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A
report on
the flora and
vegetation of areas at
Wilbinga and Breton Bay
proposed as alternatives for a
future industrial site

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1.0 INTRODUCTION

The purpose of this report is to document the flora and vegetation of two areas on the coastline north of Perth that are being considered as alternative sites for a proposed industrial area and based on this documentation to assess their conservation value for flora and vegetation. Because of the relationship of the flora and vegetation to the landforms some comment is also made on their value for conservation.

1.1 Location

The two areas lie between the northern part of the Perth metropolitan area and Lancelin, a small fishing town about 100 km north of Fremantle. Both have proposed core and buffer areas. The southern-most is the Wilbinga study area and the northern-most is the Breton Bay study area. The Wilbinga study area starts about 2.5 km north of Two Rocks, just to the north of the metropolitan area. It extends inland to Wanneroo Road and ends 3 km south of Guilderton. The core of the Wilbinga study area comes to the coast for just under half of the coastline of the entire study area and extends about halfway to Wanneroo Road, the remainder of the study area being the proposed buffer area. The Breton Bay study area starts about 1 km north of Seabird and ends about 4.5 km south of Ledge Point, extending inland to Brockway Road. The core area of the Breton Bay study area comes to the coast for two-thirds of the length of the coastline in the study area and extends inland to Lancelin Road.

1.2 Climate

The Wilbinga area is only some 50 km north from Fremantle and a similar distance from Perth and the climate is essentially similar to these locations, particularly Fremantle. That is a Mediterranean climate with a hot dry summer and reliable winter rainfall. However, there is a significant drop in rainfall along the coast north of Fremantle and Perth, which lie between the 30 and 35 inch isohyets on the rainfall map while Wilbinga lies between the 25 and 30 inch isohyets and receives approximately 5 inches less rainfall a year (Comm. Bureau Met. 1962). Another

feature of the climate of the area is the strong south-westerly sea breezes that blow on many days in summer. These not only make the summer more pleasant but, are important for their ability to cause blowouts of the dunes if the vegetation cover is disturbed. The climate of Breton Bay is also essentially similar to that of Fremantle except that being further north than Wilbinga the average annual rainfall is lower again.

1.3 Geology and soils

The study area lies on the Swan Coastal Plain and contains two major geological types. These are the Quindalup Dunes (= Safety Bay Sand) and the Spearwood dunes (= Tamala limestone). The former can be divided into dunes of various ages, often with different topography and the latter into areas with "limestone" at or very close to the surface and areas with deeper sand. There are also swales between the Quindalup dunes which can have soil of the same type, or can have siliceous sand or limestone representing the Spearwood system (see below). Moderately detailed mapping of the soil/geomorphic units is available for the Wilbinga study area (McArthur and Bartle 1980a) with less detail available for the Breton Bay study area (Gozzard 1985).

The Quindalup dunes, which abut the coastline in the study areas, are composed largely of calcareous sand formed from the remains of calcareous algae, foraminifers and molluscs with some rounded quartz material (Lowry 1974). They have been subdivided into four ages with the oldest referred to as Q1 dunes and the youngest (which are still forming in places) as Q4 dunes, the intermediate age dunes are referred to Q3 and Q2 depending on their age (McArthur and Bartle 1980a, 1980b). The Quindalup dunes form a narrow to moderately broad but, discontinuous, strip from the Bunbury area to north of Lancelin. The breaks in this strip are sometimes quite large and the development along the strip is not uniform. Some areas have only more recent dunes, others have older dunes next to the beach and no younger dunes and others have partial or well developed sequences. The Q1 and Q2 dunes tend to be well developed parabolic dunes, the Q3 dunes to be rather irregular (possibly being in places remobilised Q2 dunes with some additional sand material)

while the Q4 dunes tend to be a narrow strip of one or two dunes parallel to the coast but, also include areas of recent (but small compared to the Q1 and Q2 dunes) parabolic dunes and stabilised blowouts.

Predating the Quindalup dunes are the Spearwood dunes, the other geologic component of the study area. These have been subjected to prolonged weathering, resulting in a profile with siliceous sand at the surface underlain by a cap rock consisting of kankar (sandy accretionary limestone formed in the soil) and indurated and recrystallised eolianite. The cap rock is 1 to 3 m thick and grades down into softer, bedded eolianite. In many areas the siliceous sand has been removed by erosion, resulting in a variety of ecological situations from exposed cap rock to shallow sand over cap rock to deep sand with the latter usually on the east of the exposed cap rock (Lowry 1974). While in situ change within the Spearwood dunes has resulted in the development of a hard cap rock, similar processes have only resulted in weak lithification of some of the older Quindalup dunes (Lowry 1974), presumably because of their younger age. (Note: In the rest of this report the cap rock of the Spearwood dunes is referred to as limestone.)

The Quindalup dunes have transgressed over the earlier Spearwood dunes so that generally the surface expression of these is on the inland side of the Quindalup dunes, but they are also often exposed in swales within the older Quindalup dunes (particularly areas of cap rock but also areas of sand) and it is not unusual for Q2 or Q1 age Quindalup Dunes to occur well inland in areas that otherwise have the Spearwood dunes at the surface. In some places the border between the two ages of sand is fairly straight, in others it is quite irregular.

1.3.1 Development of the geological types in the study areas

The Wilbinga study area has an irregular strip of Q4 (the youngest) age Quindalup dunes at the back of the beach along its entire coastline. Behind this strip there are varying widths of Q3, Q2 and Q1 age dunes. In the centre of the Wilbinga study area coastline (i.e. in the core area) the width of Quindalup dunes is quite narrow due to the presence of a large area of exposed limestone (caprock) of the Spearwood dune

system which the Quindalup dunes have skirted to the north and south. To the south and north of this limestone area the Quindalup dunes extend inland for at least five kilometres, with well developed parabolic dunes of Q1 age extending the furthest inland. There are also large Q2 age dunes that extend well inland. The area of limestone extends about 4 kilometres inland and then grades into areas of the Spearwood dunes system with sandy surfaces to the south east and east. Its shape is quite irregular with patches of sandy soils occurring in lower lying areas within it. Within the swales in the Quindalup dunes there are areas of the Spearwood dune system exposed in places, as well as soil types belonging to the Quindalup system that have limestone at or very close to the surface (McArthur and Bartle 1980a).

The Breton Bay study area also has a thin strip of Q4 age Quindalup dunes along the coast however, there is a break in these dunes at the south end of Breton Bay itself where there is a small area of limestone cliffs. Near the cliffs there are also small areas where there are limestone slopes leading down to the beach. These areas have a band of Q4 dunes in front of them. To the south of Breton Bay the older Quindalup dunes extend to 3 km inland and to the north of Breton Bay they extend to 4 km inland (almost to Lancelin Road) but, for much of the core area they only extend half to 1.5 km inland. The older Quindalup dunes at Breton Bay include much more of what appear to be Q3 age dunes than at Wilbinga. Behind the Quindalup dunes in the Breton Bay study area there are areas of limestone and shallow to deep sands of the Spearwood dune system, usually with limestone abutting the Quindalup dunes.

1.4 Outline of Regional Botany

Both the study areas lie in the Drummond District of the South-West Botanical Province as defined by Beard (1980). This district is more or less equivalent to the Swan Coastal Plain and has a considerable variety of vegetation types found on it. The study areas includes a subset of these that are found on the Quindalup dunes (mostly heaths), on the limestone surface of the Spearwood dunes (mostly heaths and thickets) and on the sand surfaces of the Spearwood dunes (woodlands or low forests of *Banksia* spp. often with upper tree layers of Tuart (*Eucalyptus*

gomphocephala) or Jarrah (*Eucalyptus marginata*), or woodlands or forests of Tuart). The vegetation types found on these dunes systems are generally restricted to them, i.e. they are only found in the the South West of Western Australia on these dune systems. Many of the species found in these vegetation types are also only found in the South West of Western Australia. However, most extend into other vegetation types although some are much less abundant away from these dune systems and some are only found in them. There is also considerable variation in the composition of the flora of both dune systems along their length, probably reflecting changes in climatic variables such as rainfall and temperature, as well as local variation reflecting minor changes in the soil.

2. METHODS AND LIMITATIONS

The survey was designed to provide a basic description of the flora and vegetation of the Wilbinga and Breton Bay sites. Sufficient information was collected to do this and to enable an assessment of the conservation value of the two sites and an assessment of their relative values. The total area of the two sites (i.e. including core and buffer of each) is quite large, with the Wilbinga study area being about 10,000 ha and the Breton Bay study area being about 7,000 ha giving a total area of 17,000 ha. A detailed survey of areas totalling this size would be a considerable undertaking and was not possible with the significant constraints placed on the amount of time available for field work and analysis. However, it is reasonable to point out that the decision making process for which the current survey is required does not require great detail although it would be appropriate for more detail than that contained in this report to be acquired prior to detailed development studies of whichever site is preferred. All field work was carried out in September 1990.

2.1 Methods and Limitations of the Flora Survey

The flora survey was carried out concurrently with the vegetation survey and most of the specimens collected were from the vegetation recording sites. Species that were well known to the authors were recorded rather than collected. Lists were prepared for each core and buffer area separately. While the lists presented are largely based on the stands described in detail, a significant number of other species were encountered during foot and vehicle traverses and have been added to the lists. Given the large size of the study areas, the limited amount of foot traverses and the fact that field work was carried out only at one time of the year, it is likely that the flora list presented only records some 60-70% of the native angiosperm (flowering plant) flora of the study areas. It is obvious that the species that are not abundant in the study areas are less likely to have been collected than those that are abundant. Thus the number of rare or poorly known species in the study areas may be greater than recorded.

Emphasis was given to native angiosperm (flowering plant) species (no collections were made in pasture areas) and therefore the representation of exotic species in the

list poorly reflects their abundance in the study areas. Although there would undoubtedly be significant numbers of fungi, lichens, liverworts and mosses in the study areas it was beyond the scope of the current survey to collect these groups of plants.

The specimens collected were identified using Marchant *et al.* (1987) and by comparisons to previously identified specimens in the collections of the W.A. Herbarium. Where appropriate, specialist advice was sought on the correct identifications of specimens.

This cannot be considered a complete flora survey as such a survey needs to be undertaken to include sampling through all seasons and over several years of varying weather and fire conditions. This survey, in spring, would be somewhat biased towards species that flower at this time. Thus, plants that flower in late spring (e.g. many native grasses), summer and autumn would be less likely to be collected than those that were in flower at the time of the survey.

2.2 Methods and Limitations of the Vegetation Survey

Due to the size of the two sites and the limits on time for field work most transects had to be made using vehicles, with only a limited number of short foot traverses. The aerial photographs available were used to plan routes (using existing tracks) through the study areas to enable examination of as much of the range of vegetation types present in each area as possible. The routes taken and the location of the stands of vegetation described are shown on the vegetation maps. A total of 107 stands were described. Although this was enough to enable description of the range of vegetation types present in the study areas it is far from detailed. For comparison Trudgen (1988) in a study of the vegetation of 4,500 ha along the coast of the shire of Mandurah and with similar soils and geomorphology to the current study areas recorded over 300 sites (these were assigned to more than 160 vegetation types compared to the 26 delimited in this study).

The classification of the vegetation presented must be considered as preliminary as it is based on units as recognised in the field with limited re-interpretation afterwards and the range of floristic variation within the vegetation units recognised was not examined. The description of vegetation units presented is based on the range of variation of stands from both sites and it should be realised that there is significant variation within units along the coast.

