub Mallee, Scrub, Heath, Low Heath C, Open Dwarf D

The following common species were recorded:

Mallees: *Eucalyptus pleurocarpa*, *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus uncinata*, *Eucalyptus incrassata*, *Eucalyptus phaenophylla* subsp. *phaenophylla*

Tall shrubs: *Banksia lemanniana*, *Banksia laevigata* subsp. *laevigata*, *Beaufortia orbifolia*, *Grevillea coccinea* subsp. *coccinea*, *Hakea multilineata*, *Hakea pandanicarpa* subsp. *crassifolia*, *Melaleuca hamata*

Mid shrubs: *Acacia fragilis*, *Acacia heterochroa* subsp. *heterochroa*, *Allocasuarina humilis*, *Beyeria brevifolia* var. *brevifolia*, *Boronia ternata* var. *elongata*, *Calothamnus quadrifidus*, *Dryandra cirsiooides*, *Dryandra foliosissima*, *Dryandra pallida*, *Gastrolobium parviflorum* forma 'broad', *Hakea cygna* subsp. *cygna*, *Hakea lissocarpha*, *Hakea obtusa*, *Hakea subsulcata*, *Isopogon polycephalus*, *Jacksonia viscosa*, *Kunzea cincinnata*, *Leptospermum spinescens*, *Melaleuca rigidifolia*, *Melaleuca subtrigona*, *Petrophile seminuda*, *Rhadinothamnus rudis* subsp. *amblycarpus*, *Taxandria spathulata*

Low shrubs: *Beaufortia schaueri*, *Hakea marginata*, *Hibbertia mucronata*, *Lasiopetalum compactum*, *Leucopogon conostephioides*, *Petrophile glauca*, *Philotheca gardneri* subsp. *Ravensthorpe* (G.F. Craig 6902)

Dwarf shrubs: *Rinzia communis*

Landform: Crest, upper to lower slope, flat, and open depression

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (1060.0 ha); Cemented ironstone gravel and laterite - Czl (583.6 ha); Pelitic metasediments - Alp (79.7 ha); Metamorphosed sedimentary rock - As (67.6 ha); Colluvium and minor alluvium - Qrt (50.7 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (789.3 ha); Colluvium, scree derived from different rock types on gentle slopes - C (665.8 ha); Residual ferruginous duricrust forming ridges and capping - Rfi (196.1 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (161.4 ha)

Surface fragments: Common to very abundant sedimentary, weathered laterised and quartz small pebbles to stones

Soil: Soft to firm brown to red brown clayey sand to light clay

% Cover leaf litter: >30% **% Cover bare ground:** 30-70%

Fire regime: 2006 (664.6 ha); 2004 (8.1 ha); 2003 (16.2 ha); 2002 (115.5 ha); 2001 (3.3 ha); 2000 (217.8 ha); 1999 (45.7 ha); 1995 (52.3 ha); 1993 (29.7 ha); 1982 (5.4 ha)

A large proportion of the shrub species in this vegetation unit are obligate seeders.

Notes: This heterogeneous mallee heath complex dominates the landscape on the laterites between Mt Benson/ Mt McMahon and Mt Short and is the largest vegetation unit in the project area. It is characterized by patches of mallee, interspersed with a diversity of shrubs, many being proteaceous. *Efal/Eple* is affiliated with the broad vegetation type described by Beard (1973) as 'Shrublands; *Dryandra quercifolia* & *Eucalyptus* spp. thicket (edSc)' (Fig.3).

Due to its species composition and high number of endemics, this *Efal/Eple* unit needs to be maintained as an entity separate to other *Eucalyptus falcata/ E. pleurocarpa* communities that occur outside the Ravensthorpe Range. Many threatened species (Atkins 2007) were recorded in this unit, including *Daviesia megacalyx* (Declared Rare), *Acacia loricata* var. *crassifolia*, *Banksia laevigata*, *Dryandra corvijuga*, *Dryandra foliosissima*, *Goodenia pinifolia*, *Grevillea fulgens*, *Guichenotia anota* and *Micromyrtus navicularis*.

1. Chester formation
1.2. Colluvium & laterite – slopes

Approximately one-third of the complex was burnt in September 2006, both to the east and west of Floater Road. Mapping was largely done in these areas from aerial and satellite imagery, although broad traverses were still made for ground-truthing. Of particular concern was the lack of regeneration of obligate re-seeder species throughout the burnt area, despite it being 10 months after the fire, and these species being a dominant component of the original vegetation.



Photo no: IMG_2200 Date: 28-Jun-07
Photo direction:
Location: (L405) WGS84 S33.46277 E119.98825
Photographer: EM Sandiford



Photo no: P1000182 Date: 08-May-07
Photo direction: S
Location: (G7) GDA94 S33.52845 E120.0766
Photographer: J Newell

16. *Eucalyptus falcata* (Efal)

Unit area: 75.2 ha **% Project area:** 1.26% **Sampling:** 43 polygons

Muir classification: Shrub Mallee, Thicket, Low Scrub, Low Heath C

The following common species were recorded:

Mallees: *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus incrassata*,
Eucalyptus pleurocarpa

Tall shrubs: *Hakea multilineata*, *Acacia subcaerulea*, *Banksia laevigata* subsp. *laevigata*, *Banksia lemanniana*,
Beaufortia orbifolia, *Hakea laurina*, *Melaleuca hamata*, *Melaleuca thapsina*, *Santalum acuminatum*

Mid shrubs: *Gastrolobium parviflorum* forma 'broad', *Hakea obtusa*, *Acacia fragilis*, *Beyeria brevifolia* var.
brevifolia, *Boronia ternata* var. *elongata*, *Calothamnus quadrifidus*, *Grevillea patentiloba* subsp.
platypoda, *Hakea verrucosa*, *Hovea acanthoclada*, *Isopogon polycephalus*, *Labichea lanceolata* subsp.
brevifolia, *Persoonia teretifolia*, *Phebalium tuberculatum*, *Rhadinothamnus rudis* subsp. *amblycarpus*

Low shrubs: *Boronia oxyantha* var. *brevicalyx*, *Lasiopetalum compactum*, *Platysace maxwellii*, *Siegfriedia*
darwinoides, *Spyridium glaucum*

Sedges: *Lepidosperma* spp. (unidentified)

Climbers: *Billardiera coriacea*

Landform: Mid slope and below breakaways

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (35.6ha); Quartz diorite - Agt (13.8 ha); Metamorphosed sedimentary rock - As (8.3 ha); Cemented ironstone gravel and laterite - Czl (13.3 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (23.4 ha); Colluvium, ferruginous gravel and duricrust on proximal slopes – Cf (22.6 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (9.6 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (6.5 ha); Exposed, weathered rock with thin layer of skeletal soil on steep slopes - (3.8 ha)

Surface fragments: Very abundant sedimentary and quartz small pebbles to cobbles

Soil: Firm light to red brown sandy loam

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2004 (2.5 ha); 2003 (1.9 ha); 2001 (0.9 ha); 2000 (6.8 ha); 1999 (0.1 ha); 1982 (0.6 ha)

A significant proportion of the shrub species in this vegetation unit are obligate seeders.

Notes: *Efal* is characterized by shrub thickets and mallee, often occurring on rocky soils immediately below breakaways. It has close affinity to the large, heterogeneous *Eucalyptus falcata*/ *E. pleurocarpa* complex.

No photo available.

17. *Eucalyptus falcata/ Allocasuarina campestris (Efal/Alca)*

Unit area: 51.3 ha **% Project area:** 0.86% **Sampling:** 9 polygons

Muir classification: Open Shrub Mallee, Thicket, Heath, Low Heath C, Open Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus pleurocarpa*

Tall shrubs: *Allocasuarina campestris*, *Melaleuca hamata*, *Santalum acuminatum*, *Templetonia retusa*

Mid shrubs: *Calothamnus quadrifidus*, *Labichea lanceolata* subsp. *brevifolia*, *Phebalium tuberosum*, *Acacia sulcata* var. *platyphylla*, *Gastrolobium parviflorum* forma 'broad', *Grevillea patentiloba* subsp. *platypoda*, *Hakea obtusa*, *Hakea verrucosa*, *Hovea acanthoclada*

Low shrubs: *Hibbertia pungens*, *Leucopogon hamulosus*, *Platysace maxwellii*

Grasses: *Spartochloa scirpoidea*

Landform: Upper- and mid-slopes often near rock outcrops

Geology: Metamorphosed sedimentary rock - As (32.6 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (10.0 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (8.2 ha); Colluvium, scree derived from different rock types on gentle slopes - C (5.0 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded

% Cover bare ground: not recorded

Fire regime: No fires recorded. A large proportion of the shrub species in this vegetation unit are obligate seeders.

Notes: The *Efal/Alca* thicket of mid- to tall shrubs interspersed with mallees is characterized by *Allocasuarina campestris*, and often occurs near rock outcrops. It has close affinity with the large, heterogeneous *Eucalyptus falcata/ E. pleurocarpa* complex on laterite and *Alca* which occurs on granites.



Photo no: DSCN4277 Date: 11-May-07
Photo direction: N
Location: (G81) GDA94 S33.555314 E120.121362
Photographer: GF Craig

18. *Banksia laevigata/ Beaufortia orbifolia* (Blae/Borb)

Unit area: 77.9 ha **% Project area:** 1.3% **Sampling:** 36 polygons

Muir classification: Very Open Shrub Mallee, Thicket, Heath, Open Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus pleurocarpa*, *Eucalyptus lehmanii*

Tall shrubs: *Banksia laevigata* subsp. *laevigata*, *Beaufortia orbifolia*, *Banksia lemmaniana*, *Hakea multilineata*,
Melaleuca hamata, *Melaleuca thapsina*

Mid shrubs: *Calothamnus quadrifidus*, *Hakea obtusa*, *Acacia fragilis*, *Boronia ternata* var. *elongata*, *Gastrolobium*
parviflorum forma 'broad', *Hovea acanthoclada*, *Isopogon polycephalus*, *Kunzea cincinnata*, *Labichea*
lanceolata subsp. *brevifolia*, *Rhadinothamnus rudis* subsp. *amblycarpus*

Low shrub: *Beaufortia schaueri*, *Platysace maxwellii*

Sedge: *Lepidosperma brunonianum*

Herb: *Stylidium albomontis*

Landform: Upper, lower and simple slope, breakaways

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (45.0 ha); Colluvium and minor alluvium - Qrt (4.3 ha); Pelitic metasediments - Alp (11.3 ha); Cemented ironstone gravel and laterite - Czl (5.0 ha); Deep-weathered rock, kaolinized - Czo/As(4.9 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (36.4 ha); Colluvium, scree derived from different rock types on gentle slopes - C (24.3 ha); Colluvium, ferruginous gravel and duricrust on proximal slopes – Cf (8.4 ha); Residual ferruginous duricrust forming ridges and capping - Rfi (2.3 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (3.2 ha); Residual soil derived from ultramafic rock - Ru (3.1 ha);

Surface fragments: Very slighty rocky to rocky sedimentary outcrops, common to very abundant sedimentary small pebbles to stones

Soil: Firm red brown to yellow loam to silty clay loam

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2006 (10.5 ha); 2004 (1.4 ha); 2002 (1.8 ha); 2001 (1.9 ha); 2000 (2.6 ha); 1999 (0.1ha); 1993 (30.8 ha); 1982 (1.4 ha)

A large proportion of the shrub species in this vegetation unit are obligate seeders.

Notes: *Blae/Borb* often occurs on breakaways on the edge of the large, heterogeneous *Eucalyptus falcata/ E. pleurocarpa* complex, to which it has close affinity. In some areas, only *Banksia laevigata* or *Beaufortia orbifolia* (but not both) are present.

This unit equates to the Priority One Threatened Ecological Community referred to as “*Banksia laevigata* – *Banksia lemmaniana* – proteaceous thicket”.



Photo no: DSCN6582 Date: 8_MAY_07
Photo direction: NW
Location: (E020A) GDA94 S33.51709 E120.07837
Photographer: EJ Hickman

19. *Melaleuca thapsina* (Mtha)

Unit area: 38.3 ha **% Project area:** 0.64% **Sampling:** 21 polygons

Muir classification: Dense Thicket, Open Dwarf Scrub C and D

The following common species were recorded:

Mallees: *Eucalyptus phaenophylla* subsp. *phaenophylla*, *Eucalyptus uncinata*

Tall shrubs: *Banksia laevigata* subsp. *laevigata*, *Beaufortia orbifolia*, *Melaleuca thapsina*

Mid shrubs: *Gastrolobium parviflorum* forma 'broad', *Acacia fragilis*, *Exocarpos aphyllus*, *Hakea verrucosa*, *Phebalium tuberculosum*

Low shrubs: *Beaufortia schaueri*

Dwarf shrubs: *Acacia larinina* var. *crassifolia*, *Leucopogon infuscatus*

Herbs: *Stylidium albomontis*

Landform: Slopes, breakaways

Geology: Pelitic metasediments - Alp (18.5 ha); Cemented ironstone gravel and laterite - Czl (12.2 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (3.4 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (29.3 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (3.3 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (3.4 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 2006 (14.2 ha); 2003 (0.8 ha); 2002 (0.3 ha)

This vegetation unit is dominated by *Melaleuca thapsina*, an obligate seeder.

Notes: *Mtha* may form monotypic thickets or be a more diverse tall shrubland. It is often present in rocky areas near breakaways and adjacent to a *Blae/Borb* unit from which it differs by having *Melaleuca thapsina* dominant. It has affinity with the large, heterogeneous *Eucalyptus falcata*/ *E. pleurocarpa* complex. In numerous locations it forms the boundary between the *Efal/Eple* complex and tall mallee or mallet communities, eg *Eflo/Ephe*, *Emeg* or *Egar*.