The time limitations on the project prevented a comprehensive vegetation map showing the distribution of the vegetation types recognised, as a map of similar detail to that presented by Trudgen (1988) for the Mandurah coastal vegetation would take several months of field work for an area the size of the combined Wilbinga and Breton Bay study areas. The vegetation maps presented are of groups of units found on the different soil/geomorphology units and are based on the relationships between the vegetation and these units. The map for the Wilbinga study area is based on the map of soils presented by McArthur and Bartle (1980a) and that for the Breton Bay study area is based on the interpretation of aerial photographs. The accuracy of the latter map is less than that of the first as it has not been checked in the field also, it has not been possible to allow for distortion in the aerial photographs.

The condition of the native vegetation was assessed using a qualitative condition rating scale (Appendix two).

3.0 FLORA SURVEY

3.1 Flora Recorded

One native non-flowering plant (*Macrozamia reidleyi*, the Zamia Palm) and 240 flowering plants were recorded in the Wilbinga study area (see Appendix 1). Twenty one of the flowering plant species were introduced species. The number of species recorded from Breton Bay was somewhat smaller, with 185 flowering plants being recorded in that study area (see Appendix 1) of which seventeen were introduced species.

Of the 219 native flowering plant species recorded from Wilbinga, 52 were monocotyledons from thirteen different plant families and 167 were dicotyledons from 40 families. The families of monocotyledons with the most species were Cyperaceae (14 species), Poaceae (7), Restionaceae (7), Haemodoraceae (7), Dasypogonaceae (5) and Anthericaceae (5). The families of dicotyledons with the most species were Proteaceae (25), Myrtaceae (18), Papilionaceae (16), Asteraceae (13), Epacridaceae (12) and Mimosaceae (8).

Of the 168 native flowering plant species recorded from Breton Bay, 33 were monocotyledons from twelve different plant families and 135 were dicotyledons from 41 families. The families of monocotyledons with the most species were Haemodoraceae (7 species), Cyperaceae (6), Anthericaceae (5), Poaceae (4), Restionaceae (2) and Dasypogonaceae (2). The families of dicotyledons with the most species were Proteaceae (19), Papilionaceae (13), Asteraceae (13), Myrtaceae (12), Mimosaceae (9) and Epacridaceae (6).

3.2 Biogeographical relationships of the flora recorded

The makeup at the family level of the native flora recorded from Wilbinga and Breton Bay is relatively typical of the flora of the south-west of Western Australia and is comparable with that of three previous studies (Trudgen 1984, 1988, 1990) of coastal and near coastal areas on the Swan Coastal Plain. In all those and the current surveys the Asteraceae are somewhat higher in numbers than would be expected when compared with the flora of the south west as a whole and the number of

Mimosaceae is lower than would be expected. These differences are probably the result of the sandy soils of the study area.

3.3 Variation in the flora along the coast

The flora recorded for the Wilbinga and Breton Bay study areas confirms a pattern of change in the flora along the coast of the Drummond Botanical District, reflecting the change in environmental factors such as rainfall and temperature along the coast. Previous studies (Trudgen 1984, 1988, 1990a,b) on the Leschenault Peninsula, the coastline in the Shire of Mandurah and at Alkimos and Ningana in the northern part of the metropolitan area have demonstrated this change as far north as Ningana. The present study shows that similar changes occur between Wilbinga and Breton Bay and the areas covered in the previous studies.

When the lists of species recorded for the current study areas are compared to each other and to the previous studies (Trudgen 1984, 1988, 1990a,b) on the coast of the Drummond Botanical District it is obvious that while the makeup of the flora at the family level is relatively constant there is a very significant change at the species level. Not including twenty-nine species from the Mandurah list confined to wetlands (as there are no wetlands in the Wilbinga, Breton Bay area, Alkimos or Ningana areas) the following differences in species presence can be seen:

- 86 species recorded at Wilbinga were not recorded at Breton Bay
- 37 species recorded at Breton Bay were not recorded at Wilbinga
- 16 species were recorded at both Mandurah and Alkimos and/or Ningana but not at Wilbinga or Breton Bay;
- 81 species were recorded at Mandurah but not at Alkimos, Ningana, Wilbinga or Breton Bay;
- 52 species were recorded at Wilbinga or Breton Bay and not at Mandurah and Alkimos and/or Ningana;
- 30 species were recorded at Wilbinga and/or Breton Bay and Alkimos and/or Ningana but not at Mandurah;
- 66 species were recorded at Alkimos and/or Ningana but not at Mandurah;

While some of these differences in the presence and absence of flora species recorded at the different study areas can be attributed to variation in the habitat types present in the Mandurah, Alkimos/Ningana areas and the Wilbinga and Breton Bay areas, it is largely due to a gradual change in the flora up the coast that correlates with the gradual change in climate, particularly the decrease in rainfall.

Two well known species whose distributions reflect this trend are *Eucalyptus todtiana* (Pricklybark) which does not grow south of Jandakot and *Agonis flexuosa* (Peppermint), a characteristic species of coastal areas throughout much of the south-west, which does not grow north of Bold Park (Keighery, G. et al. in press). Other less well known species whose distributions patterns are part of this variation in species composition include *Hakea costata* which does not occur south of Burns Beach and *Persoonia comata* which does not grow south of Yanchep. *Pimelea gilgiana* is at its most southerly point in the Wilbinga area. The pattern shows up even between the Wilbinga and Breton Bay study areas, with *Banksia leptophylla* and *Acacia idiomorpha* being at their most southerly points in the Breton Bay area.

3.4 Differences between the flora recorded at Wilbinga and Breton Bay

There were significant differences in the flora recorded at Wilbinga and Breton Bay, with 86 species recorded at Wilbinga not recorded at Breton Bay and 37 species recorded at Breton Bay not recorded at Wilbinga. Also, more species were recorded in the Wilbinga study area (219 native species) than in the Breton Bay study area (168 native species) and a greater diversity in the Wilbinga buffer (181 native species) than in the core (175 native species). Some of the difference can be explained by differences in soil types, as the Wilbinga study area has a wider variety of soil types and consequently has a greater variety of vegetation types and flora. For example, there are larger areas of Spearwood sands in the Wilbinga study area than in the Breton Bay study area. These are mostly in the buffer area and support *Banksia* woodlands. These woodlands are relatively species rich compared to the vegetation types found on the Quindalup sands, having a suite of species such as Jarrah (*Eucalyptus marginata*), *Stirlingia latifolia* and *Alexgeorgia nitens* which are not

found on the Quindalup sands. However, some of the differences in flora species recorded is a result of some species only extending as far north as Wilbinga or as far south as Breton Bay or to some point between the two areas (see also the section above) while differences in the intensity of the survey and the higher proportion of cleared land at Breton Bay are probably also partly responsible.

While Wilbinga has more areas of Spearwood dunes with their associated flora, the Breton Bay study area has larger areas of coastal limestone and Quindalup dunes. These have some important populations of species in them in vegetation types such as the *Chaemalaucium uncinatum*, *Melaleuca acerosa* Open Scrub to Shrubland and *Eucalyptus* Closed Heath. (See section 3.5).

3.5 Species of particular interest

The study areas have a number of species that are of particular interest because they are declared rare flora (DRF), are poorly known, are restricted in distribution, are at the end of their range in the study area or because they are restricted to a particular habitat. An example of the latter category is species that are restricted to shallow sandy soils over limestone near the coast. Species restricted to this habitat are indicated by a # sign before their name in the discussion of individual species below. Of great interest was the rediscovery during the survey of #*Chorizema varium*, a species that prior to the survey was believed to have become extinct. The location of a previously unknown population of a rare undescribed *Eucalyptus* species (#*Eucalyptus* "argutifolia") that is a declared rare flora species was also of particular interest. Details of individual species are given below. Priority ratings given after some species are those assigned to them by the Department of Conservation and Land Management (CALM).

Monocotyledons

#*Conostylis bracteata* (Haemodoraceae)

A locally common but restricted taxon confined to the coastal heath and scrub between Perth and Lancelin (Hopper 1987). Found at site W9 in the Wilbinga study area. Appears to be restricted to well-watered depressions in undulating Quindalup

dunes.

Conostylis pauciflora ssp. *euryhipis* (Haemodoraceae)

A locally common but restricted taxon confined to the consolidated dunes within 10 km of the coast between Cervantes and Yanchep (Hopper 1987). Found at site W37 (and others) in the Wilbinga core area and Breton Bay buffer and core areas. Appears to be restricted to the Quindalup dunes.

Conostylis teretifolia ssp. *planescens* (Haemodoraceae)

An uncommon taxon found in isolated localities between Gingin, Yanchep and Wanneroo (Hopper, 1987) in *Banksia* woodland. In the study area this taxa was found at site W6 (and others) in the Wilbinga buffer and core areas and the Breton Bay buffer and core areas.

Conostylis bracteata × *C. candicans* (Haemodoraceae)

Hybrids between taxa of *Conostylis* are not uncommon and it has been suggested that *C. bracteata* could be a stabilised hybrid between *C. candicans* and *C. aculeata* (Hopper 1987). In the study area this taxa was found at site W9 (and others) in the Wilbinga buffer and core areas.

Dicotyledons

#*Chorizema varium* (Papilionaceae)

This species is known from nine collections made in the bush but, prior to the current survey had not been collected since 1902 and was presumed to have become extinct. It was first collected by James Drummond in 1839, presumably at Fremantle where the 1902 specimen was collected. In a letter to Sir William Hooker at Kew Herbarium dated October 1839, Drummond refers to the 'beautiful scarlet *Chorizema*, which still grows at Arthur's Head, but flowers in much greater perfection on the coast near Clarence road, about 4 miles south of Fremantle.' *Chorizema varium* was extensively cultivated in Europe in the 1830's being described in Edwards Botanical Register, 1839. Even at this early time it was considered rare, to quote from the Register, 'In its own country it must be a very rare

plant, for I do not find it in any of the collections of dried specimens which I have examined, excepting in that sent home by Mr Drummond in the course of the present season, and even there occurs in fragments, with ripe pods adhering to them.' (Lindley, 1839). The species has since been lost in cultivation since the late 19th Century (G. Keighery pers. com.).

The population found (in the order of 1,000 plants) is in the core of the Breton Bay study area on the southern part of the Bay itself. At this locality there is an outcrop of Spearwood dune limestone that forms a small area of seacliffs and slopes down to the sea. The *Chorizema* is restricted to this outcrop of limestone, where it grows above the cliffs and on the slopes to the south of the cliffs (a small area of slopes to the north of the cliffs was not inspected). The habitat of the plant is somewhat unusual as most areas of Spearwood dune limestone at the coast have a cover of more recent calcareous sand. The area where *Chorizema varium* is found does not have this because of the position of the outcrop at the south of the bay, which protects it from south westerly winds.

G. Keighery (pers. com.) has made extensive searches for *Chorizema varifolium* on the limestone heaths in the Fremantle to Yanchep area but, has been unable to find any populations. Recent surveys of coastal areas (Trudgen 1984, 1988, 1990a & b) have also not recorded the species. Searches in the current study areas and to the north of the study areas have also failed to locate any further populations of the species. It is considered unlikely that further populations will be found as the habitat in which the plant grows is unusual.

Although at the moment presumed extinct species do not have automatic protection as declared rare flora when they are rediscovered it is likely that this protection will be afforded to them in the near future. The fact that a CALM officer has already made extensive unsuccessful searches for this species in other areas (including those where it was previously known but has been lost to development) indicate that it is likely to be gazetted as declared rare flora.

#*Eucalyptus "argutifolia"* (Myrtaceae)

This declared rare flora species was recorded in the Breton Bay area at site B10, a new site for the species even though it is known from a locality near Seabird, just to the south. It is a smooth-barked mallee to 3m high with coarse glossy leaves and grows on limestone outcrops and slopes between Yanchep and Lancelin (Hopper et al, 1990).