Photo no: DSCN4246 Date: 10-May-07
Photo direction: SSE
Location: (G52) GDA94 S33.550214 E120.112222
Photographer: GF Craig

20. *Dryandra cirsioides* (*Dcir*)

Unit area: 372.8 ha **% Project area:** 6.2% **Sampling:** 11 polygons

Muir classification: Heath, Low Heath C and D

The following common species were recorded, those in **bold** were in 45% or more of polygons:

Mallees: *Eucalyptus pleurocarpa*, *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus uncinata*

Tall shrubs: *Allocasuarina acutivalvis* subsp. *acutivalvis*, *Banksia lemanniana*, *Hakea pandanica* subsp. *crassifolia*, *Melaleuca hamata*

Mid shrubs: *Dryandra cirsioides*, *Dryandra erythrocephala* var. *erythrocephala*, *Dryandra pallida*, *Melaleuca subtrigona*, *Gastrolobium parviflorum* forma 'broad', *Hakea cygna* subsp. *cygna*, *Petrophile seminuda*

Low shrubs: *Beaufortia schaueri*, *Beaufortia micrantha* var. *micrantha*, *Petrophile glauca*

Landform: Lower and simple slopes and flat

Geology: Cemented ironstone gravel and laterite - Czl (47.1 ha); Ultramafic rock, altered - Ae (6.9 ha); Pelitic metasediments - Alp (3.5 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (138.9 ha); Colluvium, scree derived from different rock types on gentle slopes - C (116.5 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (88.5 ha)

Surface fragments: Few to abundant weathered laterised and quartz small pebbles to cobbles

Soil: Firm yellow or red brown loamy sand, loam or clay loam

% Cover leaf litter: 10-30% **% Cover bare ground:** >70%

Fire regime: 2006 (160.1 ha); 2002 (94.2 ha); 2003 (2.5 ha); 1995 (0.04 ha); 1993 (1.6 ha)

This vegetation unit is characterised by obligate seeders, including *Dryandra cirsioides*, *D. pallida*, *Banksia lemanniana*, *Hakea pandanica* subsp. *crassifolia*, *Gastrolobium parviflorum* forma 'broad', *Hakea cygna* subsp. *cygna*, *Beaufortia schaueri*, *Beaufortia micrantha* var. *micrantha*.

Notes: This unit forms an distinct heath community within the large, heterogeneous *Eucalyptus falcata*/*E. pleurocarpa* complex. After ground-truthing areas east of Floater Road, the *Dcir* unit was largely mapped from interpretation of orthophotos and stereo-pairs of orthophotos, as this predominantly was clearly identifiable. West of Floater Road was largely burnt in September 2006 and was not fully ground-truthed due to difficulty of interpretation – areas dominated by *Allocasuarina* may be included in the *Dcir* unit, particularly towards the south of the Mt Short 'block'.

East of Floater Road, in the 1993 post-fire regeneration, an area with many dead/dying *Dryandra cirsioides* and *D. pallida* was found and subsequently tested by DEC for dieback disease (*Phytophthora* spp.) with negative results; drought was believed to have caused the decline (M.Grant, pers.comm.).



Photo no: IMGP4299 Date: 29-Jun-07
Photo direction: S
Location: (S2/L539/L535) GDA94 S33.46465 E120.01433
Photographer: J Newell

21. *Dryandra foliosissima* (Dfol)

Unit area: 100.6 ha **% Project area:** 1.7% **Sampling:** 1 polygon

Muir classification: Open Shrub Mallee, Low Heath C and D, Very Open Sedges

The common species were recorded:

Mallees: *Eucalyptus pleurocarpa*

Tall shrubs: *Banksia laevigata* subsp. *laevigata*, *Beaufortia orbifolia*

Mid shrubs: *Dryandra foliosissima*, *Daviesia euryloba*, *Hakea obtusa*, *Isopogon polycephalus*, *Taxandria spathulata*

Low shrubs: *Beaufortia micrantha* var. *micrantha*, *Dryandra corvijuga*

Herbs: *Conostylis argentea*

Landform: Upper and mid-slopes

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (55.2 ha); Cemented ironstone gravel and laterite - Czl (34.8 ha); Deep-weathered rock, kaolinized - Czo/As (7.8 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (53.8 ha); Residual ferruginous duricrust forming ridges and capping - Rfi (29.7 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (11.8 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (5.2 ha)

Surface fragments: not recorded

Soil: Yellow loamy sand

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 2006 (10.8 ha); 2000 (23.1 ha); 1999 (5.2 ha); 1995 (0.1 ha)

This vegetation unit is dominated by *Dryandra foliosissima*, an obligate seeder.

Notes: The Dfol unit was largely mapped from interpretation of the Quickbird satellite imagery, where *Dryandra foliosissima* showed as a pale green, 'shiny' dot. This unit forms a distinct plant association within the large, heterogeneous *Eucalyptus falcata*/ *E. pleurocarpa* complex, although patches were often too small to map individually.

Dfol includes a number of species currently on the Priority flora list, ie *Dryandra foliosissima*, *D. corvijuga* and *Banksia laevigata*.



Photo no: DSCN4367 Date: 27-Jun-07
Photo direction: E
Location: (G135) GDA94 S33.48746 E120.02709
Photographer: GF Craig

22. *Eucalyptus uncinata/ Eucalyptus species (Eunc/Espp)*

Unit area: 481.9 ha **% Project area:** 8.07% **Sampling:** 61 polygons

Muir classification: Shrub Mallee, Open Scrub, Heath, Dwarf Scrub C, Open Dwarf Scrub D, Very Open Sedges

The following common species were recorded:

Mallees: *Eucalyptus incrassata, Eucalyptus depauperata, Eucalyptus falcata subsp. falcata, Eucalyptus flocktoniae subsp. flocktoniae, Eucalyptus phaenophylla subsp. phaenophylla, Eucalyptus phenax subsp. phenax, Eucalyptus pleurocarpa, Eucalyptus suggrandis subsp. suggrandis, Eucalyptus uncinata*

Tall shrubs: *Banksia lemanniana, Banksia media, Hakea laurina, Leptospermum maxwellii, Melaleuca hamata, Melaleuca lateriflora subsp. lateriflora*

Mid shrubs: *Acacia fragilis, Beyeria brevifolia var. brevifolia, Calothamnus gibbosus, Calothamnus quadrifidus, Dryandra cirsioides, Gastrolobium parviflorum forma 'broad', Grevillea oligantha, Grevillea patetiloba subsp. patetiloba, Grevillea pectinata, Hakea lissocarpha, Hakea verrucosa, Isopogon polycephalus, Kunzea cincinnata, Melaleuca glaberrima, Melaleuca rigidifolia, Melaleuca societatis, Melaleuca subtrigona, Persoonia teretifolia, Rhadinothamnus rudis subsp. amblycarpus*

Low shrubs: *Acrotriche ramiflora, Beaufortia schaueri, Gastrolobium tetragonophyllum, Lasiopetalum compactum, Leucopogon conostephioides, Leucopogon fimbriatus, Platysace maxwellii, Siegfriedia darwinioides*

Dwarf shrubs: *Hibbertia pungens, Rinzia communis*

Sedges/sedge-like: *Gahnia ancistrophylla*

Landform: Crest, upper to lower slope, flat and open depression

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (277.0 ha); Colluvium and minor alluvium - Qrt (21.7 ha); Quartz diorite - Agt (22.6 ha); Cemented ironstone gravel and laterite - Czl (26.3 ha); Deep-weathered rock, kaolinized - Czo/Agb (47.3 ha); Sandplain - Czs (24.1 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (199.6 ha); Colluvium, scree derived from different rock types on gentle slopes - C (94.0 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (81.5 ha); Residual, quartzofeldspathic sand commonly over granite rock - Rg (57.3 ha)

Surface fragments: Common to abundant weathered laterised and quartz small pebbles to cobbles

Soil: Firm yellow, light brown to red brown loamy sand to light clay

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2006 (127.4 ha); 2004 (20.6 ha); 2003 (21.5 ha); 2002 (21.3 ha); 2001 (4.0 ha); 2000 (10.7 ha); 1995 (6.3 ha); 1993 (17.2 ha); 1982 (23.8 ha)

Notes: The heterogeneous *Eunc/Espp* unit usually occurs in deeper colluvial soils downslope of the large, heterogeneous *Eucalyptus falcata/ E. pleurocarpa* complex, to which it has affinities. It is characterized by a diversity of mallees and *Melaleuca* dominated thickets in the understorey. The *Eunc/Espp* that occurs on the steep, south-facing slopes below the Ridge Track differs from the *Eunc/Espp* recorded elsewhere, although it was not possible to make a clear differentiation from the data recorded. Towards Mt Benson, *Eucalyptus phaenophylla* was a major component of the unit, whereas towards Mt Short a greater complexity of mallee-form eucalypts were included.

In the northern sector, west of the Bonnymidgup Track, *Eunc/Espp* forms a mosaic with *Edep/Epil*, of which *E. scyphocalyx* was a significant component of the vegetation.

1. Chester formation
1.2. Colluvium & laterite – slopes



Photo no: IMGP4286 Date: 28-Jun-07
Photo direction: E
Location: (G188) GDA94 S33.46504 E119.99266
Photographer: J Newell



Photo no: P1000313 Date: 02-Aug-07
Photo direction: N
Location: (A103c) GDA94 S33.44534 E120.01411
Photographer: J Newell

23. *Eucalyptus uncinata/ Banksia media (Eunc/Bmed)*

Unit area: 106.4 ha **% Project area:** 1.78% **Sampling:** 9 polygons

Muir classification: Open Shrub Mallee, Open Scrub, Heath, Low Heath C, Open Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus depauperata*, *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus incrassata*, *Eucalyptus pleurocarpa*, *Eucalyptus phaenophylla* subsp. *phaenophylla*, *Eucalyptus suggrandis* subsp. *suggrandis*, *Eucalyptus uncinata*

Tall shrubs: *Banksia media*, *Melaleuca hamata*, *Hakea laurina*, *Hakea pandanica* subsp. *crassifolia*, *Leptospermum erubescens*

Mid shrubs: *Beyeria brevifolia* var. *brevifolia*, *Calothamnus gibbosus*, *Dryandra pallida*, *Grevillea oligantha*, *Hakea corymbosa*, *Melaleuca rigidifolia*, *Melaleuca societatis*, *Melaleuca subtrigona*

Low shrubs: *Beaufortia micrantha* var. *micrantha*, *Beaufortia schaueri*, *Calytrix leschenaultii*, *Isopogon* sp. *Fitzgerald River (DB Foreman 813)*, *Leucopogon fimbriatus*, *Lysinema ciliatum*, *Micromyrtus imbricata*, *Petrophile squamata* subsp. *northern (J Monks 40)*

Dwarf shrubs: *Hibbertia gracilipes*, *Rinzia communis*

Landform: Simple lower slopes and flats

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (52.7 ha); Sandplain - Czs (25.5 ha); Colluvium and minor alluvium - Qrt (20.4 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (98.9 ha)

Surface fragments: None to few weathered laterised small pebbles to cobbles

Soil: Soft brown to light brown loamy sand or clay loam sandy

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2006 (51.3 ha); 2003 (3.9 ha); 2002 (1.0 ha); 1993 (17.0 ha)

This vegetation unit is dominated by *Banksia media*, an obligate seeder as are many of the associated shrub species. In September 2006, 50% of this unit was burnt and 10 months later the only regeneration was by resuckering species, ie no seedlings were present.

Notes: The *Eunc/Bmed* mallee heath usually occurs in deeper sands, downslope of the large, heterogeneous *Eucalyptus falcata/ E. pleurocarpa* complex. Although *Eunc/Bmed* has a number of species in common with *Efal/Eple* typical of the laterites, it appears to be more closely affiliated with the sandplain vegetation type described by Beard (1973) as 'Shrublands; tallerack mallee-heath (e₂₆SZc)' (Fig.3).

1. Chester formation
1.2. Colluvium & laterite – slopes



Photo no: P1000303 Date: 02-Aug-07
Photo direction: W
Location: (A105b) GDA94 S33.45116 E120.01551
Photographer: J Newell



*Burnt September 2006 - obligate seeder
species have not reappeared.*

Photo no: DSCN4349 Date: 26-Jun-07
Photo direction: S
Location: (G126) GDA94 S33.48326 E120.0425
Photographer: GF Craig

24. *Allocasuarina acutivalvis* (Alac)

Unit area: 24.2 ha **% Project area:** 0.4% **Sampling:** 15 polygons

Muir classification: Scrub, Low Scrub, Dwarf Scrub, Open Sedges, Open Grasses

The following common species were recorded:

Mallees: *Eucalyptus pleurocarpa*, *Eucalyptus uncinata*

Tall shrubs: *Allocasuarina acutivalvis* subsp. *acutivalvis*, *Banksia laevigata* subsp. *laevigata*

Mid shrubs: *Dryandra cirsioides*, *Hakea cygna* subsp. *cygna*, *Hakea subsulcata*, *Melaleuca subtrigona*, *Petrophile seminuda*, *Verticordia inclusa*

Low shrubs: *Beaufortia schaueri*

Sedges: *Lepidosperma brunonianum*

Herbs: *Conostylis argentea*

Landform: Upper slopes and crests

Geology: Cemented ironstone gravel and laterite - Cz1 (10.8 ha); Metasediments - Pelitic metasediments - Alp (6.4 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (5.3 ha); Gravel plain - Czg (1.4 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (10.0 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (10.0 ha); Residual ferruginous duricrust forming ridges and capping - Rfi (2.6 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (1.4 ha)

Surface fragments: Common, medium pebbles to cobbles - granite

Soil: Hard light brown clay loam sandy; Soft yellow sandy loam

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2006 (11.8 ha)

This vegetation unit is dominated by *Allocasuarina acutivalvis*, an obligate seeder.

Notes: An open shrub community, often occurring on shallow soils over laterite caprock, *Alac* has close affinity to the *Eucalyptus falcata*/*E. pleurocarpa* complex and is often adjacent to a *Blae/Borb* unit. It forms mosaics with *Mham*.



Photo no: IMG_2167 Date: 26-Jul-07
Location: (L306) GDA94 E33.50180 S120.05450
Photographer: EM Sandiford

25. *Allocasuarina spinosissima* (Alsp)

Unit area: 8.7 ha **% Project area:** 0.15% **Sampling:** 6 polygons

Muir classification: Very Open Shrub Mallee, Open Scrub, Open Low Scrub, Open Dwarf Scrub C

The following common species were recorded:

Mallees: *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus pleurocarpa*

Tall shrubs: *Allocasuarina spinosissima*, *Hakea multilineata*, *Melaleuca hamata*, *Melaleuca thapsina*,
Leptospermum maxwellii

Mid shrubs: *Acacia fragilis*, *Calothamnus quadrifidus*, *Philotheca gardneri* subsp. *Ravensthorpe* (G.F. Craig 6902)

Low shrubs: *Darwinia inconspicua*

Sedges: *Lepidosperma brunonianum*

Landform: Simple slope

Geology: Pelitic metasediments - Alp (6.9 ha); Cemented ironstone gravel and laterite - Cz1 (1.3 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (5.4 ha); Colluvium, scree derived from different rock types on gentle slopes - C (2.5 ha);

Surface fragments: Common - weathered laterised small to medium pebbles

Soil: Firm red clay loam

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 1993 (0.2 ha)

Notes: *Alsp* has close affinity to the large, heterogeneous *Eucalyptus falcata*/*E. pleurocarpa* complex. It is typified by tall shrubs (where *Allocasuarina spinosissima* is a characteristic, but not necessarily the dominant species), scattered mallees and a sedge stratum.



Photo no: IMG4265 Date: 28-Jun-07
Photo direction: E
Location: (E264/G201/S15) GDA94 S33.46947 E119.98734
Photographer: J Newell

26. *Eucalyptus depauperata/ E. pileata/ Melaleuca species (Edep/Epil/Mspp)*

Unit area: 155.9 ha

% Project area: 2.6%

Sampling: 18 polygons

Muir classification: Tree Mallee, Scrub, Heath, Low Heath C, Dwarf Scrub D, Very Open Sedges

The following common species were recorded:

Mallet/Mallee: *Eucalyptus pileata*

Mallees: *Eucalyptus depauperata*, *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus phaenophylla* subsp. *phaenophylla*, *Eucalyptus scyphocalyx*

Tall shrubs: *Melaleuca cucullata*, *Melaleuca hamata*, *Melaleuca pauperiflora* subsp. *pauperiflora*, *Melaleuca eleuterostachya*, *Melaleuca lateriflora* subsp. *lateriflora*, *Melaleuca teuthidoides*, *Melaleuca torquata*, *Melaleuca undulata*

Mid shrubs: *Exocarpus aphyllus*, *Grevillea pectinata*, *Choretrum glomeratum* var. *glomeratum*, *Daviesia nematophylla*, *Hakea commutata*, *Hakea verrucosa*, *Melaleuca bracteosa*, *Melaleuca coroncarpa*, *Melaleuca glaberrima*, *Melaleuca societatis*, *Melaleuca* sp. Gorse (AS George 7224), *Microcorys glabra*

Low shrubs: *Acacia glaucoptera*, *Boronia inconspicua*, *Lasiopetalum compactum*

Dwarf shrubs: *Boronia inornata*, *Grevillea huegelii*, *Hibbertia psilocarpa*, *Pultenaea purpurea*, *Rinzia communis*, *Spyridium cordatum*

Sedges: *Gahnia ancistrophylla*, *Lepidosperma* sp. Ravensthorpe (GF Craig 5188)

Landform: Flat and gentle slopes

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (112.5 ha); Deep-weathered rock, kaolinized - Czo/Agb (36.9 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (124.0 ha); Residual, quartzofeldspathic sand commonly over granite rock - Rg (17.4 ha)

Surface fragments: Many to abundant weathered laterised and quartz small to large pebbles

Soil: Firm brown to red brown sandy clay loam to light clay

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2006 (2.4 ha); 2004 (8.8 ha); 2003 (25.4 ha); 1995 (37.3 ha); 1993 (63.2 ha); 1982 (5.15 ha)

Notes: *Edep/Epil/Mspp* is a heterogeneous mallee heath distinguished by *Eucalyptus depauperata* and/or *E. pileata* in the overstorey and a significant *Melaleuca* shrub stratum. It predominantly occurs in the north sector of the range, west of the Bonnymidgup Tracks on lower slopes and flats.

1. Chester formation
1.2. Colluvium & laterite – lower slopes & drainages



Photo no: P1000317 Date: 02-Aug-07
Photo direction: SE
Location: (A102d)
GDA94 S33.44462 E120.0235
Photographer: J Newell



Regeneration following the September 2006 burn.

Photo no: P1000295 Date: 02-Aug-07
Photo direction: S
Location: (A102/E463/L500)
GDA94 S33.44978 E120.02389
Photographer: J Newell

27. *Eucalyptus depauperata*/ *E. pileata* (Edep/Epil)

Unit area: 126.3 ha

% Project area: 2.1%

Sampling: 36 polygons

Muir classification: Tree Mallee, Open Scrub, Open Low Scrub

The following common species were recorded:

Mallets: *Eucalyptus pileata*

Mallees: *Eucalyptus calycogona* subsp. *calycogona*, *Eucalyptus depauperata*, *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus phaenophylla* subsp. *phaenophylla*

Tall shrubs: *Melaleuca acuminata* subsp. *acuminata*, *Melaleuca eleuterostachya*, *Melaleuca hamata*, *Melaleuca lateriflora* subsp. *lateriflora*

Mid shrubs: *Beyeria brevifolia* var. *brevifolia*, *Daviesia nematophylla*, *Dodonaea bursariifolia*, *Dodonaea concinna*, *Exocarpos aphyllus*, *Grevillea oligantha*, *Grevillea pectinata*, *Hakea lissocarpha*, *Hakea verrucosa*, *Melaleuca glaberrima*, *Melaleuca rigidifolia*, *Melaleuca societatis*, *Melaleuca* sp. *Gorse* (AS George 7224)

Dwarf shrubs: *Acacia erinacea*, *Boronia inornata*, *Cooperookia strophiolata*, *Pultenaea purpurea*, *Rinzia communis*

Sedges/sedge-like: *Gahnia ancistrophylla*, *Gahnia aristata*

Landform: Flat, lower slopes and drainage lines

Geology: Cemented ironstone gravel and laterite - Czl (33.4 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (20.2 ha); Deep-weathered rock, kaolinized - Czo/Agb (15.9 ha); Colluvium and minor alluvium - Qrt (14.5 ha); Ultramafic rock, altered - Ae (9.5 ha)

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (56.4 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (32.4 ha)

Surface fragments: Few granite small to large pebbles

Soil: Soft brown clayey sand

% Cover leaf litter: 10-30%

% Cover bare ground: >70%

Fire regime: 2006 (13.8 ha); 2004 (3.8 ha); 2003 (10.8 ha); 2002 (0.7 ha); 1993 (14.3 ha)

Notes: *Edep/Epil* is typified by tall mallee with a sparse shrub understorey and is common on the lower slopes and drainages of the Mt Short 'block'. It may form a mosaic with *Eunc/Espp*.



Photo no: DSCN4379 Date: 28-Jun-07
Photo direction: W
Location: (G158) GDA94 S33.48003 E119.98733
Photographer: GF Craig

28. *Eucalyptus sporadica* (Espo)

Unit area: 14.3 ha **% Project area:** 0.24% **Sampling:** 9 polygons

Muir classification: Tree Mallee, Thicket, Heath, Low Heath C

The following common species were recorded:

Mallees: *Eucalyptus falcata* subsp. *falcata*, *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus incrassata*, *Eucalyptus phenax* subsp. *phenax*, *Eucalyptus pluricaulis* ssp. *pluricaulis*, *Eucalyptus sporadica*

Tall shrubs: *Exocarpus sparteus*, *Hakea laurina*, *Melaleuca hamata*

Mid shrubs: *Acacia durabilis*, *Acacia fragilis*, *Acacia sulcata* var. *platyphylla*, *Calothamnus quadrifidus*, *Gastrolobium parviflorum* forma 'broad', *Grevillea anethifolia*, *Grevillea patentiloba* subsp. *platypoda*, *Phebalium tuberculatum*, *Rhadinothamnus rudis* subsp. *amblycarpus*, *Trymalium elachophyllum*

Low shrubs: *Dodonaea pinifolia*, *Lasiopetalum compactum*, *Platysace maxwellii*

Dwarf shrubs: *Marianthus mollis*

Grasses/herbs: *Cassytha melantha*

Sedges: *Lepidosperma* sp. *Ravensthorpe* (GF Craig 5188), *Lepidosperma* sp. GFC 8278

Landform: drainage lines

Geology: Cemented ironstone gravel and laterite - Czl (5.0 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (9.3 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (5.0 ha); Colluvium, ferruginous gravel and duricrust on proximal slopes - Cf (2.5 ha); Sheetwash, low gradient slope, sheet flood, distal slope - W (6.2 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 2000 (2.3 ha); 2004 (0.5 ha)

Many of the shrubs species, eg *Acacia*, *Hakea*, *Grevillea*, are obligate seeders.

Notes: *Espo* is generally a diverse, thicket community with an overstorey of mallees that include *Eucalyptus sporadica*. It is generally restricted to drainage lines.



Photo no: DSCN4414 Date: 19-Jul-07
Photo direction: N
Location: (G169a) GDA94 S33.52455 E120.08337
Photographer: GF Craig

29. *Eucalyptus indurata/ Melaleuca pauperiflora (Eind/Mpau)*

Unit area: 90.8 ha **% Project area:** 1.52% **Sampling:** 10 polygons

Muir classification: Open Shrub Mallee, Scrub, Heath, Open Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus brachycalyx*, *Eucalyptus flocktoniae* subsp. *flocktonia*, *Eucalyptus indurata*

Tall shrubs: *Melaleuca pauperiflora* subsp. *pauperiflora*

Mid shrubs: *Beyeria* sp. *A Ravensthorpe* (AS George 9474), *Exocarpos aphyllus*, *Grevillea oligantha*, *Hakea verrucosa*, *Melaleuca cliffortioides*, *Melaleuca* sp. *Gorse* (AS George 7224), *Pomaderris brevifolia*

Low shrubs: *Acacia diaphylloidea*, *Boronia inornata*

Dwarf shrubs: *Acacia ingrata*, *Daviesia anceps*

Landform: Low rise and slopes

Geology: Serpentinite - Au (52.3 ha); Metamorphosed sedimentary rock - As (29.0 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (8.8 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (72.5 ha)

Surface fragments: Common sedimentary and magnesite small pebbles to cobbles

Soil: Light brown loam

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2004 (30.6 ha); 1990 (1.6 ha); 1982 (8.8 ha); 1977 (2.9 ha)

Notes: *Eind/Mpau* is dominated by a *Melaleuca pauperiflora* shrub layer with an open *Eucalyptus indurata* overstorey. It is common on the pale, talc-like soils typical of the low rises towards the south end of Bonnymidgup Track.



Photo no: P1000199 Date: 08-May-07
Photo direction: E
Location: (A15a) GDA94 S33.52222 E120.09595
Photographer: J Newell

30. *Eucalyptus indurata* (Eind)

Unit area: 14.5 ha **% Project area:** 0.24% **Sampling:** 7 polygons

Muir classification: Open Shrub Mallee, Low Scrub, Open Dwarf C, Dwarf Scrub B

The following common species were recorded:

Mallees: *Eucalyptus brachycalyx*, *Eucalyptus incrassata*, *Eucalyptus indurata*, *Eucalyptus phenax* subsp. *phenax*, *Eucalyptus* sp. *Ravensthorpe* (A.S. George 616)

Tall shrubs: *Melaleuca hamata*, *Melaleuca pauperiflora* subsp. *pauperiflora*

Mid shrubs: *Choretrum glomeratum* var. *glomeratum*, *Daviesia benthamii*, *Grevillea oligantha*, *Hakea verrucosa*, *Hybanthus floribundus* subsp. *adpressus*, *Melaleuca cliffortioides*

Low shrubs: *Acacia diaphyllodinea*, *Boronia inornata*, *Platysace maxwellii*

Dwarf shrubs: *Acacia ingrata*, *Daviesia anceps*

Sedges: *Lepidosperma* spp. (unidentified)

Landform: Low rise and slopes

Geology: Serpentinite - Au (5.5 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (5.4 ha); Metamorphosed sedimentary rock - As (3.7 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (14.5 ha)

Surface fragments: Abundant sedimentary and magnesite small pebbles to cobbles

Soil: Light brown loam

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 1982 (0.6 ha); 2004 (0.6 ha)

Notes: *Eind* is a more open community than *Eind/Mpau* and is distinguished by the presence of *Eucalyptus indurata*, numerous shrub species and a sedge stratum.



Photo no: IMG4030 Date: 9-May-2007
Photo direction: S
Location: (A16c) GDA94 S33.52351 E120.09475
Photographer: AM Rick

31. *Eucalyptus flocktoniae*/ *Melaleuca* sp. Gorse (Eflo/Mgor)

Unit area: 19.2 ha **% Project area:** 0.32% **Sampling:** 10 polygons

Muir classification: Very Open Shrub Mallee, Heath, Open Dwarf Scrub C and D

The following common species were recorded:

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus indurata*, *Eucalyptus phenax* subsp. *phenax*

Tall shrubs: *Melaleuca eleuterostachya*, *Melaleuca pauperiflora* subsp. *pauperiflora*

Mid shrubs: *Melaleuca* sp. Gorse (A.S. George 7224), *Hakea commutata*, *Pomaderris brevifolia*

Dwarf shrubs: *Acacia ingrata*, *Acacia pusilla*, *Boronia inornata*

Herbs: *Cassytha melantha*

Landform: Mid slope

Geology: Metamorphosed sedimentary rock - As (8.0 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (7.9 ha); Serpentinite - Au (3.0 ha);

Geomorphology: Sheetwash, low gradient slope, sheet flood, distal slope - W (8.8 ha); Residual soil derived from ultramafic rock - Ru (8.8 ha)

Surface fragments: Many sedimentary medium pebbles to cobbles

Soil: Firm brown loam

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: 2006 (0.5 ha); 2004 (0.2 ha); 1999 (0.7 ha); 1993 (0.1 ha); 1982 (0.03 ha)

This vegetation unit is dominated by *Melaleuca* sp. Gorse, an obligate seeder. No regeneration of this species was observed after a strip of fire went through one area in October 1999.

Notes: Eflo/Mgor is dominated by *Melaleuca* sp. Gorse (A.S. George 7224) and has an open mallee overstorey. It can form a mosaic with Eflo/Ephe. It is usually restricted to 'komatiite' red-brown loams.