#*Allocasuarina lehmanniana* (Casuarinaceae)

Although this species has a large distribution, vegetation types dominated by it on the Swan Coastal Plain are very rare, being found in only one reserve, the small Trigg Dune Reserve (G. Keighery pers. com.). In the study area this species was confined to the Wilbinga buffer where only a small number of plants were seen.

Banksia leptophylla (Proteaceae)

This species was collected in the Breton Bay buffer area, which is near the southern most point in its distribution, which is from Guilderton to Kalbarri (Taylor and Hopper, 1988).

#*Petrophile* affinity *brevifolia* (Proteaceae)

The specimens referred to this name appears to be an undescribed ("new") species that occurs on the coastal plain and has been confused with *Petrophile media* a widespread species occurring from the Murchison River to Ongerup (Marchant et al 1987). It was found in the Wilbinga buffer and core areas and the Breton Bay buffer and core areas.

#*Petrophile* affinity *serruriae* (Proteaceae)

This name has been applied to a pink "variant" of *Petrophile serruriae* found on the coastal plain from Perth to Geraldton. Further study will probably result in its recognition as a separate species allied to *Petrophile serruriae* which is a widespread variable taxa found from Geraldton to Albany (Marchant et al 1987). It was found in the core and buffer areas of both Wilbinga and Breton Bay

Calandrinia brevipedata (Portulacaceae)

An annual species which is at the northern extent of its range in the study area (Marchant et al 1987). Found in the Wilbinga buffer and core areas and the Breton Bay core area.

#*Stenopetalum gracile* (Brassicaceae)

Formerly known as *Stenopetalum robustum*, *S. gracile* is a small straggling annual herb that is near the northern end of its range in the study area. This species is found on the coastal plain from Yalgorup to Leeman and is known from Yalgorup, Neerabup and Yanchep National Parks (G. Keighery pers. com. and Marchant et al 1987). Found in the Wilbinga buffer and core and the Breton Bay buffer and core areas.

Acacia idiomorpha (Mimosaceae)

This small wattle is at the southern end of its range in the Breton Bay study area. It was found at sites B29 and B30, both in the Breton Bay core area.

Acacia truncata (Mimosaceae)

Another small wattle shrub which is near the northern extent of its range in the study area, being recorded north to Leeman (Marchant et al 1987). Found in Wilbinga buffer and core and Breton Bay buffer and core.

Nemcia reticulatum (Papilionaceae)

This species has a distinct broad leaved coastal form which is very common on near-coastal sands and limestones on the Coastal Plain extending from Burns Beach to Northhampton but which is confined to this area (Marchant et al 1987). It is not known in any conservation reserves south of Nambung and is found in both the Wilbinga and Breton Bay buffer and core areas. The taxonomic status of this variant is unclear but it is probably at least a separate subspecies.

#*Diplolaena microcephala* aff. var. *microcephala* (Rutaceae)

Diplolaena microcephala is a widespread species found from Esperance to Kalbarri. The variety found in the study area (in the Wilbinga core area and the Breton Bay buffer and core areas) is only known from a few collections made from Yanchep to Jurien. It is closest to, but quite distinct from, variety *microcephala* which is confined to the south coast. The two varieties differ in habit, leaf shape and indumentum and are geographically isolated from each other.

#*Alyogyne huegelii* ? var. *glabrescens* (Malvaceae)

Alyogyne huegelii is a widespread variable species with several varieties. The variety occurring in the study area appears to match var. *glabrescens*. It grows from Yanchep to south of Dongara. Unlike other varieties of *Alyogyne huegelii* which have lilac flowers, this variety has a cream corolla covered with rusty hairs and a purple throat. It was found in the Wilbinga and Breton Bay buffer and core areas.

#*Trymalium albicans* (Rhamnaceae)

This species was considered extinct (Conservation and Land Management Priority 4 species in the Metropolitan Region) but recent work on the genus (G. Keighery, 1989) found that it had been included with *Trymalium ledifolium* as this species had previously been recognised at the W.A. Herbarium. It was found at Wilbinga site 31 and other sites in the Wilbinga buffer and core and the Breton Bay buffer and core areas. It is quite common on coastal limestone.

#*Hibbertia spicata* ssp. *leptotheca* (Dilleniaceae)

This subspecies is confined to near coastal limestone between Yalgorup and Lancelin. In the study area it was found at sites W13 & 29 as well as others in the Wilbinga buffer and core and Breton Bay buffer areas.

#*Pimelea gilgiana* (Thymelaeaceae)

This taxon was not previously recorded south of Leeman and this study extends this species range to Breton Bay and Wilbinga (Rye, 1990). It was fairly common on limestone in the Wilbinga buffer and core and Breton Bay buffer and core areas.

#*Chamelaucium uncinatum* ("Geraldton Wax", Myrtaceae)

In the wild, this species grows as far south as Bold Park but it is not reserved on the coastal plain between Perth and Nambung National Park and the populations in the Breton Bay buffer and core could represent the largest populations in this area. The principal area of distribution of this species is coastal but there some inland populations whose taxonomic status needs to be determined (G. Keighery, pers. com.). The coastal populations also show some variation, with the populations in the study area having short leaves and small flowers.

#*Eucalyptus foecunda* (Myrtaceae) Priority 5

This species is a coastal endemic found from south of Mandurah to north of Lancelin. It is not common, occurring in small patches on shallow sandy soils over limestone and has been previously recorded from the Seabird area (Napier et al 1988 and CALM 1990). It was found at site B36 in the Breton Bay buffer area.

#*Eucalyptus "petrensis"* (Myrtaceae) Priority 3

A taxon confined to limestone ridges from Yalgorup to Seabird (Napier et al 1988 and CALM 1990). Recorded from the Fewster property in the Breton Bay buffer.

Hydrocotyle diantha (Apiaceae)

A small inconspicuous annual herb found at site W28 in the Wilbinga core, which is the most northern record of this species (G. Keighery pers. com.)

#*Astroloma microcalyx* (Epacridaceae)

A poorly collected species found on shallow sandy soils over limestone from Cervantes to Yalgorup with a possible record from Lake Indoon (A. Wilson pers. com.). Found in the Wilbinga buffer and core.

Stylidium sp. ("*maritima*") (Stylidiaceae)

This species occurs in near coastal locations on older Quindalup dunes and less frequently on limestone, on the coastal plain from Yanchep to Yalgorup. The

specimens collected in this survey at site B34, in the Breton Bay buffer area and a recent collection from Cervantes extend its range north from the Yanchep area. Although it can be common over quite small areas, populations are not common and much of its habitat between Yanchep and Yalgorup has been cleared or degraded and it should be considered uncommon and possibly rare.

3.6 Introduced flora

Poaceae and Asteraceae were the families with the most exotic species present in the study area, some members of these families were very common. Other families represented included Caryophyllaceae and Brassicaceae. Many introduced species were widespread in the study area but except for those abundant in cleared areas tended to have low population levels.

The parts of the study area that have been cleared have had their native flora replaced entirely (or almost entirely) by exotic species while the bushland areas mostly do not have bad weed infestations. **Briza maxima*, **Crassula glomerata*, **Dischisma arenarium*, **Hypochaeris glabra* and **Ursinia anthemoides*, were established in relatively undisturbed areas. Some species, for example **Solanum sodomaeum* were only found in pasture areas while other such as **Bromus diandrus* were very common in pasture areas (as were many other exotics) but were also found sporadically in bushland.

4.0 VEGETATION SURVEY

The major factor determining the presence and distribution of the different vegetation types in the study area is the geomorphology/soil types found in the two blocks. The analysis of the 107 stand descriptions resulted in 26 vegetation types, about one third of these are variants of the more basic types. It is probable that the 26 units represent 80-85% of the vegetation of the study area. The other 15-20% would be types that are of limited extent and would only be sampled by a more intensive survey than that carried out. Because of the method of deciding upon the types it is probable that a more thorough floristic based analysis would produce a somewhat different interpretation of the data.

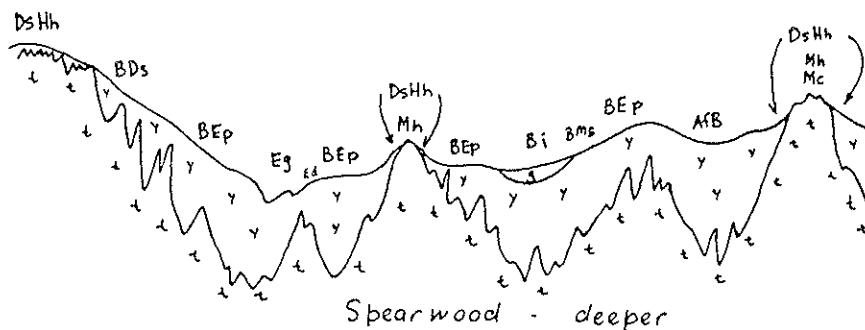
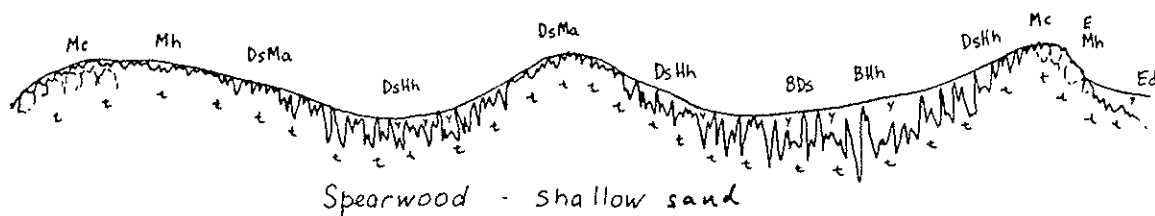
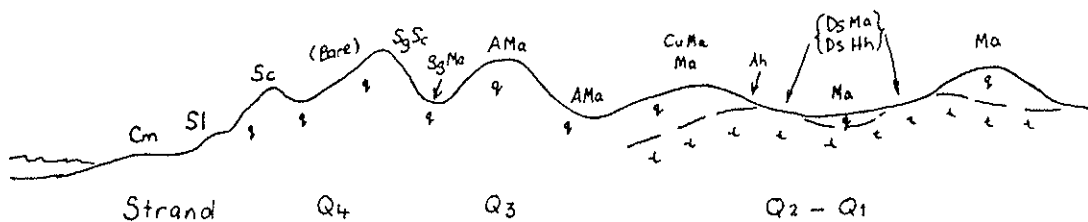
4.1 Description of the Vegetation Types

The vegetation types are grouped according to the soil/geomorphological unit that they occurred on and are referred to by a code based on the botanical name of the dominant species. The groups are:

- 1) the strand
- 2) the Q4 age Quindalup dunes
- 3) the Q3, Q2 and Q1 age dunes and deflation basins
- 4) the Spearwood Dunes, shallow soils
- 5) the Spearwood Dunes, deeper soils.

The Spearwood Dunes have been divided into two major units, essentially depending on the depth of quartz sand over the limestone (Tamala Limestone). For convenience the division chosen corresponded to the absence and presences of tree species (*Banksia* and *Eucalyptus*). Thus the "shallow soils" correspond to Heaths and Shrublands while the "deep soils" correspond to Woodlands and Forests. This division enables mapping based largely on aerial photograph interpretation with minimal field checking, whereas division at other structural levels or on a floristic basis (or a combination) would require very extensive field checking. Figure 1 shows a diagrammatic representation of the perceived relationship between the vegetation types found in the study areas and the geomorphology/soil units found in them.

Figure One: Relationship of vegetation types to geomorphological types



q - Quindalup sands

y - Spearwood sands, yellow

g - Spearwood sands, grey

t - Tamala Limestone

4.1.1 The Strand

The Strand vegetation is poorly developed in both the Wilbinga and Breton bay areas as the beaches are typically narrow as a result of erosion by the sea. Only small areas of strand are present and in some places this too has been truncated by the erosion. Several distinct vegetation types were recognised, appearing to represent different phases of the stabilising of the strand. Firstly (and nearest the beach) is an area of essentially only *Cakile maritima* (Cm) Herbland, further back from the beach (and presumably older) a Grassland dominated by young *Spinifex longifolius*. This appears to be replaced by a Hummock Grassland dominated by *Spinifex longifolius* (Sl). Species typical of the youngest stabilised Quindalup dunes (Q4) invade these areas and an overlap of species between the two develops. The soil of all strand vegetation types is loose, essentially sand sized, shell fragments and there is no sign of soil profile development.

Cm *Cakile maritima* Herbland

The one site from which this was recognised was dominated (40% cover) by this species growing to only 0.3m in height. The only other species recognised were *Tetragona decumbens* (5% cover, 0.2m tall), **Arctotheca populifolia* (5%, 0.2m) and young *Spinifex longifolius* (1%, 0.4m).

Sl *Spinifex longifolius* Hummock Grassland

Two species of *Spinifex* (*S. longifolius* and *S. hirsutus*) occur along the coast on which the stud area is located. However, at both Wilbinga and Breton Bay *Spinifex longifolius* was dominant (40-70% cover, 0.4 & 1.5m tall). Other species present included *Tetragona decumbens* (5-20%, 0.3m), *Olearia axillaris* (1-10%, 0.6-1.0m) *Isolepis nodosus* (1%, 0.6m) plus the weed species *Carpobrotus* (2%, 0.2m) and *Trachyandra divaricata* (Onion Weed, 2%, 0.4m). *Helichrysum chordatum* is usually only sparingly present but, in areas stabilised for longer, it may exceed 2m in height.

This unit grades into the stabilising eroded primary dune vegetation (unit Sc, see below).

4.1.2 Q4 age Quindalup Dunes

This category covers the youngest Quindalup Dunes which have formed relatively recently and recently restabilised blowouts. Typically it includes the sea side of the first dune which has often been eroded by the sea, the landward side of these dunes and the parabolic mobile dunes. These areas usually have moderately steep slopes and soil which lacks podogenic development and which is largely composed of sand sized shell fragments.

There was mostly only one very variable vegetation type recognised in this group of situations. This was unit Sc, which was dominated by *Scaevola crassifolia* however, several variants were recognised generally related to how old the stabilisation was. The unstable slope facing the beach usually has low cover of *Scaevola crassifolia* but higher cover of species such as *Olearia axillaris* and *Tetragona ? decumbens* (unit ScOa). Similar vegetation is present in naturally regenerating Quindalup dunes away from the beach.

The stabilising slopes of the parabolic dunes have much more open vegetation with larger individual plants than most other vegetation types of the Quindalup dunes in the study areas. Generally the species present are similar to unit Sc but also had additional ones such as *Spyridium globulosum* and *Acacia cyclops* (unit SgSc).

Several transitional vegetation types were recognised between these younger Quindalup dunes and either the older Quindalup or Spearwood dunes. Most noticeable were areas of unit SgMa dominated by *Spyridium globulosum* which grows in swales and appear to be superimposed on a low heath dominated by *Melaleuca acerosa*. In a more detailed study some of these stands would warrant description as separate units.

Sc *Scaevola crassifolia* Low Open Heath

Scaevola crassifolia dominates the stable Q4 dunes, especially those close to the sea. It can exceed 40% cover but is only 0.3-0.6m tall. The only other shrub species with significant cover is *Myoporum insulare* (10-25%, 0.3-0.6m). Other shrub species

include *Olearia axillaris* (2-5%, 0.6-1.2m), *Helichrysum cordatum* (1-5%, 0.5m), *Acanthocarpus preissii* (10-15%, 0.3m) and *Arcrotriche cordata* (1-5%, 0.4m). The sedge species *Lepidosperma gladiatum* (0-10% 0.6m) and *Isolepis nodosus* (0-2%, 0.6m) reach a similar height to the shrubs and hence do not form a distinct stratum. The creeper *Hardenbergia comptoniana* may exceed 10% cover in some areas. In some areas an introduced annual grass can be present up to 30% cover.

ScOa *Scaevola crassifolia*, *Olearia axillaris* Low Open Heath

In disturbed dunes of this age *Olearia axillaris* becomes the most conspicuous species (up to 30% cover and 0.4-1.0m tall). *Scaevola crassifolia*, however, usually has more cover (25-35%) but is shorter (0.3-0.5m). Only in the less well vegetated areas is *Scaevola crassifolia* not important. In such areas the importance of other species is increased: *Tetragona decumbens* (10-20%, 0.3m) and *Isolepis nodosus* (1-5%, 0.6m).

SgSc *Spyridium globulosum*, *Scaevola crassifolia* Shrubland

The steep stabilising slopes of the Q4 parabolic dunes are dominated by *Scaevola crassifolia* (25-40%, 0.5-1.5m) but several larger species are more conspicuous giving this vegetation its typically patchy appearance. *Spyridium globulosum* is often the most conspicuous of these species (10% and up to 2m). Also present are *Acacia cyclops* (5%, 2-3m), *Myoporum insulare* (0-5%, 1.5m) and *Olearia axillaris* (0-10%, 1.5m).

There is a significant component of native grass and sedge species within the lower shrub layer. *Spinifex longifolius* is commonly present at the top (and least stable) part of these slopes. It can be between 5-15% cover. Others include *Acanthocarpus preissii* (10-15%, 0.5m), *Lepidosperma gladiatum* (5%, 0.7m) and *Isolepis nodosus* and *Conostylis pauciflora*.

The creepers can be very important, *Hardenbergia comptoniana* (5%) and *Cassytha racemosa* (to 10%).

SgMa *Spyridium globulosum*, *Melaleuca acerosa* Open Heath to Closed Scrub

Often at the foot of the steep stabilising dunes are dense narrow strips of shrub vegetation. The species present suggest that this is a transition between Q4 and

Q3-Q1 dunes. *Spyridium globulosum* is generally present in this vegetation type and can exceed 2m in height and be up to 70% cover. *Acacia rostellifera* and *Acacia cyclops* may also be present with similar stature and range of cover.

A lower shrub layer is generally present, usually *Melaleuca acerosa* and other species typical of Q3-Q1 dunes. Abundances of shrub species noted were *M. acerosa* (20-25%, 0.5-1.5m), *Calothamnus quadrifidus* (0-20%, 2m), *Rhagodia baccata* (0-5%, 0.5-1.1m).

A distinct sedge layer is present and is typical in composition to that of Q3-Q1 dunes. The most conspicuous include *Loxocarya flexuosa* (0-30%, 0.2m), *Lomandra maritima* (0-20%, 0.3m) and *Acanthocarpus preissii* (0-5%, 0.3m). Very few herb species were noted in the sites described.

4.1.3 Q3, Q2 and Q1 age Quindalup Dunes and Deflation Basins

As defined by McArthur and Bartle (1980a) these dunes are less steep and often lower than the Q4 dunes although the Q3 dunes can be an exception to this. It was not possible to separate the vegetation on the different ages of these dunes into separate units in the current study. However, in other studies (Trudgen 1988) this has been possible for at least some areas. Factors (e.g. fire history, grazing) other than the age of the dunes are influencing the vegetation developed and may be obscuring differences in floristics and the abundance of the species present. However, it is still likely that a detailed study would discriminate more units on these dunes than the current study.

One very broad vegetation type (unit Ma) dominated by *Melaleuca acerosa* was defined to cover the vegetation of this group of dunes. The sporadic occurrence of other species, mostly shrubs such as *Acacia* species and *Chamalaucium uncinatum*, produced a number of other vegetation types which are here considered as distinct variants (e.g. units AMa and CuMa). Generally the *Acacia* species were more important on the steeper, and usually more seaward dunes. These we have interpreted as being Q3 dunes.

The differences in fire history and grazing of different parts of the study areas have

made it difficult to provide accurate circumscriptions of these units, which gave the impression of being highly vulnerable to modification by these practices.

Ma *Melaleuca acerosa* Low Open Heath to Low Open Shrubland ✓

The shrub layer is essentially dominated by *Melaleuca acerosa* (3-30% 0.3-0.5m) which occurs over all components of the landscape of these older Quindalup dunes. There is significant variation in the abundance of this species in different parts of the landscape, with less on the dune crests and more on the lower slopes and deflation basins and its abundance also varies in different parts of the study areas. In a detailed study this variation would be described as different units.

A number of other shrub species may be present but few consistently. Several are obviously present in the recently burnt (? and grazed) areas. This group includes *Acacia lasiocarpa* (0-30%, 0.5m), *Scaevola thesoides* (0-5%, 0.3m), *Hybanthus calycinus* (0-15%, 0.2m) and *Senecio lautus* (0-2%, 0.3m). Other species which were found, but not consistently, include *Calothamnus quadrifidus* (0-10%, 0.5m), *Acacia truncata* (0-20%), *Bossiaea eriocarpa* (0-10%, 0.3m), *Hemiandra pungens* (0-5%, 0.2m), *Acanthocarpus preissii* (0-15%, 0.3m) and *Hibbertia racemosa* (0-5%, 0.3m).

The monocotyledons are extremely important in this vegetation type and are often more important than the shrubs. In places the stands would be best classified as herblands or herbland/sedgeland. *Lomandra maritima* (0-45%, 0.3m) is usually the most abundant of these species. Others include, *Loxocarya flexuosa* (0-20%, 0.15m) and *Conostylis pauciflora* (0-2%, 0.3m). However, annual herbs are not usually important although a few species (eg. *Brachycome*) are commonly present. Some areas have been invaded by alien annual weed species (eg. *Vulpia myuros*) with up to 30% cover.

Some areas have additional taller species present and appeared consistent enough to warrant recognition as variants, these are described below. Others species such as *Santalum acuminatum* were less consistently present but stands of these might warrant similar status were a more detailed study to be undertaken. One deflation

basin observed had the typical species of this unit plus pioneer species such as *Olearia axillaris* and *Helichrysum chordatum*.

CuMa *Chamalaucium uncinatum*, *Melaleuca acerosa* Low Open Heath to Low Open Shrubland.

Chamalaucium uncinatum was often present on the older dunes in the Breton Bay area, particularly in the slopes of the more easterly dunes. It occurs at up to 30% cover and 1.5m in height. Individual plants are more sparse than in cultivation. *Calothamnus quadrifidus* is more important (up to 30% and up to 1.5m) in this variant than in areas of typical unit Ma. *Melaleuca acerosa* and the monocotyledon species remain important.

AMa *Acacia*, *Melaleuca acerosa* Open Scrub to Shrubland

A significant area of the Q3, Q2, Q1 dunes have stands of one (or occasionally more) of a number of tall *Acacia* species (*A. rostellifera*, *A. cyclops*, *A. cochlearis* or *A. xanthina*) present. The superficial examination which has been possible in this study of the species composition in these stands has resulted in the conclusion that understorey found in these stands was essentially similar to unit Ma with reductions in abundance due to the competition of the overstorey.