Photo no: P1000210 Date: 09-May-07
Photo direction: NW
Location: (G32) AGD66 S33.536294 E120.116892
Photographer: J Newell

32. *Eucalyptus oleosa* subsp. *corvina* (Eole)**Unit area:** 82.3 ha **% Project area:** 1.38% **Sampling:** 16 polygons**Muir classification:** Tree Mallee, Open Scrub, Open Low Scrub, Open Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus oleosa* subsp. *corvina*, *Eucalyptus myriadena* subsp. *myriadena***Tall shrubs:** *Melaleuca pauperiflora* subsp. *pauperiflora*, *Melaleuca acuminata* subsp. *acuminata*, *Melaleuca cucullata*, *Melaleuca lanceolata*, *Santalum acuminatum***Mid shrubs:** *Acacia sulcata* var. *platyphylla*, *Daviesia nematophylla*, *Dodonaea concinna*, *Exocarpus aphyllus*, *Hakea verrucosa*, *Olearia muelleri*, *Senna artemisioides* subsp. *x artemisioides***Low shrubs:** *Acacia lachnophylla*, *Boronia inornata***Dwarf shrubs:** *Acacia erinacea*, *Acacia glaucoptera* forma 'spreading', *Acacia ingrata*, *Pultenaea purpurea***Grasses/herbs:** *Austrostipa* sp. , *Sclerolaena diacantha***Landform:** Flat, drainage lines**Geology:** Serpentinite - Au (26.4 ha); Metamorphosed sedimentary rock - As (24.2 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (20.9 ha)**Geomorphology:** Sheetwash, low gradient slope, sheet flood, distal slope - W (30.1 ha); Residual soil derived from ultramafic rock - Ru (9.4 ha)**Surface fragments:** Very few weathered laterised small to large pebbles**Soil:** Firm red brown clay loam sandy**% Cover leaf litter:** 30-70% **% Cover bare ground:** 30-70%**Fire regime:** 2004 (6.3 ha); 2003 (1.8 ha); 1993 (0.3 ha); 1982 (0.2 ha); 1977 (0.7 ha)**Notes:** *Eole* is usually a mid-dense tall mallee community with an open shrub understorey; *Eucalyptus oleosa* subsp. *corvina* is often co-dominant with *Eucalyptus myriadena*. It prefers broad drainage lines and lower slopes where it grows in deep, red-brown loams.

Photo no: DSCN4327 Date: 19-Jun-07
 Photo direction: SSE
 Location: GDA94 S33.57365 E120.14151
 Photographer: GF Craig

33. *Eucalyptus oleosa subsp. corvina*/ *Melaleuca cucullata* (*Eole/Mcuc*)

Unit area: 17.6 ha **% Project area:** 0.30% **Sampling:** 3 polygons

Muir classification: Open Low Woodland, Very Open Tree Mallee, Scrub, Open Dwarf Scrub C and D

The following common species were recorded:

Mallets: *Eucalyptus cernua*, *Eucalyptus extensa*

Mallees: *Eucalyptus oleosa subsp. corvina*

Tall shrubs: *Melaleuca cucullata*, *Melaleuca hamata*, *Melaleuca pauperiflora subsp. pauperiflora*

Mid shrubs: *Dodonaea concinna*

Low shrubs: *Boronia inornata*, *Westringia rigida*

Dwarf shrubs: *Wilsonia humilis*

Landform: Flat

Geology: Quartz diorite - Agt (15.9 ha); Colluvium and minor alluvium - Qrt (1.7 ha)

Geomorphology: Residual, quartzofeldspathic sand commonly over granite rock - Rg (14.2 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (3.3 ha);

Surface fragments: Few granite medium pebbles to cobbles

Soil: Firm brown clay loam sandy

% Cover leaf litter: >30% **% Cover bare ground:** >30%

Fire regime: none

Notes: *Eole/Mcuc* is dominated by *Melaleuca cucullata* with an open *Eucalyptus oleosa subsp. corvina* overstorey. It has close affinity to the *Eole* unit, but appears to occur where there is a granite influence.



Photo no: P1000232 Date: 10-May-07
Photo direction: S
Location: (L94) WGS 84 S33.54323 E120.0786
Photographer: J Newell

34. *Eucalyptus oleosa subsp. corvina*/ *Melaleuca pauperiflora* (Eole/Mpau)

Unit area: 29.5 ha **% Project area:** 0.49% **Sampling:** 6 polygons

Muir classification: Open Tree Mallee, Scrub, Low Scrub, Open Dwarf Scrub D

The following common species were recorded:

Mallets: *Eucalyptus cernua*, *Eucalyptus extensa*

Mallees: *Eucalyptus oleosa subsp. corvina*, *Eucalyptus indurata*

Tall shrubs: *Melaleuca cucullata*, *Melaleuca pauperiflora subsp. pauperiflora*, *Melaleuca sp. Gorse* (A.S. George 7224)

Mid shrubs: *Dodonaea concinna*, *Exocarpos aphyllus*, *Senna artemisioides subsp. x artemisioides*

Low shrubs: *Boronia inornata*

Dwarf shrubs: *Acacia glaucoptera forma 'spreading'*, *Acacia ingrata*

Landform: Lower slopes and drainage lines

Geology: Serpentinite - Au (15.6 ha); Fine-grained mafic rock - Ab (9.9 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (3.4 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (28.0 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 1977 (10.5 ha); 1982 (1.5 ha); 1990 (0.01 ha); 2004 (5.2 ha)

Notes: *Eole/Mpau* is dominated by *Melaleuca pauperiflora* and has an open overstorey of *Eucalyptus oleosa subsp. corvina*. It has close affinity to the *Eole*, *Eole/Mcuc* and *Eind/Mpau* units.



Photo no: P1000258 Date: 10-May-07
Photo direction: W
Location: (L140b) WGS 84 S33.54211 E120.07888
Photographer: J Newell

35. *Eucalyptus proxima* (Epro)

Unit area: 12.5 ha **% Project area:** 0.21% **Sampling:** 5 polygons

Muir classification: Very Open Shrub Mallee, Heath, Open Dwarf Scrub D

The following common species were recorded:

Mallees: *Eucalyptus pleurocarpa*, *Eucalyptus proxima*, *Eucalyptus sp. Ravensthorpe* (A.S. George 616)

Tall shrubs: *Melaleuca hamata*, *Santalum acuminatum*

Mid shrubs: *Hakea verrucosa*, *Hybanthus floribundus subsp. adpressus*, *Melaleuca cliffortioides*, *Melaleuca sp. Gorse* (A.S. George 7224)

Low shrubs: *Cryptandra nutans*, *Dodonaea pinifolia*

Dwarf shrubs: *Acacia erinacea*, *Acacia ingrata*, *Daviesia anceps*

Grasses: *Neurachne alopecuroidea*

Landform: Lower, north-facing slopes

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (12.5 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (8.8 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (3.1 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 1982 (1.8 ha); 2000 (1.1 ha); 2004 (2.1 ha)

Notes: *Epro* is a heterogeneous, mallee heath community growing on the lower, north-east facing slopes between Carlingup Road and Mt Benson. It has affinities with *Acop* and *Mcli*.

No photo available.

36. *Melaleuca cliffortioides* (*Mcli*)

Unit area: 9.9 ha

% Project area: 0.17%

Sampling: 2 polygons

Muir classification: Very Open Shrub Mallee, Heath, Open Dwarf Scrub D, Very Open Sedges

The following common species were recorded:

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus phenax* subsp. *phenax*, *Eucalyptus proxima*, *Eucalyptus* sp. *Ravensthorpe* (A.S. George 616)

Tall shrubs: *Melaleuca pauperiflora* subsp. *pauperiflora*, *Santalum acuminatum*

Mid shrubs: *Acacia ophiolithica*, *Grevillea oligantha*, *Hakea verrucosa*, *Hybanthus floribundus* subsp. *adpressus*, *Kunzea cincinnata*, *Melaleuca cliffortioides*

Low shrubs: *Hibbertia pungens*, *Styphelia pulchella*

Dwarf shrubs: *Hibbertia gracilipes*, *Persoonia helix*

Sedges/sedge-like: *Gahnia ancistrophylla*, *Lepidosperma* spp. (unidentified)

Landform: Lower slopes & flat

Geology: Metamorphosed sedimentary rock - As (4.1 ha); Serpentinite - Au (3.0 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (8.4 ha)

Surface fragments: Common granite medium pebbles to stones

Soil: Surface crust light brown silty clay loam

% Cover leaf litter: >70%

% Cover bare ground: 10-30%

Fire regime: 2004 (3.5 ha); 1982 (1.6 ha)

Notes: *Mcli* is predominantly a heath community characterized by *Melaleuca cliffortioides*. It has affinity with the *Epro* and *Acop* units, and is usually found in small patches of rocky areas where there is a granite influence.



Photo no: P1000209 Date: 08-May-07
Photo direction: NE
Location: GDA94 S33.52138 E120.09291
Photographer: J Newell

37. *Acacia ophiolithica* (Acop)

Unit area: 6.2 ha **% Project area:** 0.1% **Sampling:** 2 polygons

Muir classification: Very Open Tree Mallee, Open Scrub, Heath, Dwarf Scrub D

The following common species were recorded:

Tall shrubs: *Melaleuca hamata*, *Santalum acuminatum*

Mid shrubs: *Acacia ophiolithica*, *Acacia sulcata* var. *platyphylla*, *Calothamnus quadrifidus*, *Grevillea oligantha*,
Hakea verrucosa, *Hybanthus floribundus* subsp. *adpressus*, *Leucopogon cuneifolius*, *Philotheca gardneri*
subsp. *Ravensthorpe* (GF Craig 6902)

Low shrubs: *Dodonaea pinifolia*, *Platysace maxwellii*

Landform: Lower slopes

Geology: Ultramafic/ Serpentinite-Au (3.6 ha); Sandstone, quartzite, phyllite, chert-Metamorphosed sedimentary rock - As (2.6 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (4.7 ha)

Surface fragments: not recorded

Soil: Red-brown loams associated with komatiite

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 1982 (2.1 ha); 2004 (2.4 ha)

This vegetation unit is dominated by *Acacia ophiolithica*, an obligate seeder.

Notes: A heath community with no emergent mallees, *Acop* is generally found in narrow bands running parallel to drainage lines and upslope of *Eole* or *Ecer* units. It has affinity to the *Epro* and *Mcli* units.

Acop equates with the Priority One Threatened Ecological Community of “heath on komatiite” originally recorded on Bandalup Hill.

No photo available.

38. *Allocasuarina hystricosa* (Alscba)

Unit area: 1.2 ha

% Project area: 0.02%

Sampling: 1 polygon

Muir classification: Open Scrub, Heath, Open Dwarf Scrub D

The following species were common:

Tall shrubs: *Allocasuarina hystricosa*

Mid shrubs: *Hakea verrucosa*, *Melaleuca cliffortioides*

Low shrubs: *Dodonaea pinifolia*, *Platysace maxwellii*

Landform: Mid- and lower slopes and hilltops

Geology: Pelitic metasediments - Alp (1.2 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (1.2 ha)

Surface fragments: not recorded

Soil: Orange, red or brown loam with limestone or granite outcropping

% Cover leaf litter: not recorded

% Cover bare ground: not recorded

Fire regime: No fires recorded.

This vegetation unit is dominated by *Allocasuarina hystricosa*, an obligate seeder.

Notes: *Allocasuarina hystricosa* was originally referred to as *Allocasuarina scleroclada* sp. *Bandalup* (G Cockerton 7773). It usually forms a monotypic, tall shrubland and is associated with calcareous soils.



Photo no: IMG_2209 Date: 28-Jun-07
Location: (L425) WGS84 S33.46327 E119.99775
Photographer: EM Sandiford

39. *Allocasuarina scleroclada* (*Alsc*)

Unit area: 4.4 ha **% Project area:** 0.07% **Sampling:** 6 polygons

Muir classification: Scrub, Heath, Dwarf Scrub C, Open Sedges

The following species were common:

Mallees: *Eucalyptus depauperata*, *Eucalyptus phaenophylla* subsp. *phaenophylla*

Tall shrubs: *Allocasuarina scleroclada*, *Melaleuca hamata*

Mid shrubs: *Acacia sulcata* var. *platyphylla*, *Calothamnus quadrifidus*, *Hakea verrucosa*, *Hybanthus floribundus* subsp. *adpressus*, *Kunzea strigosa*

Dwarf shrubs: *Rinzia communis*

Landform: Flat; slopes

Bedrock: Pelitic metasediments - Alp (2.4 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (1.4 ha)

Geomorphology: Colluvium, scree derived from different rock types on gentle slopes - C (2.6 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (1.0 ha)

Surface fragments: Very rocky granite outcrops with many small pebbles to cobbles of granite and quartz

Soil: Firm brown silty clay loam

% Cover leaf litter: 10-30% **% Cover bare ground:** >70%

Fire regime: 2006 (2.2 ha); 2002 (0.3 ha); 2003 (0.2 ha)

Notes: This unit may be more closely associated with granites (cf. ultramafics). Further mapping of the Ravensthorpe Range should give a clearer indication of where *Alsc* typically lies in the landscape.



Photo no: DSCN6598 Date: 9_MAY_07
Photo direction: SW
Location: (E47) GDA94 S33.52787 E120.10139
Photographer: EJ Hickman

40. *Allocasuarina campestris* (Alca)

Unit area: 22.3 ha **% Project area:** 0.4% **Sampling:** 8 polygons

Muir classification: Scrub, Heath, Open Dwarf Scrub C and D, Very Open Sedges, Open Grasses

The following common species were recorded:

Tall shrubs: *Allocasuarina campestris*, *Leptospermum maxwellii*, *Melaleuca hamata*, *Santalum acuminatum*

Mid shrubs: *Calothamnus quadrifidus*, *Hakea verrucosa*, *Kunzea cincinnata*, *Melaleuca rigidifolia*, *Petrophile seminuda*

Low shrubs: *Dodonaea pinifolia*, *Platysace maxwellii*

Sedges/sedge-like: *Lepidosperma brunonianum*

Grasses: *Spartochloa scirpoidea*, *Neurachne alopecuroidea*

Landform: Flat, slopes, granite outcrops

Geology: Metamorphosed sedimentary rock - As (11.2 ha); Quartz diorite - Agt (9.7 ha)

Geomorphology: Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (6.8 ha); Residual, quartzofeldspathic sand commonly over granite rock - Rg (2.2 ha)

Surface fragments: Very abundant, medium to large pebble, weathered laterised

Soil: Hard setting - light red brown clay loam sandy

% Cover leaf litter: 30-70% **% Cover bare ground:** >70%

Fire regime: 1982 (0.1 ha); 2004 (0.1 ha)

Notes: *Alca* is a shrub community dominated by *Allocasuarina campestris* usually associated with outcrops of granite. It forms mosaics with *Mham* and *Eplu/Esug/Mspp* units.



Photo no: DSCN6614 Date: 9_MAY_07
Photo direction: SW
Location: (E67A) GDA94 S33.52905 E120.1066
Photographer: EJ Hickman

41. *Allocasuarina huegeliana* (Alhu)

Unit area: 10.9 ha **% Project area:** 0.2% **Sampling:** 1 polygon

Muir classification: Scrub, Dwarf Scrub C and D, Open Sedges and Grasses

The following species were common:

Mallees: *Eucalyptus flocktoniae* subsp. *flocktoniae*, *Eucalyptus phaenophylla* subsp. *phaenophylla*, *Eucalyptus pluricaulis* subsp. *pluricaulis*, *Eucalyptus uncinata*

Tall shrubs: *Allocasuarina huegeliana*

Mid shrubs: *Calothamnus quadrifidus*, *Gastrolobium parviflorum* forma 'broad', *Hakea verrucosa*, *Hovea acanthoclada*

Low shrubs: *Chamelaucium ciliatum*, *Dodonaea pinifolia*, *Thomasia foliosa*

Sedges: *Gahnia ancistrophylla*

Landform: Low ridges; lower slopes and open depressions

Geology: Metamorphosed sedimentary rock - As (9.4 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (1.1 ha)

Geomorphology: Colluvium, ferruginous gravel and duricrust on proximal slopes - Cf(0.8 ha)

Surface fragments: Granite rockland with very abundant granite medium pebbles to stones

Soil: Soft red clay loamy sand

% Cover leaf litter: 30-70% **% Cover bare ground:** 30-70%

Fire regime: none

Notes: *Alhu* is usually a tall shrub community dominated by *Allocasuarina huegeliana* and is associated with outcrops of granite.



Photo no: IMGP4208 Date: 26-Jun-07
Photo direction: S
Location: (E188) GDA94 S33.50559 E120.03362
Photographer: J Newell

42. *Eucalyptus pluricaulis/ E. suggrandis/ Melaleuca species (Eplu/Esug/Mspp)*

Unit area: 13.1 ha **% Project area:** 0.22% **Sampling:** 5 polygons

Muir classification: Open Shrub Mallee, Open Scrub, Heath, Open Dwarf Scrub C, Very Open Sedges

The following common species were recorded:

Mallees: *Eucalyptus pluricaulis subsp. pluricaulis, Eucalyptus suggrandis subsp. suggrandis*

Tall shrubs: *Melaleuca hamata*

Mid shrubs: *Calothamnus quadrifidus, Melaleuca glaberrima, Melaleuca lateriflora subsp. lateriflora, Acacia sulcata var. platyphylla, Melaleuca rigidifolia*

Low shrubs: *Baeckea corynophylla, Dodonaea pinifolia*

Sedges/sedge-like: *Gahnia ancistrophylla*

Grasses/herbs: *Neurachne alopecuroidea*

Landform: Simple lower slope and flat

Geology: Quartz diorite - Agt (10.4 ha); Colluvium and minor alluvium - Qrt (1.9 ha)

Geomorphology: Residual, quartzofeldspathic sand commonly over granite rock - Rg (7.2 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (5.0 ha)

Surface fragments: Many granite medium pebbles to cobbles

Soil: Surface crust light brown clay loam sandy

% Cover leaf litter: <70% **% Cover bare ground:** <30%

Fire regime: none

Notes: This unit is restricted to granites, largely on the lower, southern slopes of Mt Benson. It has close affinities to the *Mallee/Mspp* unit in the same area and has been mapped as a mosaic with *Mallee/Mspp*, *Mham* and *Alca*.

North of Mt Short, the understorey species in an *Edep/Epil* unit, in the upper reaches of a creekline, are similar to those recorded here.



Photo no: P1000237 Date: 10-May-07
Photo direction: W
Location: (L97)
WGS 84 S33.54599 E120.07866
Photographer: J Newell

43. *Eucalyptus platypus* (Epla)**Unit area:** 102.2 ha**% Project area:** 1.71%**Sampling:** 19 polygons**Muir classification:** Dense Low Forest

The following common species were recorded:

Mallets: *Eucalyptus clivicola*, *Eucalyptus platypus***Mallees:** *Eucalyptus depauperata*, *Eucalyptus flocktoniae* subsp. *flocktoniae***Tall shrubs:** *Melaleuca cucullata*, *Melaleuca eleuterostachya*, *Melaleuca pauperiflora* subsp. *pauperiflora*, *Melaleuca torquata*, *Melaleuca undulata***Mid shrubs:** *Daviesia nematophylla*, *Exocarpus aphyllus*, *Hakea commutata*, *Hakea verrucosa*, *Melaleuca* sp. Gorse (A.S. George 7224)**Dwarf shrubs:** *Grevillea huegelii***Landform:** Lower slopes and flat**Geology:** Deep-weathered rock, kaolinized over granite - Czo/Agb (43.4 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (24.1 ha); Cemented ironstone gravel and laterite - Czl (13.2 ha)**Geomorphology:** Sheetwash, low gradient slope, sheet flood, distal slope - W (51.4 ha); Residual, quartzofeldspathic sand commonly over granite rock - Rg (28.4 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (8.3 ha)**Surface fragments:** not recorded**Soil:** Red-brown loamy clay**% Cover leaf litter:** not recorded**% Cover bare ground:** not recorded**Fire regime:** 1982 (0.6 ha); 1993 (30.2 ha); 1995 (4.2 ha); 2001 (0.05 ha); 2003 (0.1 ha); 2004 (19.5 ha); 2006 (3.5 ha)This vegetation unit is dominated by *Eucalyptus platypus*, an obligate seeder.**Notes:** Generally, *Epla* is a monotypic unit with few, if any, understorey species. In creeklines near the Bonnymidgup Cutoff track, *Eucalyptus platypus* and *E. clivicola* grow together. *Epla* has close affinity with the *Epla/Mcuc* unit.

Photo no: DSCN4511 Date: 21-Aug-07
 Photo direction: S
 Location: Bonnymidgup Track
 GDA94 S33.47629 E120.04568
 Photographer: GF Craig

44. *Eucalyptus platypus/ Melaleuca cucullata (Epla/Mcuc)***Unit area:** 14.4 ha **% Project area:** 0.24% **Sampling:** 5 polygons**Muir classification:** Dense Low Forest, Very Open Shrub Mallee, Scrub, Open Low Scrub

The following common species were recorded:

Mallets: *Eucalyptus platypus***Tall shrubs:** *Melaleuca cucullata, Melaleuca undulata***Sedges/sedge-like:** *Gahnia aristata***Landform:** Lower slopes and flats**Geology:** Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (5.9 ha); Deep-weathered rock, kaolinized over granite - Czo/Agb (3.5 ha); Colluvium and minor alluvium - Qc (2.6 ha); Cemented ironstone gravel and laterite - Cz1 (2.4 ha);**Geomorphology:** Sheetwash, low gradient slope, sheet flood, distal slope - W (12.4 ha)**Surface fragments:** not recorded**Soil:** not recorded**% Cover leaf litter:** not recorded **% Cover bare ground:** not recorded**Fire regime:** 2006 (3.6 ha)This vegetation unit is characterised by the obligate seeders *Eucalyptus platypus*, *Melaleuca cucullata* and *M. undulata*.**Notes:** This unit is characterized by a dense low forest of *Eucalyptus platypus* with a shrub layer dominated by *Melaleuca cucullata* and/or *M. undulata*. It has close affinity to the *Epla* unit.

Photo no: IMG_2194 Date: 27-Jun-07
 Location: (L366) WGS84 S33.5026 E120.0646
 Photographer: EM Sandiford

Burnt September 2006. Obligate seeders - Eucalyptus platypus and Melaleuca species- have not reappeared.

Photo no: DSCN4361 Date: 26-Jun-07
 Photo direction: SE
 Location: (G123) GDA94 S33.47868 E120.04544
 Photographer: GF Craig

45. *Eucalyptus dielsii* (Edie)**Unit area:** 49.4 ha **% Project area:** 0.8% **Sampling:** 6 polygons**Muir classification:** Low Forest, Open Low Scrub, Open Dwarf Scrub

The following common species were recorded:

Mallets: *Eucalyptus dielsii*, *Eucalyptus extensa***Mallees:** *Eucalyptus oleosa* subsp. *corvina***Tall shrubs:** *Melaleuca cucullata*, *Melaleuca teuthidoides*, *Melaleuca pauperiflora* subsp. *pauperiflora***Mid shrubs:** *Exocarpos aphyllus***Landform:** Flat and gentle slopes**Geology:** Deep-weathered rock, kaolinized over granite - Czo/Agb (30.9 ha); Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (12.5 ha); Granite - Agb (6.0 ha)**Geomorphology:** Sheetwash, low gradient slope, sheet flood, distal slope - W (35.4 ha); Residual, quartzofeldspathic sand commonly over granite rock - Rg (14.0 ha)**Surface fragments:** Few weathered laterised and quartz small to large pebbles**Soil:** Cracking brown light clay**% Cover leaf litter:** 30-70% **% Cover bare ground:** 30-70%**Fire regime:** 2004 (4.4 ha); 2003 (2.9 ha); 1993 (37.3 ha)

This vegetation unit is characterised by *Eucalyptus dielsii*, which has both a mallee and mallet habit. It was found that after the 1993 fire, most of the regeneration west of Bonnymidgup Track was from seedlings. This suggests that the mallet form (obligate seeder) probably dominates in the Ravensthorpe Range.

Notes: *Edie* is a low forest dominated by *Eucalyptus salubris* with a sparse shrub understorey of *Melaleuca* species. It is restricted to the north-east sector of the project area and has close affinity to the *Esab* unit.



Photo no: P1000275 Date: 1-Aug-07
 Photo direction: S
 Location: (A99) GDA94 S33.44462 E120.0278
 Photographer: J Newell



Regeneration following the 1993 wildfire.

Photo no: DSCN4488 Date: 21-Aug-07
 Photo direction: W
 Location: (G203) GDA94 S33.46449 E120.03707
 Photographer: GF Craig

46. *Eucalyptus salubris* (Esab)**Unit area:** 4.9 ha**% Project area:** 0.08%**Sampling:** 2 polygons**Muir classification:** Low Forest, Open Scrub, Open Low Scrub, Open Dwarf Scrub D

The following common species were recorded:

Mallets: *Eucalyptus salubris*, *Eucalyptus dielsii***Tall shrubs:** *Melaleuca cucullata*, *Melaleuca teuthidoides*, *Melaleuca undulata***Mid shrubs:** *Exocarpos aphyllus*, *Hakea commutata*, *Olearia muelleri***Landform:** Flat**Geology:** Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (2.9 ha); Colluvium and minor alluvium - Agb (1.1 ha)**Geomorphology:** Sheetwash, low gradient slope, sheet flood, distal slope - W (2.4 ha)**Surface fragments:** none**Soil:** Firm red brown silty clay loam**% Cover leaf litter:** >70% **% Cover bare ground:** >70%**Fire regime:** 2003 (0.09 ha)This vegetation unit is characterised by *Eucalyptus salubris* and *Melaleuca* species, that are obligate seeders.**Notes:** *Esab* forms low forests with a sparse shrub understorey dominated by *Melaleuca* species. It is restricted to the north-east sector of the project area and has close affinity to the *Edie* unit.

Photo no: P1000319 Date: 02-Aug-07
 Photo direction: NE
 Location: (A100/L496) GDA94 S33.44574 E120.02423
 Photographer: J Newell

47. *Acacia acuminata* (Acac)

Unit area: 3.5 ha

% Project area: 0.06%

Sampling: 1 polygon

Muir classification: Open Low Woodland, Thicket, Very Open Sedges, Very Open Grass

The following common species were recorded:

Trees: *Eucalyptus occidentalis*

Tall shrubs: *Acacia acuminata*

Sedges/sedge-like: *Gahnia ancistrophylla*

Grasses/herbs: *Spartochloa scirpoidea*

Landform: Flat, adjacent to drainage line

Geology: Drainage/ Alluvium of mature drainage - Qpv (2.0 ha); Fine-grained mafic rock - Ab (1.5 ha)

Geomorphology: not available

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded

% Cover bare ground: not recorded

Fire regime: none

Notes: *Acac* occurs as a low, open woodland with a sedge/grass understorey in the south-west sector of the project area, near the confluence of Jerdacuttup River and Cordingup Creek.



Photo no: DSCN4420 Date: 27-Jul-07
Photo direction: E
Location: (T72) GDA94 E33.5808 S120.16035
Photographer: GF Craig

48. *Eucalyptus occidentalis* (Eocc)

Unit area: 15.9 ha **% Project area:** 0.27% **Sampling:** 3 polygons

Muir classification: Open Low Woodland, Scrub, Heath, Open Dwarf Scrub C and D, Open Sedges, Very Open Grasses

The following common species were recorded:

Trees: *Eucalyptus occidentalis*

Tall shrubs: *Dodonaea ptarmicaefolia*, *Melaleuca acuminata* subsp. *acuminata*, *Melaleuca cuticularis*, *Santalum acuminatum*, *Templetonia retusa*

Mid shrubs: *Grevillea anethifolia*, *Rhagodia crassifolia*, *Trymalium elachophyllum*

Sedges: *Gahnia trifida*

Grasses/herbs: *Spartochloa scirpoidea*

Landform: Drainage line

Geology: Fine-grained mafic rock - Ab (7.6 ha); Qpv (7.9 ha)

Geomorphology: not available

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: none

Notes: *Eocc* is restricted to the Jerdacuttup River and the lower reaches of Carlingup Creek where scrub, sedges and grasses grow with an overstorey of scattered *Eucalyptus occidentalis*. It has close affinity with the *Macu* and *Mcut* units.