Rarely were more than one of the four tall *Acacia* species found in the one stand however, in the stands examined those present were very important in the structure of the vegetation. For example stands with *Acacia rostellifera* (50-60%, 1-2m), *Acacia cyclops* (10-30%, 2-4m), *Acacia cochlearis* (10-25%, 1-2m) and *Acacia xanthina* (7-40%, 1.3-2m) were observed. In a detailed study these would be treated as separate units. Generally the areas where these species were more important (taller and with greatest cover) were the deflation basins. These areas had very much darker soil (probably more organic matter). Increasing age since fire results in the increasing height of the over-storey species accompanied by a reduced cover. No differences in either the composition of the under-storey species present or the edaphic factors were detected between stands with different over-storey species. These *Acacia* species are

more important on the steeper dunes which lead to the conclusion that these were Q3 dunes.

4.1.4 Spearwood Dunes, shallow soils

This category includes vegetation that grows on sites that have limestone exposed at the surface or have a shallow cover of sand over the limestone. The latter sites tend to occur on the slopes of rises that have the former on the crests. Two major soil attributes are important for determining the distribution of the vegetation units recognised in this group. These are the depth of sand present and the degree of fracture of the limestone where it is exposed. In addition, there is variation depending on the presence or absence of species whose distribution is controlled by proximity to the coast.

A significant proportion of the area assigned to this group of units is in deflation basins within the Quindalup dunes. The proportion of shell fragments left behind by the Quindalup dunes and the degree to which these have been leached has probably had some influence on the species composition of these areas. The variation present probably represents several units.

Several distinct vegetation types were recognised for areas with exposed limestone at the surface. The major two were dominated by *Melaleuca huegelii* (unit Mh) and *Melaleuca cardiophylla* (unit Mc). The structure of these depended on the extent of the stands and their proximity to the coast. They could form a Closed scrub, an Open heath or even a Low closed heath. The mallee eucalypts (*Eucalyptus "argutifolia"* and *Eucalyptus "petrensis"*) appeared to form a distinct variant of these vegetation types (unit E). Where the limestone outcropped within the zone of salt water spray a distinct halophytic vegetation type was obvious (Fp). This was dominated by *Frankenia pauciflora*.

Where the surface has a thin soil cover over the limestone the vegetation types are dominated by *Dryandra sessilis* (especially DsHh and DsMa). This species may be present in virtually all of the units in this group.

Several heath stands dominated by *Allocasuarina humilis* were found (Ah). These were considered to be transitional between Quindalup and Spearwood dunes. For some vegetation types there was evidence that the presence or absence of some species (and for some species abundance) was due to the fire history of particular stands.

DsHh *Dryandra sessilis*, *Hibbertia hypericoides* Open heath

This is probably the most extensive of the vegetation units present in this group in both study areas. It occurs in lower parts of the landscape with brown to orange surface soil over yellow sand with only occasional outcrop of limestone. *Dryandra sessilis* (30-70%, 0.5-2m) is generally both the tallest species in this vegetation type and the one with the greatest cover. Its abundance is greatly affected by age since fire. Mature stands are generally 30-40% cover and 1.2-2m tall. Greatest cover occurs in young to moderate ages (5-12 years post fire). In areas not burnt for long periods of time it may decline to 20% or less. Other tall species usually present include *Hakea trifurcata* (2-30%, 0.4-2m), *Xanthorrhoea preissii* (3-5%, 1-1.6m) and *Calothamnus quadrifidus* (0-15%, 0.6-1.5m). The *Hakea* is also a fire sensitive species but appears to be slower maturing than the *Dryandra* and appears most important in the older areas. It has an uneven distribution throughout the extent of this unit probably reflecting as yet unrecognised variation in the soil and also the variation in fire history. The *Xanthorrhoea* is also patchy and often occurs in clumps in which it might have up to 30 or 40% cover. This is clearly a response to a soil factor. *Calothamnus quadrifidus* was not often important but apparently in some long unburnt areas it can be important, particularly if the *Dryandra* and *Hakea* have declined due to old age.

Hibbertia hypericoides (30-60%, 0.3-0.6m) is the most important low shrub species in this unit. It is quick to regenerate after fire and appears to remain important in old stands. Several other low shrub species may be important, particularly in the first years after fire. In many areas *Jacksonia stricta* (10-70%, 0.5m) is the most important species between about 3 and 8 years. It was present in most areas observed but was

virtually unimportant in older areas. *Leucopogon polymorphus* (0-30%, 0.3-0.6m), *Scaevola thesoides* (0-10%, 0.4m) and *Acacia truncata* (0-10%, 0.5-1.2m) all appear to be more important in the early rather than the latter years after fire.

There are quite a few other shrub species present, much more than on the Quindalup dunes. Examples include *Melaleuca acerosa* (less than 10% cover), *Grevillea thelemanniana*, *Hakea prostrata*, *Templetonia retusa*, *Bossiaea eriocarpa*, *Petrophile serruriae* and *Lysinema ciliatum*. *Loxocarya flexuosa* (5-10%, 0.15m) and *Schoenus ? subflavus* (5-10%, 0.03m) are the most common sedge species. *Mesomelaena stygia* is also often present. Some areas have a significant cover (up to 30%) of herbs. These are generally of small stature and even those which are weed species (eg. *Hypochoeris glabra*, *Anagallis arvensis*) are generally not aggressive species and have little impact on the structure or dynamics of the vegetation.

In several of the areas inspected and included in this vegetation type *D. sessilis* was virtually absent. This was justified since they had the same soil type and the presence of most of the accompanying species, particularly *H. hypericoides*. The structurally dominant species included *Conospermum canaliculata* and *Calothamnus quadrifidus*. A period of frequent fires could explain the absence of *D. sessilis*. As well as this variation several small patches of *Acacia rostellifera* and two of a mallee (*Eucalyptus foecunda*) were found within this vegetation type. Except for these over-storey species these areas appeared to fit within the circumscription provided above for this vegetation type. More work is necessary to adequately determine if these patches warrant recognition as different vegetation types. However, in other more detailed studies (e.g. Trudgen 1988) similar stands have been treated as separate units as detailed recording shows the presence of significant variation in species presence and abundance and it is likely that more intensive study of the Wilbinga and Breton Bay areas would subdivide unit DsHh into a number of units.

DsMa *Dryandra sessilis*, *Melaleuca acerosa* Open heath ✓

This vegetation type appears to occupy areas with more limestone outcropping than

DsHh, and is generally in the more elevated parts of the landscape. *Dryandra sessilis* (40-50%, 0.5-1.5m) and *Hakea trifurcata* (5%, 0.6-1.5m) are the important tall species in this unit. As mentioned in the description of unit DsHh (see above) these species vary through time after fire in both height and cover. In unit DsMa *Melaleuca acerosa* (20-30%, 0.3-0.9m) was more important than *Hibbertia hypericoides* (5-10%, 0.5m) and this is the main criterion by which this unit was distinguished from DsHh in which the relative importance of these species was reversed.

A similar range of less abundant shrub species to those mentioned for unit DsHh are also present in unit DsMa, for example *Acacia truncata*, *Calothamnus quadrifidus*, *Grevillea thelemanniana* and *Jacksonia stricta*. *Loxocarya flexuosa* (10-30%, 0.2) and *Schoenus ? subflavus* (5%, 0.03) are important in the sedge layer.

Mh *Melaleuca huegelii* Open Heath to Shrubland ✓

This unit takes over from unit DsMa where much of the soil surface is covered by limestone. This is usually on a hill top especially the edge of a slight crest or where the limestone is fractured. Where the unit occurs within the Quindalup dunes the slopes of the limestone "outcrop" appear to be obscured by the more recent Quindalup sand. The patches of this vegetation type are generally small and it is probably for this reason that the abundance of *Melaleuca huegelii* within stands is quite variable (5-60%, 1.5-2m). It is generally surrounded by unit DsMa with which it has many species in common but, these are usually less abundant in unit Mh. *Dryandra sessilis* is generally of low importance (0-10%, to 1.5m) and *Hakea trifurcata* is rarely present.

As noted above the composition of the lower shrub stratum bears a high similarity to that of unit DsMa. The abundance of these shrub species is quite variable, probably in parallel with *Melaleuca huegelii*. They include *Melaleuca acerosa* (5-40%, 0.7 m), *Acacia truncata* (2-50%, 0.6-0.8 m) and *Calothamnus quadrifidus* (0-20%, 0.3-0.8 m). Other species present include *Grevillea thelemanniana* (2-5%, 0.3-0.7 m), *Hakea lissocarpha* (0-2%, 1 m), *Templetonia retusa* (0-5%, 0.6-1.2 m), *Leucopogon parviflora* (1%, 0.7m) and *Trymalium albicans* (0-5%, 0.7-1.1 m). The last two are more

commonly found in this type than in unit DsMa. In some places the tall stratum is absent leaving the vegetation as a low open heath. *Loxocarya flexuosa* (15-30%, 0.15m) is the most important sedge species found in this unit. It is relatively common for there to be up to 20% cover of herb species.

A number of the stands inspected were a relatively young age post fire. In these stands some of the species present appeared to be short lived and often very important in the early years post fire. Most obvious was *Scaevola nitida* (0-20-50%, 1-1.5m) which because of its fast growth rate was the post fire dominant species both in terms of structure and cover. *Scaevola thesoides* (0-40%, 0.7m) can also be very important in the early years after fire and more or less absent in later years. Where a Quindalup dune adjoins areas of unit Mh *Acacia rostellifera* (0-70%, 1.5-2.5m) and *Spyridium globulosum* (0-30%, 1.5-2m) can be quite important. Occasionally *Acacia rostellifera* also occurs in other patches. These situations might warrant recognition as a different vegetation type or types.

E *Eucalyptus* Closed Mallee Heath

unclear with Euc. (occasional)

This vegetation type is in a sense a variant of unit Mh since it appears to occupy the same soil type and position in the landscape and has many of the same species in common. However, the upper stratum was often taller than areas with just *Melaleuca huegelii* and the *Eucalyptus* species give the unit a very different appearance. The unit was found in at least four patches in the Breton Bay area but the reason for its sporadic distribution is unknown, although it is possible that the stands are relicts that are surviving by vegetative growth only. *Eucalyptus "argutifolia"* and *Eucalyptus "petrensis"* (both mallees) are the tallest species in these stands at between 1.2 and 2.5 m. Their cover varied from 20-70%. The most common other tall species present were *Melaleuca huegelii* (2-10%, 1.2-1.5 m), *Dryandra sessilis* (7-15%, 1-1.5 m) and *Acacia truncata* (2-3%, 1.2-1.5 m). Stands with the different *Eucalyptus* species could be considered different vegetation types in a more detailed survey.

A distinct lower shrub layer was dominated by *Melaleuca acerosa* (10-35%, 0.6-1.2 m).

Other species in this layer included *Trymalium albicans*, *Templetonia retusa* and *Gompholobium tomentosum*. The creepers *Hardenbergia comptoniana* and *Thysanotus patersonii* were usually present. *Loxocarya flexuosa* (15-30%, 0.15 m) and *Lepidosperma angustatum* (10%, 0.3 m) were the most common sedge species. Herbs are uncommon.

Mc *Melaleuca cardiophylla* Closed Scrub to Low Closed Heath / *uncommon*

This vegetation unit also occupies areas with massive outcropping limestone but, seemingly more fractured than those preferred by unit Mh, into which it may grade. Although *Melaleuca cardiophylla* had clear dominance in all stands (60-95% cover) it was highly variable in height (0.5-2.5 m) and hence structure. In general terms two structural types can be identified. Close to the coast (within 10m on Eagle Head) it is a low closed heath, presumably wind and salt pruned. Further inland it formed a closed heath or even a closed scrub. When it has the structure of a low closed heath the *Melaleuca cardiophylla* occurs at the lower range of cover with for example *Acacia truncata* (10%, 0.4-0.9 m), *Olearia axillaris* (5%, 0.6-1 m) and *Thomasia triphylla* (5%, 0.4 m). This structural type is generally richer in shrub species than the closed scrub end of the range, which has just a few, for example *Dodonaea aptera* (0-5%, 1-1.5m) and *Thomasia triphylla* (2%, 0.5m).