No photo available.

49. *Melaleuca cuticularis* (Mcut)

Unit area: 0.9 ha **% Project area:** 0.02% **Sampling:** 1 polygon

Muir classification: Scrub

The following common species were recorded:

Tall shrubs: *Melaleuca cuticularis*, *Callistemon phoeniceus*

Landform: drainage line

Geology: Quartz diorite - Agt (0.8 ha)

Geomorphology: Residual, quartzofeldspathic sand commonly over granite rock - Rg (0.9 ha)

Notes: This was a distinctive scrub community, recorded only once on the lower, southern slopes of Mt Benson. It has close affinity to the *Eucalyptus occidentalis* unit.

No photo available.

50. creekline with mixed shrubs (ck_shrub)

Unit area: 3.0 ha **% Project area:** 0.05% **Sampling:** 4 polygons

Muir classification: Thicket, Heath, Open Sedges

The following common species were recorded:

Tall shrubs: *Dodonaea ptarmicaefolia*, *Melaleuca acuminata* subsp. *acuminata*, *Melaleuca elliptica*, *Acacia harveyi*, *Callistemon phoeniceus*, *Melaleuca eleuterostachya*

Mid shrubs: *Acacia sulcata* var. *platyphylla*, *Hakea verrucosa*, *Senna artemisioides* subsp. *x artemisioides*

Low shrubs: *Phyllanthus calycinus*

Grasses/herbs: *Spartochloa scirpoidea*

Landform: drainage line

Geology: Colluvium of deeply eroded surfaces; contains rock fragments and minor outcrops - Qrg (2.2 ha); Quartz diorite - Agt (0.6 ha)

Geomorphology: Residual soil derived from ultramafic rock - Ru (1.8 ha); Residual, deep red rock unconsolidated soil overlying mafic rock - Rm (0.6 ha)

Surface fragments: not recorded

Soil: not recorded

% Cover leaf litter: not recorded **% Cover bare ground:** not recorded

Fire regime: 1982 (0.3 ha); 2004 (0.3 ha)

Notes: This unit of dense shrubs and sedges occurs on the lower, southern slopes of Mt Benson on creeklines where granite is exposed.



Photo no: creek Date: 10-May-07
Location: Block south of Mt Benson
Photographer: J Newell

Discussion

Fifty vegetation units have been described for the northern sector of the Ravensthorpe Range. The large heterogeneous *Eucalyptus falcata*/*E. pleurocarpa* complex was mapped as one vegetation unit and a number of plant associations were identified and mapped within it; these units have high plant diversity and many proteaceous species. Combined, they accounted for 58% of the project area and were closely associated with colluvium and laterites in the Chester formation.

Also within the Chester formation, crests showed three low forest communities (10% of project area) dominated by the mallets *Eucalyptus gardneri* subsp. *ravensthorpensis*, *E. clivicola* or *E. megacornuta*. Slopes had seven different mallee, mallee-heath, or dense thicket units (10% of project area), while lower slopes and drainages had three units (5% of project area).

The 11 vegetation units associated with the Bandalup Ultramafics occupied a relatively small area (3%), although were usually distinctive. The small size of some of the units meant that it was difficult to assign them to a 'characteristic' habitat, and may eventually be assigned to another geological formation/ soil type as more of the Ravensthorpe Range is mapped.

Areas of the range influenced by granite close to the surface had either shrublands of *Allocasuarina* or mallee-heath with *Eucalyptus suggrandis* and *E. pluricaulis* being common, while deep kaolinized soils over granite (3%) had four units dominated by the mallets *Eucalyptus platypus*, *E. dielsii* or *E. salubris*.

Field work

Although areas of approximately 400 m width were generally a suitable spacing for survey, botanists found that they were not confident in determining what the vegetation type was beyond their restricted field of view. Ideally, extra time could have been spent in the field, ground-truthing areas that were later identified as 'different' during preparation of the map. Instead, these areas were interpreted using of stereo-pairs of aerial photos.

Assigning each of the vegetation units a 'shape number' caused much confusion and heart-ache! Amalgamating 'shape numbers' within polygons and consequent reviewing of databases took an inordinate amount of time. As well, it became difficult to determine what was a full complement of species for a polygon, or merely a representative list, because as a botanist tended to become familiar with a particular vegetation type, fewer species were recorded, consequently a 'shape number' did not necessarily represent the diversity of a polygon.

In consequence, it was found that *relevées*, ie plotless quadrats, of the most common species are a preferred method for collection of species data (cf. a continuum) with GPS position taken. If species composition appears to vary within the same unit further along the traverse, then another *relevée/s* should be recorded. The preferred methodology is provided in greater detail below.

Data analysis

Although example spreadsheets had been given to input data, everyone at some stage or other, included different information than was required or failed to include information that was required. It therefore took far longer than anticipated to get all the datasets into a coherent format. This problem was exacerbated as by the time the collation of data for this report was in progress, three consultants and the technical officer were working on other projects and/or were on leave. Prior to field work a minimum dataset for each *relevée* should be defined (see below).



Plate 3. Libby Sandiford explains the intricacies of vegetation mapping to Sarah Barrett (left) and Sarah Comer (right)

As the field work progressed, the botanists' concept of a particular vegetation association tended to change and some of the vegetation units blurred the more one surveyed, especially on the lower slopes, eg what was clearly an *Eucalyptus uncinata*/*E. incrassata* association at the southern end of the project area, had become a variable combination of *E. uncinata*/*E. phaenophylla*/*E. leptocalyx*/*E. scyphocalyx*/*E. incrassata* towards Mt Short. Numerical analysis of vegetation data using PRIMER® and PATTERN® assisted with defining the vegetation units, although it did not change the botanists' overall concept for a unit, rather it tended to show where a few associations should be amalgamated instead of being kept as individual units.

Imagery

The 1:10 000 scale orthophotos were excellent for use in the field, but were too small to overlay the vegetation boundaries and annotate the polygons; 1: 5 000 scale was preferred for map preparation.

The orthophotos were generally good for interpreting the complete boundary of each vegetation unit, although boundaries between some of the mallee – heath communities, and those in the valleys were difficult to define. The low resolution imagery for the Mt Short area was appalling, and very difficult to interpret. As well, a fire over a large area in September 2006 (Fig.7) had made ground-truthing difficult.

The Quickbird satellite imagery was excellent for interpreting particular units, eg the *Eucalyptus clivicola* and *E. salmonophloia* woodlands were obvious, and for clarification of some boundaries. Unfortunately it did not extend as far north as the Mt Short area.

The 1987 set of aerial photographs (stereo pairs) was sourced after the first field trip, and the 2007 set after the second field trip; these would have been useful prior to the survey. One botanist preferred to use this imagery and would have liked to have aerial photos available at 1:10 000, as it would have made the interpretation work quicker and in some cases more accurate where the resolution of the orthophotos was of poor quality.

Generally, a combination of the 1987 and 2007 stereo pairs of aerial photos were useful to define the most difficult boundaries. They were used almost exclusively to determine the boundaries in the area Mt Short to Floater Road, where the orthophoto resolution was poor and no satellite imagery was available. The 1987 set was especially needed for areas burnt during the September 2006 fire, as the 2007 set was taken after the burn.

The geology and geomorphology maps were not useful for vegetation mapping, rather they were used to interpret the preferred habitat of a vegetation unit and assist in creating the unit descriptions. A digitized version of Witt's (1997) 'Interpreted geology and mineralization of Ravensthorpe and Cocanarup' map would have been preferred for interpretation of the vegetation units with respect to geology.

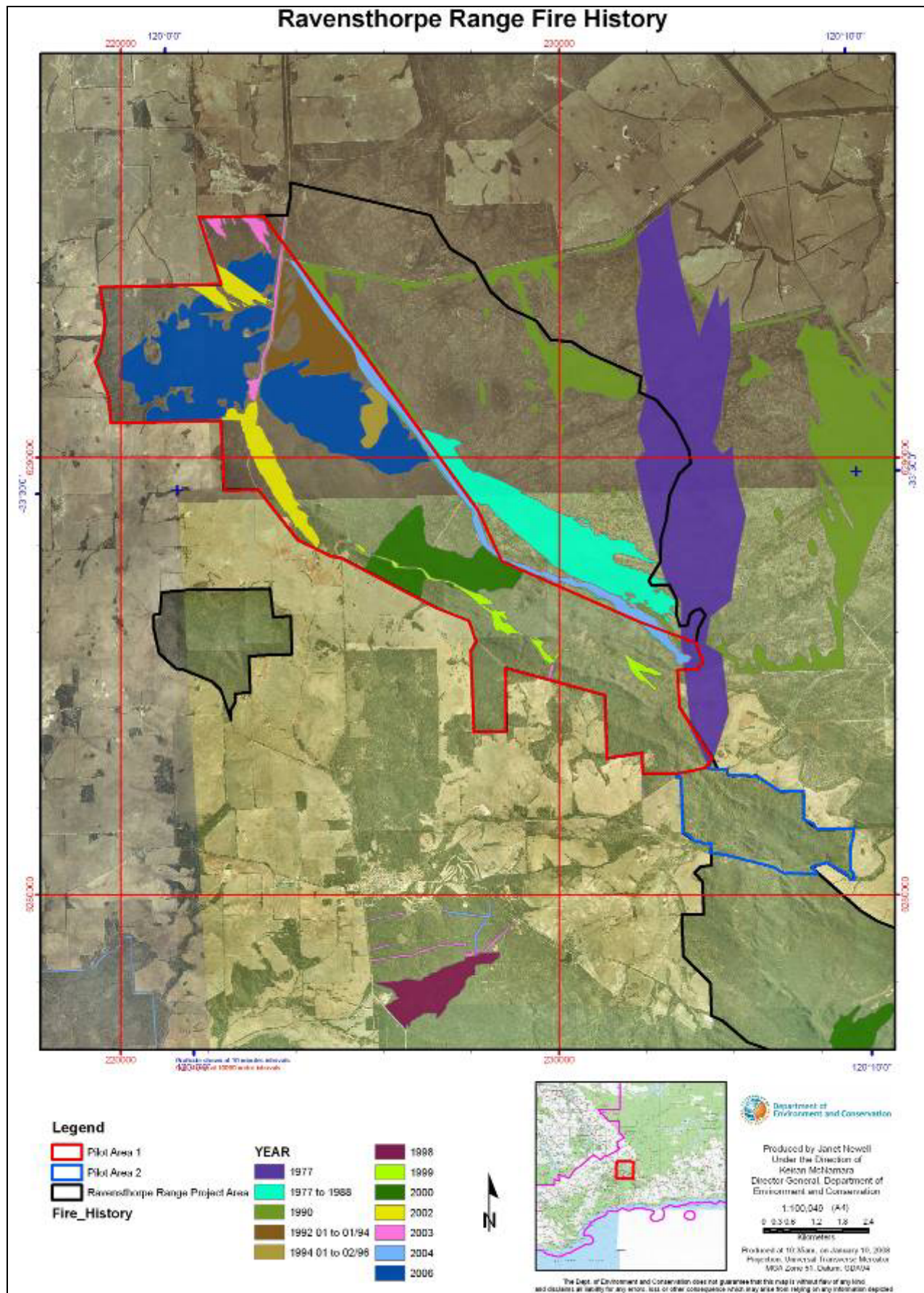


Figure 7. Fire history of the Ravensthorpe Range project area

Digitizing

The irregularity of the size of the plastic overlays provided to the digitizer caused unnecessary problems. Phil Tasker ended up photocopying all the overlays to A3 size to make an effective set of 'tiles'. It would have been preferable for the orthophotos DEC provided to have an index of tiles prepared at 2 km x 2.5 km (for 1: 5000 scale) and hard copies printed based on that index. The plastic overlays would then be prepared as a standard sheet size (A2) and edge-matching would be a minor problem compared to irregular sheets.

The whole of the project area should have been mapped and finalised before being digitized, as many of the vegetation unit names changed as the botanists familiarized themselves with the variation in plant associations as they moved across the landscape.

Linking of datasets

With the assistance of Deon Utber (DEC Albany), a number of datasets were generated that summarized information on the geology, geomorphology and fire history of each vegetation unit. The linking of datasets into a report form that could be used to generate the 'hard copy' description of each vegetation unit however, proved to be an onerous/difficult task that could not be achieved within the project's timeframe. It would be desirable for this task to be pursued, as it could eventually save much time in summarizing data, particularly as the number of vegetation units is likely to increase as mapping of the vegetation of the Ravensthorpe Range progresses.

Recommendations

Methodology

The preferred methodology for carrying out future vegetation mapping projects is outlined below.

Field work

The basic field equipment should include, besides personal safety needs:

- orthophotos printed at 1:10 000 scale
- GPS using Geocentric Datum Australia 94 (GDA94)
- digital camera taking images of at least 4 MegaPixels
- UHF radio
- CDMA/ NextG mobile phone

Botanists with at least two years experience in South Coast vegetation communities are preferred, as the complexity of the vegetation and number of endemic flora in the Ravensthorpe Range would make this a difficult project for inexperienced personnel. The provision of a Technical Officer is desirable to undertake printing of maps, taking of photographs and collection of site data (landform, rocks, soils) and other technical responsibilities.

Prior to field work, desktop investigation of the orthophotos and 1:25 000 stereo aerial photos is desirable to determine distinctive areas to be ground-truthed. In the Ravensthorpe Range, mapping areas 400 m wide over the range provides a good basis for design of field work. Within a particular area, however, if communities become consistent on a particular landform, eg *Eucalyptus falcata* communities on upper slopes, then field survey should concentrate on more complicated areas.

Data collection

Boundaries between vegetation units are marked with a GPS waypoint. Boundaries are based on changes in species composition, rather than vegetation structure.

Across a 5 km² area, at least five *relevées*, ie plotless quadrats, should be recorded for each type of vegetation unit, and repeated where the 'type' of community is unclear. The *relevées* should measure 10 m x

10 m for the shrub (< 2 m) and sedge/herb layers and 20 m x 20 m for the tall shrub (>2 m)/mallee/tree layer. If an individual vegetation unit extends for more than 200 m, another *relevée*/s should be recorded, particularly if there is a change in species composition. Data to record includes:

- *relevée* number
- GPS waypoint
- dominant and common/ characteristic plant species
- life form of the species
- vegetation structure based on the Muir classification
- landform, broad soil type (sand, clay or loam) and soil colour
- photo and compass bearing of photo
- date

Relevées should be recorded until the botanist is confident that they are familiar with each type of vegetation unit and that there is enough data for statistical analysis. Occasionally, one is uncertain what type of vegetation type they are in, so a *relevée* should be taken to determine where it fits in the overall complex.

Analysis of data

GPS waypoint and track data should be electronically downloaded to a mapping program, eg OziExplorer® or ArcMap®. Tracks are saved as .plt files and waypoints as both .wpt and .txt files (UTM/UPS and hddd.dddd°), the latter allows importing of data in Excel® spreadsheets.

Plant species and the *relevée* number are recorded in a MAX V3 data table, a software program developed by DEC's Western Australian herbarium which links datasets to the Census of Western Australian Plants master list. A 'supplement table' is made for species which are not identified in the WACensus.

Separate Microsoft® Office Excel or Access spreadsheets should be made for each data type, as linkage of datasets is easier when there is restricted data in each spreadsheet. Suggested spreadsheets are:

- *relevée* number/ vegetation unit
- *relevée* number/ GPS location
- *relevée* number/ landform, rock, surface fragment and soil data
- *relevée* number / Muir classification
- *relevée* number / photograph number, photographer, direction
- taxon 'NameID' / species/ life form

The *relevée* number is common to all datasets and can be used to link them in Access® and to the final digitized vegetation map.

Numerical analysis of vegetation data (*relevée*) using hierarchical agglomerative cluster techniques, eg PRIMER®, PATN® or PATTERN®, is recommended to assist with vegetation classification.

Map production

High resolution orthophotos at 1:5 000 scale and printed as an index of tiles (2.5 km x 2 km area on A2 sheet size) provide the base maps. Satellite imagery at 1:5 000 and stereo pairs of aerial photos (1: 25 000) assist with field and final mapping.

GPS waypoints of vegetation boundaries are overlaid on the base maps with botanists marking boundaries of vegetation units on plastic overlays ready for digitising. Proofing of maps can be assisted by linking the *relevée* number/ vegetation unit data to the map.

All mapping should be finalized by the botanists before sending to be digitized.

Digitized maps can be proofed at 1:10 000 scale. Final maps are provided as shapefiles for compatibility with ArcMap.

Linking of datasets

Using ArcMap, other digital maps can be overlaid on the vegetation map and used to provide a greater understanding of the area being surveyed, eg geology and fire regimes. The areas are calculated for each vegetation unit in relation to the various attributes in the overlaid maps. The data from the various databases is imported into the report form and then formatted to provide a summary for each vegetation unit.

Although it wasn't achieved in this pilot project, it is desirable for all datasets to be linked in Access® and a report form developed to summarise the data for the hard copy report.

Future mapping

It is highly recommended that mapping of the vegetation of the Ravensthorpe Range and eventually the whole Ravensthorpe System continue. A number of mining companies have already mapped sections of the Ravensthorpe System and it is desirable that their maps are integrated into one vegetation map available to all stakeholders. Only when the whole System is mapped will it be possible to put each vegetation unit in context within the local and greater region.

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Appendix 1. Maps and imagery used in the survey

Digital orthophotos (1:100 000 sheet area):

Ravensthorpe – March 2002 – high resolution

Moolyall – January 2004 – medium resolution, dark exposure

King – March 2003 – low resolution, dark exposure (Mt Short area, very poor quality)

Digital multispectral satellite imagery (Quickbird):

Ravensthorpe – (south of GDA94 UTM 6291000 mS, excludes Mt Short, north Floater Rd and north Bonnymidgup track areas) - 2007 (courtesy Pioneer Nickel Pty Ltd)

Stereo-pairs of aerial photos:

Ravensthorpe 1:25 000 – 18/8/1987 (Aerial Surveys Australia) [pre-fires]

Ravensthorpe 1:25 000 – 8/1/2007 (Landgate) [post-fires]

Moolyall 1:25 000 – 14/1/2004 (DLI) [pre/post-fires]

Other maps that were used to some extent at some time during the project:

Geology – Ravensthorpe 1:100 000 (Witt 1997, 1998)

Interpreted geology and mineralization of the Ravensthorpe Region (Witt 1998)

Geomorphology - (Traka Resources NL, unpublished map, 2007)

Vegetation – Ravensthorpe 1:250 000 (Beard 1973)

Fire history – northern Ravensthorpe Range (DEC Ravensthorpe, unpub)

Appendix 2. Muir's (1977) Vegetation Classification and vegetation unit summary

The classification was modified in this project by combining the 'Shrubs 1-1.5 m' and 'Shrubs 1.5 – 2 m' into a single layer, ie Shrubs 1-2 m.

| LIFE FORM/ HEIGHT CLASS | | CANOPY COVER | | | |
|-------------------------|-------------------|---------------------|-------------------------|-------------------|------------------------|
| | | DENSE 70-100% | MID-DENSE 30-70% | SPARSE 10-30% | VERY SPARSE 2-10% |
| T | Trees >30m | Dense Tall Forest | Tall Forest | Tall Woodland | Open Tall Woodland |
| M | Trees 15-30m | Dense Forest | Forest | Woodland | Open Woodland |
| LA | Trees 5-15m | Dense Low Forest A | Low Forest A | Low Woodland A | Open Low Woodland A |
| LB | Trees <5m | Dense Low Forest B | Low Forest B | Low Woodland B | Open Low Woodland B |
| KT | Mallee tree form | Dense Tree Mallee | Tree Mallee | Open Tree Mallee | Very Open Tree Mallee |
| KS | Mallee shrub form | Dense Shrub Mallee | Shrub Mallee | Open Shrub Mallee | Very Open Shrub Mallee |
| S | Shrubs >2m | Dense Thicket | Thicket | Scrub | Open Scrub |
| SA | Shrubs 1.5-2m | Dense Heath A | Heath A | Low Scrub A | Open Low Scrub A |
| SB | Shrubs 1-1.5m | Dense Heath B | Heath B | Low Scrub B | Open Low Scrub B |
| SC | Shrubs 0.5-1m | Dense Low Heath C | Low Heath C | Dwarf Scrub C | Open Dwarf Scrub C |
| SD | Shrubs <0.5m | Dense Low Heath D | Low Heath D | Dwarf Scrub D | Open Dwarf Scrub D |
| P | Mat plants | Dense Mat Plants | Mat Plants | Open Mat Plants | Very Open Mat Plants |
| H | Hummock grass | Dense Hummock Grass | Mid-Dense Hummock Grass | Hummock Grass | Open Hummock Grass |
| GT | Bunch grass >0.5m | Dense Tall Grass | Tall Grass | Open Tall Grass | Very Open Tall Grass |
| GL | Bunch grass <0.5m | Dense Low Grass | Low Grass | Open Low Grass | Very Open Low Grass |
| J | Herbaceous spp. | Dense Herbs | Herbs | Open Herbs | Very Open Herbs |
| VT | Sedges >0.5m | Dense Tall Sedges | Tall Sedges | Open Tall Sedges | Very Open Tall Sedges |
| VL | Sedges <0.5m | Dense Low Sedges | Low Sedges | Open Low Sedges | Very Open Low Sedges |
| X | Ferns | Dense Ferns | Ferns | Open Ferns | Very Open Ferns |
| | Mosses, liverwort | Dense Mosses | Mosses | Open Mosses | Very Open Mosses |

| VEGETATION UNIT | TREES/ MALLETS >5 m | TALL MALLEE >5m | SHRUB MALLEE <5m | SHRUBS >2m | SHRUBS 1-2m | SHRUBS 0.5-1m | SHRUBS 0-0.5m | SEDGE | RUSH | GRASS |
|-----------------|------------------------|--------------------|---------------------|---------------|----------------|------------------|------------------|-------|------|-------|
| Acac | V | | | M | | | | V | | V |
| Acop | | V | | V | M | | S | | | |
| Alac | | | L | S | S | S | S | S | | S |
| Alca | | | | S | M | V | V | V | | S |
| Alhu | | | | S | | S | S | S | | S |
| Alsc | | L | L | S | M | S | V | S | | |
| Alscba | | | | V | M | | V | | | |
| Alsp | | | V | V | V | V | L | S | | |
| Blae/Borb | | L | V | M | M | M | V | I | | |
| ck/shrub | | | | M | M | | | S | | |
| Dcir | | L | L | L | M | M | M | L | | |
| Dfol | | | S | | | M | M | V | | |
| Ecer | M | | | I | V | V | V | | | |
| Ecer/Macu | M | | | M | | | | | | |
| Ecli | M | | | V | V | | V | I | | |
| Ecli/Macu | M | | | M | | | V | | | |
| Edep/Epil | | M | | V | V | I | V | I | | |
| Edep/Epil/Mspp | | M | | S | M | M | V | V | | |
| Edie | M | | | | S | | S | | | |
| Eext | M | | | M | S | | V | | | |
| Efal | | | M | M | S | M | I | I | | |
| Efal/Alca | | | S | M | M | M | V | I | | I |
| Efal/Eple | | | S | S | M | M | V | I | | |
| Eflo/Ephe | | M | | V | S | V | V | I | | |
| Eflo/Mcuc | | | V | M | V | | V | | | |
| Eflo/Mgor | | | V | | M | V | V | | | |
| Egar | M | | | I | V | V | V | | | |
| Eind | | | S | | S | V | S | I | | |
| Eind/Mpau | | | S | S | M | | V | | | |
| Emeg | M | | | I | S | V | V | I | | |
| Eocc | V | | | S | M | V | V | S | | V |
| Eole | | M | | V | V | I | V | | | I |
| Eole/Mcuc | V | V | | S | | V | V | | | |
| Eole/Mpau | | S | | S | S | I | V | | | |
| Epla | M/D | | | | I | I | | | | |
| Epla/Mcuc | M/D | | V | S | V | | | I | | |
| Eplu/Esug/Mspp | | | S | V | M | V | I | V | | I |
| Epro | | | V | | M | M | V | I | | I |
| Esab | M | | | V | V | | V | | | |
| Esal | S | I | | V | I | V | V | I | | I |
| Espo | | M | | M | M | M | I | I | | |
| Eunc/Bmed | | | S | V | M | M | V | I | | |
| Eunc/Espp | | | M/S | V | M | S | V | V | | |
| Macu | | | | M | S | S | I | I | | I |
| Mallee/Mspp | | | S | V | M | S | V | V | | I |
| Mallee/Mund | | | V | I | M | | V | V | | |
| Mcli | | | V | | M | | V | V | | |
| Mcut | | | | S | | | | | | |
| Mell | | | | D | | | V | | | |
| Mham | | | I | M/D | M | M | S | I | | |
| Mtha | | | I | M/D | I | V | V | I | | |

Appendix 3. Landform, rock, surface fragment and soil attributes

(after McDonald RC et al. *Australian Soil and Land Survey: Field Handbook*)

LANDFORM ELEMENT (40m across)

| | | | | |
|---------------------------|---------------------|---|-------------------------------|----|
| Morphological type | | | | 13 |
| C | <i>Crest</i> | F | <i>Flat</i> | |
| U | <i>Upper slope</i> | V | <i>Open depression (vale)</i> | |
| M | <i>Mid slope</i> | D | <i>Closed depression</i> | |
| L | <i>Lower slope</i> | H | <i>Hillock</i> | |
| S | <i>Simple slope</i> | R | <i>Ridge</i> | |

ROCK OUTCROP

TYPE

| | | | | |
|------------------|----------------------------|--------|--|-----|
| Abundance | | | | 101 |
| 0 | <i>No bedrock exposed</i> | | | |
| 1 | <i>Very slightly rocky</i> | <2% | | |
| 2 | <i>Slightly rocky</i> | 2-10% | | |
| 3 | <i>Rocky</i> | 10-20% | | |
| 4 | <i>Very rocky</i> | 20-50% | | |
| 5 | <i>Rockland</i> | >50% | | |

COARSE FRAGMENTS ON THE SURFACE

TYPE

| | | | | |
|------------------|---------------------------------|---------|---|----|
| Abundance | | | | 97 |
| 0 | <i>No coarse fragments</i> | | 0 | |
| 1 | <i>Very slightly; very few</i> | <2% | | |
| 2 | <i>Slightly; few</i> | 2%-10% | | |
| 3 | <i>No qualifier; common</i> | 10%-20% | | |
| 4 | <i>Moderately; many</i> | 20%-50% | | |
| 5 | <i>Very; abundant</i> | 50%-90% | | |
| 6 | <i>Extremely; very abundant</i> | >90% | | |

| | | | | |
|-------------|--|------------|--|----|
| Size | | | | 99 |
| 1 | <i>Fine gravelly; small pebbles</i> | 2-6 mm | | |
| 2 | <i>Medium gravelly; medium pebbles</i> | 6-20 mm | | |
| 3 | <i>Coarse gravelly; large pebbles</i> | 20-60 mm | | |
| 4 | <i>Cobbly; or cobbles</i> | 60-200 mm | | |
| 5 | <i>Stony; stones</i> | 200-600 mm | | |
| 6 | <i>Bouldery; or boulders</i> | 600 mm-2 m | | |
| 7 | <i>Large boulders</i> | >2m | | |

| | | | | |
|--------------|---------------------------|----|---------------------------|----|
| Shape | | | | 99 |
| A | <i>Angular</i> | S | <i>Subangular</i> | |
| U | <i>Subrounded</i> | R | <i>Rounded</i> | |
| AT | <i>Angular tabular</i> | ST | <i>Subangular tabular</i> | |
| UT | <i>Subrounded tabular</i> | RT | <i>Rounded tabular</i> | |
| AP | <i>Angular platy</i> | SP | <i>Subangular platy</i> | |
| UP | <i>Subrounded platy</i> | RP | <i>Rounded platy</i> | |

MUIR CLASSIFICATION

| | | |
|-------------------------------|--------------------|--------|
| Crown cover percentage | | |
| D | <i>Dense</i> | >70% |
| M | <i>Mid-dense</i> | 30-70% |
| S | <i>Sparse</i> | 10-30% |
| V | <i>Very sparse</i> | <10% |