The small size of stands means that species typical of unit Mh (e.g. *Melaleuca huegelii* and *Trymalium albicans*) were also found in some stands but then had low covers. The creepers *Hardenbergia comptoniana*, *Thysanotus patersonii* and ? *Sollya* are also present in some stands. The importance of sedges is quite variable. *Loxocarya flexuosa*, the main species may reach 40% cover in the low open heath. Under the Closed scrub it is 10% or less. Annual herbs, however, tend to follow the reverse pattern and are greater under the seemingly better soil of the closed scrub. It is obvious from the above discussion that a more detailed study would split this unit as it is defined here into several units on floristics alone, let alone structure.

Fp *Frankenia pauciflora* Low shrubland

This unit grows in shallow sand in pockets of limestone right on the edge of the cliff at Eagle Head, within the zone of salt water spray. It is only a few metres wide and away from the spray zone is replaced by unit Ma or unit Mh depending on the adjoining soil type. The plant cover is quite open with the *Frankenia* (30-40%, 0.3-0.5 m) by far the most important species. Accompanying species are also salt tolerant and include *Tetragona decumbens* (0-10%, 0.1 m), *Calocephalus brownii* (0-10%, 0.3 m), *Enchylaena tomentosa* (0-5%, 0.3 m), *Rhagodia baccata* (0-10%, 0.4-0.5 m), *Sarcocornia* sp. (0-5%, 0.25 m) and *Sporobolus virginicus* (0-10%, 0.1 m).

Ah *Allocasuarina humilis* Low open heath

Some areas of low open heath were found in which *Allocasuarina humilis* (20-30%, 0.5-1.3 m) was the dominant species. These were small stands probably no more than about 30-50 m wide but usually 50-100 m or more long. It appears to occur in some areas where shallow Quindalup sand overlays some Spearwood soils but a lot more study would be required to confirm this. The accompanying species are mainly the same as those typical of units DsHh and DsMa, i.e. *Dryandra sessilis* (1-2%, 1-1.3 m), *Melaleuca acerosa* (5-15%, 0.5-0.8 m), *Hibbertia hypericoides* (5%, 0.4 m), *Calothamnus quadrifidus* (5%, 0.7-1.2 m), *Hakea prostrata* (5-10%, 0.5-1 m) and even *Jacksonia stricta* (0-20%, 0.4-0.7 m). The main sedge species were *Mesomelaena stygia* (0-30%, 0.4 m) and *Loxocarya flexuosa* (10-25%, 0.1 m). *Lomandra maritima* (0-5%, 0.25 m), more typical of the Quindalup Dunes, was present in some areas.

4.1.5 Spearwood Dunes, deeper soils

As mentioned above the deeper soils of the Spearwood dune system are dominated by woodlands and forests, with the major vegetation types dominated by *Banksia attenuata*. The majority of these areas typically have yellow sands, at least at depth. The degree of leaching appears to be fundamental to the distribution of the different vegetation types recognised, with the more eastern areas appearing to be more leached.

Two vegetation units were recognised on the apparently less leached soils that

occupy the western portion of the zone of woodlands. These are units BHh and BDs, with their under-storeys dominated by *Hibbertia hypericoides* and *Dryandra sessilis* respectively. East of these, on the more leached soils, the major unit is BEp, which also has *Banksia attenuata* but with an understorey dominated by *Eremaea pauciflora* beneath it. As the few low lying areas are approached the importance of *Banksia attenuata* declines and it is eventually replaced by *Banksia ilicifolia* and the vegetation units change from BEp to BMs to Bi, with the the understorey dominants changing from *Eremaea pauciflora* to *Melaleuca ? scabra* and *Hakea prostrata*.

There are several other woodland vegetation types in the more eastern portion of the Spearwood dunes studied. Areas of unit Eg with a tree layer of Tuart (*Eucalyptus gomphocephala*) occur in certain depressions of brown sands with shallow to steep banks. These have an under-storey of *Banksia* and *Acacia* species. Generally in a zone associated with the Tuart there are areas of *Banksia* woodland with *Allocasuarina fraseriana* as an over-storey specie, this is described as unit AfB.

BAh *Banksia attenuata* Low Woodland to Low Open Woodland over *Allocasuarina humilis*

This low woodland appears to be related to unit Ah described above, presumably the soil is deeper allowing the development of an overstorey of *Banksia*. The stands investigated are close to Quindalup dunes and some still have calcareous fragments in the topsoil. *Banksia attenuata* (7-25%, 1.5-4 m) was the main tree species present in these stands. It was occasionally accompanied by *Nuytsia floribunda* (<1%, 4 m) and *Eucalyptus todtiana* (< 1%, 4 m). *Allocasuarina humilis* (20-45%, 0.8-1.3 m) was clearly the major shrub species. It was accompanied by the taller shrubs *Melaleuca acerosa* (5-25%, 0.4-0 m), *Calothamnus quadrifidus* (0-5%, 0.4-0.9 m) and *Daviesia divarivcata* (5%, 0.6-1.2 m) and in some places a lot of *Dryandra nivea* (0-15%, 0.15 m). *Dryandra sessili*. (0-1%, 1.2 m) and *Hakea prostrata* (0-2%, 0.5 m), species typical of shallow soils over limestone were occasionally present. *Lomandra maritima* (5-20%, 0.3 m), *Loxocarya flexuosa* (10-20%, 0.2 m) and *Mesomelaena stygia* (0-5%, 0.3 m) were the most important preennial herb and sedge species. Annual herbs had only about 3% cover.

BHh *Banksia attenuata*, *Banksia menziesii*, *Eucalyptus todtiana* Low Open Forest to Low Woodland over *Hibbertia hypericoides*

Banksia attenuata (5-35%, 2-9 m), *Banksia menziesii* (0-20%, 2-5 m) and *Eucalyptus todtiana* (0-5%, 6-9 m) occur in a range of relative and total abundance to form this broadly defined unit, the upper storey of which covers several structural units. *Xanthorrhoea preissii* (0-10%, 1-3 m) is commonly present and is usually the main tall shrub species. Important shorter shrubs are *Hibbertia hypericoides* (30-60%, 0.5-0.7 m) and *Allocasuarina humilis* (5-20%, 0.6-1.3 m). Other species commonly present include *Calothamnus quadrifidus* (0-15%, 0.9 m), *Conospermum canaliculata* (0-10%, 0.8 m), *Jacksonia stricta* (10-25%, 0.4-0.5 m), *Petrophile macrostachya* (0-5%, 0.5 m), *Leucopogon polymorphus* (0-20%, 0.5 m), *Acacia pulchella* var. *glaberrima* (0-15%, 0.8 m) and *Calothamnus sanguineus* (0-15%, 0.5-0.6 m). The most important sedges are *Mesomelaena stygia* (0-15%, 0.3 m) and *Loxocarya flexuosa* (5%, 0.15m). Other herbs and sedges present included *Schoenus ?subflavus* (0-15%, 3 cm) and *Conostylis teretifolia* (0-2%, 10 cm).

BDs *Banksia*, *Dryandra sessilis* Low open forest to Low woodland

The under-storey of extensive areas of *Banksia* Low woodlands in the Wilbinga area were dominated by *Dryandra sessilis*. Since these areas were only 5 or 6 years post fire it was difficult to define what the species composition of the understoreys of these stands would be when they were mature and in consequence their relationship to other the vegetation types defined here. Examinations made suggest that this type is quite similar to unit BHh (see above). The range of abundance of lower shrub species found beneath this stand, particularly *Hibbertia hypericoides* (30-40%, 0.4-0.7m) and *Allocasuarina humilis* (0-20%, 0.8-1.1 m), fall easily into the range defined for BHh. The main differences were the generally more open tree stratum and the greater abundance of *Dryandra sessilis* (50%, 1.2-2 m) and *Hakea trifurcata* (1-2%, 0.7-1 m).

AfB *Allocasuarina fraseriana*, *Eucalyptus todtiana* Woodland over *Banksia attenuata*, *B. grandis*, *B. menziesii* Low Woodland to Low Open Forest

In areas of lower relief within the Caraban MPA (Wilbinga Buffer) the *Banksia*

woodlands often include the taller *Allocasuarina fraseriana*. This species (5-20%, 8-12m) and *Eucalyptus todtiana* (10%, 8-10 m) tend to form an upper tree stratum. Beneath this are *Banksia attenuata* (25-30%, 5-9 m) and *Banksia menziesii* (0-10%, 4-6m) as well as *Banksia grandis* (1-15%, 5-8 m). These trees form a much denser cover than other woodlands recognised in the study areas. The shrub species appear to be correspondingly less dense, particularly beneath the *Allocasuarina* with its often dense litter. Occasionally tall shrubs species are present including *Xanthorrhoea preissii* (0-4%, 1-2.5 m) *Jacksonia sternbergiana* (0-1%, 1.5-2 m) *Acacia rostellifera* (< 1%, 1.6 m) and *Hakea ruscifolia* (0-5%, 1-1.2 m). The low shrub layer was dominated by *Hibbertia hypericoides* (25-30%, 0.5-0.8 m) and *Stirlingia latifolia* (2-20%, 0.6-0.8 m). Other species present included *Calytrix flavescens*, *Petrophile linearis*, *Leucopogon propinquus*, *Bossiaea eriocarpa* and *Gompholobium tomentosum*. Sedges are rather sparse with *Mesomelaena stygia* (0-2%, 0.3m) the only species of significance. The perennial herb *Drosera erythrorrhiza* was locally abundant but annual herbs were uncommon.

BEp *Banksia attenuata*, *Banksia menziesii* Low Open forest to Low Woodland over *Eremaea pauciflora*

Much of the *Banksia* Low woodlands of the eastern part of the Wilbinga buffer is of this type. The tree species are *Banksia attenuata* (20%, 1.5-7 m) and *Banksia menziesii* (5-15%, 1.5-5 m) with some *Eucalyptus todtiana* (0-5%, 5-7 m) and *Nuytsia floribunda* (<1%, 3 m). The tall shrub species *Xanthorrhoea preissii* (0%, 1-1.5 m) and *Hakea ruscifolia* (0-1%, 1.1.5 m) are occasionally present. *Eremaea pauciflora* (30-60% 0.5-0.7 m) dominates the low shrub layer. Other species commonly present include *Stirlingia latifolia* (10%, 0.4-1 m), *Hibbertia hypericoides* (0-20%, 0.5-0.9 m), *Allocasuarina humilis* (0-25%, 0.7-1.2 m) and *Eremaea* sp. (0-5%, 0.5 m). Sedges are also not very important with those present including *Loxocarya flexuosa* (0-2%, 0.15 m), *Lepidobolus ? chaetocephalus* (0-1%, 0.3 m) and *Mesomelaena stygia* (0-5%, 0.3 m). The perennial herbs *Patersonia occidentalis* (1%, 0.3 m) and *Drosera erythrorrhiza* (0-2%, 2 cm) are important in some areas but few annual herbs are present. *Stirlingia latifolia* is much more abundant after fire and can exceed 50% cover. Also after fire the tall shrub species *Jacksonia sternbergiana* is relatively

common in some of this woodland type, particularly those near areas of *Allocasuarina fraseriana*.

BMs *Banksia attenuata*, *Banksia menziesii* Low Woodland to Low Open Forest over *Melaleuca ? scabra*

This vegetation type occurs generally between unit BEp and the small areas of *Banksia ilicifolia* (unit Bi). It may be a broad band if the relief is only slight or narrow if the relief is steeper. The tree species are *Banksia attenuata* (15-40%, 3-6 m), *Banksia menziesii* (5%, 4 m) and the occasional *Banksia ilicifolia* (< 1%, 3-4 m). A few tall shrubs may be present including *Xanthorrhoea preissii* (0-2%, 1-2 m), *Hakea prostrata* (0-1%, 1.5-2 m) and *Hakea ruscifolia* (< 1%, 1-1.5 m). The lower shrub layer is dominated by *Melaleuca ? scabra* (50-60%, 0.3 m). Other shrubs present include *Eremaea pauciflora* (0-7%, 0.6 m), *Stirlingia latifolia* (0-10%, 0.5 m), *Scholtzia laxiflora* (0-25%, 0.4 m), *Conostephium pendulum* (0-10%, 0.4 m), *Melaleuca acerosa* (0-8%, 0.5 m), *Petrophile macrostachya* (0-2%, 0.5 m) and *Eremaea* sp. (< 1%, 0.4 m). The few sedges include *Schoenus ? subflavus*, *Lyginea barbata* and *Loxocarya flexuosa*. The perennial herb *Patersonia occidentalis* was also present.

Bi *Banksia ilicifolia* Low Woodland

The few old drainage depressions in the eastern part of the Wilbinga buffer are occupied by a variable low woodland dominated by *Banksia ilicifolia* (5-20%, 2-8 m) and *Banksia attenuata* (2-25%, 4-6.5 m). Shrub species are also variable seemingly responding to differences in soil development. In some areas there is a well developed tall shrub layer including *Hakea prostrata* (35%, 1.5-2.5 m) and some *Xanthorrhoea preissii* (to 15%, 1-3 m). In other areas these are absent or only sparingly present along with occasional plants of *Hakea ruscifolia* and *Jacksonia furcellata*. The low shrub layer is important throughout this vegetation type but is apparently suppressed when the taller species are more abundant. Where there is a relatively large patch of this vegetation type, the low shrub species include *Melaleuca ? scabra* (40%, 0.3 m), *Calytrix ? flavescens* (25%, 0.3 m) and *Scholtzia laxiflora* (2-10%, 0.3 m). One small patch inspected had *Eremaea pauciflora* (60%, 0.7 m). The sedge layer is always important but again variable, perhaps reflecting different moisture

conditions. Species noted include *Baumea juncea* (0-30%, 0.4m), *Schoenus ? subflavus* (0-10%, 3 cm), *Alexgeorgia nitens* (2-30%, 0.1 m), *Caustis dioica* (2%, 0.3 m), *Lepidobolus chaetocephalus* (1%, 0.3 m) and *Hyplaena exsulcata* (1%, 0.4m). The perennial herb *Patersonia occidentalis* (0-2%, 0.3m) was also present.

Ed *Eucalyptus decipiens* Low Open Forest

Small areas of *Eucalyptus decipiens* (10-50%, 5-8 m) form low open forests. The geomorphic relationship is not clear but stands are apparently associated with dissection or re-working of the Spearwood soil types. It appears to be associated with stands of Tuart (*Eucalyptus gomphocephala*) and like Tuart often occurs as isolated trees. The shrub layer is sparse beneath the denser stands of *E. decipiens* but, quite important beyond the canopy. Two stands of this tree were inspected and the shrub species were different in each indicating that in a detailed study they would be separated. The understorey of one was similar in composition to unit DsHh with *Dryandra sessilis*, *Hakea trifurcata* and *Hibbertia hypericoides*. The other reflected the shrub composition of unit BEp in having *Eremaea pauciflora* as the most abundant understorey species. It was concluded therefore that the *E. decipiens* trees were growing in various heath units and were not of sufficient extent to exhibit any characteristic suite of shrub and sedge species.

Eg *Eucalyptus gomphocephala* (Tuart) Open Forest

Tuart (*Eucalyptus gomphocephala*, 0-60%, 5-20 m) occurs from single trees to stands with enough cover to be called open fores. The most extensive stands are in the eastern portions of the study sites and generally occur on the Spearwood Sand soil unit recognised by McArthur and Bartle (1980a). They are usually in depressions, these apparently reflecting subsidence associated with dissolution or collapses of the underlying Tamala Limestone. In a similar situation to that described for unit Ed, the shrub species beneath the Tuart can reflect that of the surrounding shrubland or woodland. Often present are small trees including *Banksia attenuata* (0-40%, 3-5 m) and *Acacia cyclops* (0-5%, 3-4 m). The shrub layer was relatively sparse, the tall shrubs found including *Hakea prostrata* (0-1%, 1.2 m), *Hakea ruscifolia* (0-5%, 1.5 m) and *Xanthorrhoea preissii* (1-10%, 1-2 m). Low shrubs included *Hibbertia*

hypericoides (5-15%, 0.3 m), *Dryandra nivea* (5%, 0.2 m), *Melaleuca acerosa* (0-35%, 0.3 m), *Melaleuca scabra* (0-15%, 1 m) and *Petrophile brevifolia* (0-5%, 0.3 m). *Loxocarya flexuosa* (5-15%, 0.15m) was the most consistently recorded sedge species.

4.2 Representation of the different vegetation types at Wilbinga and Breton Bay

The two study areas are both coastal although, Wilbinga extends further inland than Breton Bay. They also have basically similar geomorphology and soils, are in the same botanical district and are not very far apart. Consequently they have reasonably similar vegetation developed in them. However, there are significant differences. Some of these are due to the inclusion of more areas of the deeper soil types of the Spearwood dunes in the Wilbinga area and as a result larger areas of woodland and open forests. Others are due to slight differences in soil (e.g. the occurrence of the *Eucalyptus* species on the limestone at Breton Bay) or the development of different situations such as the area of Spearwood limestone at the southern end of Breton Bay that has the *Chorizema varium* population on it.

The representation of the different groups of vegetation units in the two areas are discussed in the same groupings in which they have been described above and the representation of individual units tabulated in table 1. The groupings are: the strand; the Q4 age Quindalup dunes; the Q3, Q2 and Q1 age dunes and deflation basins; the Spearwood Dunes, shallow soils and the Spearwood Dunes, deeper soils.

The strand

The strand vegetation types are poorly developed in both areas as the coastline is eroding, and as it does forces the species that comprise the strand vegetation types into narrow bands at the base of the Q4 age Quindalup dunes.

Q4 age Quindalup dunes

The narrow beaches in both areas are generally backed by areas of Quindalup dunes perched on Tamala limestone of significantly higher elevation than the mean sea level. The first dune is generally a recently truncated (by erosion of the coastline) and now partially stabilised Q4 dune. These rise up to 10 or 15 m above sea level and occur as a narrow strip along the coastline of both the Wilbinga and Breton Bay areas.

The area of mobile dunes (ie. Q4 dunes that are not stabilised) is small, with the most significant area being in the north of the Breton Bay buffer area. The Q4 dunes and consequently the vegetation on them are only minor parts of the landscape in both areas but there appears to be a larger area of them at Wilbinga (both in the buffer and the core) than at Breton Bay.

Q3, Q2 and Q1 age Quindalup dunes and deflation basins

Unfortunately detailed mapping of the ages of the Quindalup dunes is not available for Breton Bay however, from their form (more irregular and steeper than Q1 & Q2) and vegetation (more *Acacia* spp. in the dominants) it appears that there are larger areas of Q3 age dunes at Breton Bay than at Wilbinga. They occur in the northern part of the Breton Bay buffer area, where they extend several kilometres inland. In contrast, the areas of Q3 dunes are mostly localised and near to the coast at Wilbinga.

The Q2 and Q1 dunes are wide spread in both study areas and extend a considerable distance inland. Much of them, especially the interdunal deflation basins, has been cleared in the Breton Bay site. In contrast only some have been cleared in the northern part of the Wilbinga buffer. Shrub species (eg. *Chamalauceum uncinatum* in unit CuMa) appear to be more important in the vegetation remaining on these dunes in the Breton Bay site than at Wilbinga. Stands of *Santalum* were much more common at Breton Bay (particularly in location 3091) than at Wilbinga. These differences appear to reflect a difference in fire history with the Wilbinga site having been burnt more recently. However, it is possible that soil factors are also involved.

The deflation basins within the older Quindalup dunes can have exposed Spearwood dunes or a layer of shallow Quindalup sands over the Spearwood dunes. Without detailed mapping it is not possible to say how much of the different categories is present at Breton Bay however, both situations were present at both Wilbinga and Breton Bay. The completely exposed Spearwood Dunes are more often associated with the older (Q1 and Q2) dunes. Commonly a deflation basin contained a mixture of the two situations.

Spearwood dunes, shallow soils

There are extensive areas of this complex, including shallow sand over limestone and limestone at the surface at both sites.

- **shallow sand over limestone:** Areas of *Dryandra sessilis* (unit DsHh) on shallow sands over limestone occur consistently along the western side of the Spearwood dunes. This vegetation type, together with unit DsMa is extensive and in Good to Excellent condition at both sites. Most stands at Wilbinga are of a relatively young age since last fire. A number of stands at Breton Bay are relatively long unburnt.

- **limestone surface:** Areas of exposed limestone are common in both sites. Generally these occur as peaks within areas of heaths on shallow sands over the limestone. These often have *Melaleuca huegelii* (unit Mh) with some *M. cardiophylla* (unit Mc). In particular the Caraban MPA (part of the Wilbinga buffer) has many limestone peaks which are in a matrix of woodlands (deep sand) but Breton Bay has none. In contrast the Breton Bay buffer (mainly location 5710) has all of the stands of mallee eucalypts (unit E) found on exposed limestone during this survey. *Eucalyptus "argutifolia"* is reported to occur within the Caraban MPA (pers. com. W. Muir, CALM Wanneroo) but it is not at all conspicuous on aerial photographs as the Breton Bay stands are. No stands of *Eucalyptus "petrensis"* were found in the Wilbinga site. Small stands of another mallee (*E. foecunda*) were found at Wilbinga but not at Breton Bay. These stands were within areas of *Dryandra sessilis* (unit DsHh) on shallow sands over limestone.

East of the belt of shallow sand and outcropping limestone is a belt within the Spearwood Dunes of deeper yellow sand with hills and rises of exposed limestone. The proportion of limestone outcrops reduces from west to east within this belt. It is well developed in the Wilbinga study area but occurs east of the Breton Bay site. The vegetation associated with this soil unit is common at Wilbinga and uncommon to absent at Breton Bay.

Only one coastal limestone exposure was found, Eagle Head at the Breton Bay site. This forms a sea cliff of limestone. Near coastal exposures are localised in the Breton Bay site near Eagle Head but are still much more extensive than at Wilbinga. Thus stands of *Melaleuca cardiophylla* (unit Mc) are more common at Breton Bay than at Wilbinga, while Wilbinga appears to have more of those limestone exposures which are remote from the coast

Spearwood dunes, deeper soils

The Wilbinga core contains sizable stands of *Banksia* woodlands (units BAh, BDs and BHh) but Breton Bay has only a few very small patches. Other types of *Banksia* woodlands and forests (units BEp, AfB, BMs and Bi) are totally absent from Breton Bay but moderately common in the Wilbinga buffer, mainly in the Caraban MPA.

Stands of eucalypt woodland and forest are present at both sites but again much more common in the Caraban MPA than at Breton Bay. A couple of moderately sized stands of Tuart (unit Eg) occur at Wilbinga in Caraban MPA. The only stands at Breton Bay are much smaller, and almost without exception, in cleared or partially cleared paddocks. Similarly, small stands of *E. decipiens* woodlands (unit Ed) are present in the Caraban MPA and virtually only in cleared paddocks at Breton Bay (Location 5710).