SOIL

COLOUR

| | |
|----------------------------|--------------------------|
| Field Texture (118) | |
| S | <i>Sand</i> |
| LS | <i>Loamy sand</i> |
| CS | <i>Clayey sand</i> |
| SL | <i>Sandy loam</i> |
| L | <i>Loam</i> |
| ZL | <i>Silty loam</i> |
| SCL | <i>Sandy clay loam</i> |
| CL | <i>Clay loam</i> |
| CLS | <i>Clay loam sandy</i> |
| ZCL | <i>Silty clay loam</i> |
| LC | <i>Light clay</i> |
| LMC | <i>Light medium clay</i> |
| MC | <i>Medium clay</i> |
| MHC | <i>Medium heavy clay</i> |
| HC | <i>Heavy clay</i> |

% Cover Leaf Litter
 % Cover Bare Ground (including litter, rock cover and bare soil, excluding live vegetation)

Cover Classes

| | |
|---|------------------------|
| D | >70% |
| M | 30-70% |
| S | 10-30% |
| V | <10% |
| I | <i>Isolated plants</i> |
| L | <i>Isolated clumps</i> |

FIRE REGIME

| | |
|-------------------|------------------|
| YEAR BURNT | |
| 0 | <i>pre-1977</i> |
| 1 | <i>1977-1989</i> |
| 2 | <i>1990-1996</i> |
| 3 | <i>1996-1999</i> |
| 4 | <i>2000</i> |
| 5 | <i>2001</i> |
| 6 | <i>2002</i> |
| 7 | <i>2003</i> |
| 8 | <i>2004</i> |
| 9 | <i>2005</i> |
| 10 | <i>2006</i> |

GEOMORPHOLOGY (after Hocking et al 2001)

- A *Clay, sand, silt and gravel in channels and on flood plains*
- C *Colluvium, scree derived from different rock types on gentle slopes*
- Cf *Ferruginous gravel and duricrust on proximal slopes*
- W *Low gradient slope, sheet flood, distal slope*
- Rfi *Ferruginous duricrust forming ridges and capping*
- Rg *Quartzofeldspathic sand commonly over granitic rock*
- Rm *Residual deep red unconsolidated soil overlying mafic rock*
- Ru *Soil derived from ultramafic rock*
- X *Weathered rock with thin layer of skeletal soil on steep slope*

Appendix 4. Example of spreadsheets for landform, rock, surface fragment and soil attributes

| VEGUNIT ID | SHAPE_NO | Wpt_No | COLLECTOR | SURVEY_DATE | Morphology | | | | | | | | | Aspect | Code | Rock Outcrop | | Coarse fragments at surface | | | |
|------------|--------------|------------|-----------|-------------|------------|---|---|---|---|---|---|---|---|--------|------|--------------|--|-----------------------------|---------|-----------------------------------|---|
| | | | | | C | U | M | L | S | F | V | D | H | | | R | Type | Abundance | Type | Abundance | |
| Alac | L100 | L013 | JN | 10-May-07 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | | | 0 | N | granite pink | 3 |
| Alac | G202 | SB015 | JN | 28-Jun-07 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | | | | 0 | | | 0 |
| Alca | L128 | L068 | JN | 10-May-07 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | | | 0 | R | weathered laterised | 5 |
| Alhu | E188 | E013 | JN | 26-Jun-07 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | | | granite | 5 | | granite | 4 |
| Alhu | E188 | E014 | JN | 26-Jun-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | | | granite | 5 | | granite | 4 |
| Alsc | A121 | A038 | JN | 2-Aug-07 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | N | granite | 4 | N, R | granite + quartz | 4 |
| Alsp | xxxxx | SB013 | JN | 28-Jun-07 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | | | | 0 | R | weathered laterised | 3 |
| Blae/Borb | G12 | G12 | JN | 8-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 160 | F | ultramafic | 1 | F, A | ultramafic | 4 |
| Blae/Borb | G30 | G30 | JN | 9-May-07 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | H | sedimentary | 2 | H | sedimentary | 4 |
| Blae/Borb | E192 | E019 | JN | 26-Jun-07 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 260 | | sedimentary | 3 | | sedimentary | 3 |
| Blae/Borb | E204 | E034 | JN | 26-Jun-07 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 200 | | | 0 | | weathered laterised | 6 |
| Dcir | xxxxx | E023 | JN | 26-Jun-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | | weathered laterised | 1 | | weathered laterised | 4 |
| Dcir | S2/L539/L535 | SB003 | JN | 29-Jun-07 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | | | 0 | E | weathered laterised + quartz | 2 |
| Dcir | S2/L539/L535 | SB005 | JN | 29-Jun-07 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | | | | 0 | E | weathered laterised + quartz | 2 |
| Dcir | S14 | SB013 | JN | 29-Jun-07 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | | | | 0 | | weathered laterised | 5 |
| Ecer | G23 | G23 | JN | 9-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | | | | 0 | H | sedimentary | 4 |
| Ecer | E114 | E3 | JN | 11-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | | | 0 | C | weathered laterised | 3 |
| Ecli | A66 | G4 | JN | 07-May-07 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | B, C | Sedimentary and weathered laterised and quartz | 1 | B, C, D | sedimentary + weathered laterised | 5 |
| Ecli | A66 | G6 | JN | 07-May-07 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | C | weathered laterised gosen? | 4 | C, D | sedimentary + weathered laterised | 4 |
| Ecli | A11 | AR WPT 016 | JN | 8-May-07 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | 0 | A, D | sedimentary + quartz | 5 |
| Ecli | A11 | AR WPT 017 | JN | 8-May-07 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | A | sedimentary + quartz | 5 | A | sedimentary + quartz | 5 |
| Ecli | A78/E119/G66 | E4 | JN | 11-May-07 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | C | weathered laterised | 1 | C, D | sedimentary + weathered laterised | 4 |
| Ecli | A78/E119/G66 | E6 | JN | 11-May-07 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200 | C, T | weathered laterised | 3 | C, T | weathered laterised | 4 |
| Ecli | A78/E119/G66 | E7 | JN | 11-May-07 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 180 | | | 0 | U, D | sedimentary + weathered laterised | 4 |
| Ecli | A78/E119/G66 | E8 | JN | 11-May-07 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 180 | B, C | sedimentary + weathered laterised | 4 | C | weathered laterised | 6 |

| VEGUNIT_ID | SHAPE_NO | Course fragment size | | | | | | | fragment shape | | | | Soil Colour | Soil Texture | | | | | | | | | | | | | | |
|------------|--------------|----------------------|---|---|---|---|---|---|----------------|---|---|---|-----------------|--------------|----|----|----|---|----|-----|----|-----|-----|----|-----|----|-----|----|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | A | R | T | P | | S | LS | CS | SL | L | ZL | SCL | CL | CLS | ZCL | LC | LMC | MC | MHC | HC |
| Alac | L100 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | light brown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alac | G202 | | | | | | | | | | | | yellow | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alca | L128 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | light red brown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alhu | E188 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | red | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alhu | E188 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | red | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alsc | A121 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | brown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alsp | xxxxx | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | red | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Blae/Borb | G12 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | red brown | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Blae/Borb | G30 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | red | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Blae/Borb | E192 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | red brown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Blae/Borb | E204 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | yellow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dcir | xxxxx | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | yellow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dcir | S2/L539/L535 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | yellow | | 1 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dcir | S2/L539/L535 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | yellow | | 1 | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dcir | S14 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | red brown | | | | | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecer | G23 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | brown | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecer | E114 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | brown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A66 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | brown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A66 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | brown | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A11 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | brown | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A11 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | red brown | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A78/E119/G66 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | red brown | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A78/E119/G66 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | yellow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A78/E119/G66 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | brown | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecli | A78/E119/G66 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | red brown | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| VEGUNIT_ID | SHAPE_NO | VEGUNIT_ID | Soil surface | | | | | | | %Leaf_Litter | %Bare_Ground | |
|------------|--------------|------------|--------------|---|---|---|---|---|---|--------------|--------------|---|
| | | | G | M | L | S | F | H | C | | | X |
| Alac | L100 | Alac | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | M | M |
| Alac | G202 | Alac | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | | |
| Alca | L128 | Alca | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | M | D |
| Alhu | E188 | Alhu | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | M | M |
| Alhu | E188 | Alhu | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | M | M |
| Alsc | A121 | Alsc | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | S | D |
| Alsp | xxxxx | Alsp | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | | |
| Blae/Borb | G12 | Blae/Borb | | | | | | | | | V | M |
| Blae/Borb | G30 | Blae/Borb | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | D | M |
| Blae/Borb | E192 | Blae/Borb | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | M | M |
| Blae/Borb | E204 | Blae/Borb | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | M | M |
| Dcir | xxxxx | Dcir | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | S | D |
| Dcir | S2/L539/L535 | Dcir | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | M | D |
| Dcir | S2/L539/L535 | Dcir | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Dcir | S14 | Dcir | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | S | S |
| Ecer | G23 | Ecer | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | D | M |
| Ecer | E114 | Ecer | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | D | D |
| Ecli | A66 | Ecli | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | M | M |
| Ecli | A66 | Ecli | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | D | D |
| Ecli | A11 | Ecli | | | | | | | | | M | D |
| Ecli | A11 | Ecli | | | | | | | | | M | M |
| Ecli | A78/E119/G66 | Ecli | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | D | D |
| Ecli | A78/E119/G66 | Ecli | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | M | M |
| Ecli | A78/E119/G66 | Ecli | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | D | D |
| Ecli | A78/E119/G66 | Ecli | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | S | M |

Appendix 5. Example of spreadsheet for photographs

| Hardcopy report? | VEGUNIT_I D | SHAPE_NO | PHOTO_NO | COLLECTOR R | SURVEY_DATE | DIRECTION | WPT_NO | DATUM | deci latitude | deci longitude | GEOCODE _METHOD | Comments |
|------------------|----------------|----------|----------|----------------|-------------|-----------|--------|--------|---------------|----------------|--------------------|----------|
| y | Acac | T72 | DSCN4420 | GFC | 27-Jul-07 | E | 15 | GDA94 | -33.5808 | 120.16035 | GPS | |
| y | Alac | L306 | IMG_2167 | EMS | 26-Jun-07 | | 59 | WGS84 | 33.50180 | 120.05450 | GPS | |
| | Alac | | DSCN4350 | GFC | 26-Jun-07 | SW | 22 | GDA94 | -33.485 | 120.03574 | GPS | burnt |
| | Alac | G187 | DSCN4442 | GFC | 02-AUG-07 | W | 11 | GDA94 | -33.46681 | 119.99189 | GPS | |
| | Alac | G202a | DSCN4465 | GFC | 02-AUG-07 | N | 53 | GDA94 | -33.46879 | 119.98928 | GPS | |
| | Alac | | DSCN4466 | GFC | 02-AUG-07 | N | 53 | GDA94 | -33.46879 | 119.98928 | GPS | |
| | Alac | | DSCN4467 | GFC | 02-AUG-07 | N | 53 | GDA94 | -33.46879 | 119.98928 | GPS | |
| | Alac | G202b | DSCN4468 | GFC | 02-AUG-07 | SSE | 57 | GDA94 | -33.46901 | 119.98684 | GPS | |
| | Alac | E270 | DSCN6759 | EJH | 28_JUN_07 | NE | 15 | GDA94 | -33.47212 | 119.98584 | GPS | |
| | Alac | E270 | DSCN6760 | EJH | 28_JUN_07 | NW | 17 | GDA94 | -33.47229 | 119.98669 | GPS | |
| | Alac | G202 | IMG4262 | JN, SB | 28-Jun-07 | S | 14 | GDA94 | -33.46963 | 119.98681 | GPS | |
| | Alac | L100 | P1000239 | JN, EMS | 10-May-07 | S | 013 | WGS 84 | 33.54727 | 120.07866 | GPS | |
| y | Alca | G96 | DSCN4325 | GFC | 19-Jun-07 | E | 23 | GDA94 | -33.57207 | 120.13671 | GPS | |
| y | Alca | E067A | DSCN6614 | EJH | 9_MAY_07 | SW | 84 | GDA94 | -33.52905 | 120.1066 | GPS | |
| | Alca | * | DSCN4323 | GFC | 19-Jun-07 | E | 20 | GDA94 | -33.57146 | 120.13486 | GPS | |
| | Alca | * | DSCN4324 | GFC | 19-Jun-07 | E | 20 | GDA94 | -33.57146 | 120.13486 | GPS | |
| | Alca | E068 | DSCN6615 | EJH | 9_MAY_07 | SE | 84 | GDA94 | -33.52905 | 120.1066 | GPS | |
| | Alca | L128 | P1000253 | JN, EMS | 10-May-07 | E | 068 | WGS 84 | 33.5411 | 120.07223 | GPS | |
| | Alca | L130 | P1000255 | JN, EMS | 10-May-07 | E | 070 | WGS 84 | 33.54121 | 120.07311 | GPS | |
| y | Alhu | E188 | IMG4207 | JN, EJH | 26-Jun-07 | W | 13 | GDA94 | -33.50559 | 120.03362 | GPS | |
| | Alhu | E188 | IMG4208 | JN, EJH | 26-Jun-07 | S | 13 | GDA94 | -33.50559 | 120.03362 | GPS | |
| y | Alsc | E047 | DSCN6598 | EJH | 9_MAY_07 | SW | 60 | GDA94 | -33.52787 | 120.10139 | GPS | |
| | Alsc | G142 | DSCN4374 | GFC | 27-Jun-07 | SW | 60 | GDA94 | -33.4992 | 120.02217 | GPS | |
| | Alsc | G189 | DSCN4443 | GFC | 02-AUG-07 | SE | 15 | GDA94 | -33.46593 | 119.99369 | GPS | |
| | Alsc | G189 | DSCN4444 | GFC | 02-AUG-07 | SSW | 15 | GDA94 | -33.46593 | 119.99369 | GPS | |
| | Alsc | E047 | DSCN6599 | EJH | 9_MAY_07 | SW | 60 | GDA94 | -33.52787 | 120.10139 | GPS | |

Appendix 6. Cross tabulation of species presence and % occurrence in sampling sites for each vegetation unit

[digital version - please refer to file '**Appendix 6.doc**']