Table 1: Summary of occurrence of vegetation units in the core and buffer areas of the Wilbinga and Breton Bay study areas. (p = unit is present, ? = presence or absence not known, low or very low = present but area of unit small or very small)

<u>Soil/Geomorphic group and Vegetation units</u>	<u>WILBINGA</u>		<u>BRETON BAY</u>	
	<u>Core</u>	<u>Buffer</u>	<u>Core</u>	<u>Buffer</u>
<u>Strand</u>				
Cm	p	?	?	?
Sl	p	p	p	p
<u>Q4 age Quindalup dunes</u>				
Sc	p	p	p	p
ScOa	p	p	p	p
SgSc	p	p	p	p
SgMa	p	p	p	p
<u>Q3,2,1 age Quindalup dunes (including deflation basins)</u>				
Ma	p	p	p	p
CuMa	v. low	v. low	p	p
AMa	low	low	p	p
<u>Spearwood dunes, shallow soils</u>				
DsHh	p	p	p	p
DsMa	p	p	p	p
Mh	p	p	low	p
E	-	-	-	p
Mc	p	?	p	p
Fp	-	-	p	-
Ah	p	p	p	p
<u>Spearwood dunes, deeper soils</u>				
BAh	p	p	low	low
BHh	p	p	v. low	v. low
BDs	p	p	-	-
AfB	-	p	-	-
BEp	-	p	-	-
BMs	-	p	-	-
Bi	-	p	-	-
Ed	-	low	-	v. low
Eg	-	p	-	v. low

4.3 Condition of the vegetation in the Wilbinga and Breton Bay study areas

The condition of the native vegetation on both study sites was assessed partly during the vegetation survey and partly from the aerial photographs. Very little of the Wilbinga site has been cleared whereas much of the Breton Bay site has been. The uncleared land in the Wilbinga site is only slightly affected by weed invasion and fires while the uncleared land in the Breton Bay site has much more weed invasion and soil disturbance. The greater invasion by weeds reflecting the smaller size of the uncleared blocks and the presumably greater grazing pressure resulting from more intensive use of the area. However, many of the uncleared areas in the Breton Bay study area are still in "Good" to "Excellent" condition (see Appendix two for definition of the categories in the condition scale) partly because they tend to be the limestone or shallow soil over limestone areas of the Spearwood dunes which have dense heath vegetation. The condition of the core and buffer areas of the two areas are commented on separately below, the condition ratings (Excellent, Very Good, Good, Poor, Very Poor and Completely Degraded) are defined in Appendix two.

Wilbinga core

The majority of the Wilbinga core (location 9756) is in Good to Excellent condition. The property (owned by the Crown but under lease to a primary producer) has been grazed for some time and about one eighth of it is cleared with pasture established. The clearing is almost entirely in one block in the south east and the extent appears to have been static for at least 15 years. Fences limit the access of cattle to other parts of the block although it is obvious that some rough grazing of the uncleared vegetation appear to still occur.

Despite the history of the area being grazed, the majority of the vegetation shows only minor signs of having been degraded. Weeds are concentrated mainly along some tracks and a few sites with obviously higher nutrient status. Essentially the weeds are only present in some of the areas of *Acacia* thickets (on both Quindalup and Spearwood soils) and a few small stands of Tuart (*Eucalyptus gomphocephala*) which have had much of their original understorey replaced by weeds. The low heaths which occupy the majority of the Wilbinga core, show little sign of having been

adversely affected by the grazing. There is little evidence of soil erosion due to grazing and associated activities and this is almost entirely due to vehicle traffic on only a few of the tracks.

The effect of fires caused by european man was difficult to assess since a large proportion of the core had been burnt too recently for the vegetation to regain its mature ("climax") structure. However, the presence of obligate seed species (i.e. species that depend on seed rather than rootstocks for re-establishment after fire or other disturbance and whose populations can be significantly reduced or removed by frequent fire) such as *Dryandra sessilis* in the expected areas suggests that the floristic composition of the vegetation types has changed little.

The coastline is essentially undisturbed and the limited access has ensured that the narrow strand and the Q4 dunes are in excellent condition.

Wilbinga buffer

The proposed buffer is composed of land of various ownerships, landuse and corresponding condition. There are five blocks of alienated land (two of which are Crown owned) and an area of State Forest. These are described sequentially in a clockwise direction.

Locations 2914 and 2424 are a partially cleared grazing property. The majority of clearing has been in the north of these locations. The uncleared patches in the north are somewhat disturbed, presumably by grazing or over burning. The coastal portions seem to be in good to excellent condition. While some of the south east portion of the property shows signs of grazing it is still in mainly good condition. Location 8185 shows only minor signs of European landuses. Past burning and grazing appear to have had only minor localised impacts. Essentially it is in Very Good to Excellent condition.

The portion of State Forest 65 within the buffer is in Very Good to Excellent condition, except for three relatively small trial pine plantations which, from the

view of condition of native vegetation, are Very Degraded. Few weeds have been introduced to the area either at the several apiary sites or along the tracks. Most of the vegetation exhibits no evidence of there having been excessively frequent burning. The absence of *Dryandra sessilis* from a few areas with limestone close to the surface suggests that some minor modification of species composition may have occurred in the buffer areas for the adjacent pine plantations.

Locations 9757 and 9755 both show signs of having been grazed in the past although neither currently have any stock on them. The disturbance is concentrated along tracks and around old watering points and stock yards and weed species have intruded little into the areas dominated by native vegetation. However, like in the Core, there are high concentration of weeds in the *Acacia* thickets. Although these two locations have not been burnt in recent years, the absence of *Dryandra sessilis* and *Hakea trifurcata* from some of the limestone areas suggests modification of the vegetation by too frequent burning has occurred in some vegetation types.

Location M1688 (a portion of which is in the buffer) was only inspected from its northern boundary and via aerial photography. It shows significant signs of impact from grazing activities, the interdunal areas of the Quindalup dunes are cleared and the dunes extensively modified. The eastern part appears to have been parkland cleared but the native species are gradually re-establishing (at least in the NE corner). Even so the condition of this portion has been rated as Poor. The central portion dominated by vegetation on limestone and shallow sands is believed to be in Good condition.

Breton Bay core

The Breton Bay core is composed of several locations, all alienated and privately owned. The condition and landuse varies greatly. Much of it is cleared but some is not. The latter parts are still in Good to Excellent condition however, much of the uncleared area is in small blocks and therefore has a high perimeter to area ratio.

Most of location 5274 has been cleared and a number of areas of unstable soil are

apparent on it. The uncleared remnants are essentially the taller (younger) dunes. These appear to be essentially in Good condition but are highly vulnerable since they are narrow and are open to the cattle which graze the area. The coast adjacent to location 5274 is in Good to Excellent condition except for a few small areas where vehicle have access. Location 5277 is mostly cleared area and also has some areas of unstable soil. The few remnants were not closely inspected but appear to be only Poor condition or Poor to Good. Location 3083 is extensively cleared and is grazed, it is mainly Quindalup dunes and most of the interdunal areas are cleared. The lower (older) dunes are also cleared or greatly modified by grazing. The steeper (younger) dunes including most of the area adjacent to the coast are not cleared. However, significant weed invasion has occurred particularly in those remnants in the paddocks. Much of these remnant areas are therefore only in Poor to Good condition. Grazing and movement of stock and vehicles have created a number of unstable areas in the Quindalup Dunes. The strand and primary dune are in Good to Excellent condition except for the small areas which are occupied by shacks which are in Poor condition. The one area of Spearwood Dunes in the south east corner of the location has not been cleared and appears to be in Good to Excellent condition. The extent of weed invasion is not known but it is likely that most weeds are limited to a margin of a few 10's of metres. It has not been burnt for many years and appears to have not been affected by too frequent burning. It is contiguous with uncleared areas to its south and east.

Location 5707 is entirely uncleared. It appears to be in Good to Excellent condition. No evidence suggesting that the area has been grazed, at least in recent years was seen and weed invasion was low. Since it had been burnt recently and the vegetation did not have a mature structure it was not possible to determine whether its fire history had affected the vegetation.

Location 5708 is virtually all Spearwood dunes. Most of the deeper soils in this location have been cleared and have pasture and lupins established. The uncleared areas are mainly shallow sand over limestone and in some cases outcropping limestone. Cattle graze the location and have access to all but the south western

corner. Small remnants are mostly invaded by weeds to some degree and were considered as being of Poor to Good condition. The larger remnant which abuts uncleared areas to the west and south is generally in Good to Very Good condition. There are a number of tracks in this remnant and these have provided a route by which weeds have become established. It also appear to be periodically used for grazing. There was no evidence of erosion or instability on this location.

Location 3091 was entirely uncleared and the Quindalup and Spearwood Dunes areas both appear to be in Very Good to Excellent condition. Weed invasion is minor and generally confined to a few metres from the tracks. However, some small areas have been totally modified including the sites of several shacks adjacent to the foredune. There is little obvious signs of the area having been disturbed but there are some subtle ones. Although there has apparently been some grazing, frequent fires at some time in the past have probably had the greatest impact on the area. They seem to have modified the structure and composition of some vegetation types by local elimination of some fire sensitive species. For example, in some areas *Dryandra sessilis* is absent or of lower than expected importance and *Banksia prionotes*, also fire sensitive, is represented by only three plants.

Breton Bay buffer

Like the core much of the buffer at Breton Bay is cleared. Most of the uncleared remnants are small but many of these are in Good to Very Good condition.

Location 3056 is only partly cleared, essentially just the eastern part. In this part the few remnants are either disturbed or seriously invaded by weeds. The majority of the western part of the location is uncleared. This includes most of the steeper dunes of this location. The interdunal areas are a mixture of Quindalup and Spearwood soils. Although the majority of the uncleared vegetation of the western part was burnt only a few years ago fire does not appear to have caused significant changes in structure and composition and these areas are in Good to Excellent condition. Cattle have access to these uncleared areas but appear to have had no significant impact on the condition of the uncleared vegetation (possibly they prefer grazing in the cleared

areas). Weed invasion appears to be limited to old tracks and fence lines and there is soil instability in parts of the cleared areas.

Location 5706 is mostly cleared and the few remnants are in Poor condition. Locations 5705 and 6515 are both uncleared and are in Good to Excellent condition however, they are little more than wide road reserves. Locations 5703 and 5709 are both virtually all cleared and appear to be both grazed and cropped and have been considered Totally Degraded from a nature conservation point of view. Some regrowth, particularly on location 5703, is in Poor condition, the few remaining trees are small groves of Tuart.

The northern part of location 5710 is mostly uncleared. The western two-thirds is fenced off and is in Good to Excellent condition, with weeds mostly confined to near the tracks. Although it has been many years since most of this area has been burnt, there is evidence that frequent fires might have changed the composition of some of the vegetation types. The eastern portion has a central uncleared remnant which appears to be in Good to Excellent condition despite the access which sheep have to it. Weeds in the uncleared area are again confined to the margins, old tracks and a gravel pit.

The southern part of location 5710 is about half cleared, with the clearing mostly in the east. This has left a large uncleared remnant in the west which is mostly in Good to Excellent condition. Small disturbances, particularly in the Quindalup dunes, have caused the loss of some native species and the invasion of weeds. Although much of the Spearwood dunes area in this large remnant has been burnt recently, its composition appears to not have been changed significantly. The eastern part of the block has a number of uncleared remnants. These are mostly the uplands which are non-arable because of the exposure of limestone. They are not fenced off but the stock appear to have only affected the margins. Most of these remnants are in Good to even Excellent condition. Several areas of pasture have trees and mallees.

Reserve 31772 is essentially uncleared except where extraction of gravel has destroyed

a part of the native vegetation. The condition of the remainder of it has been difficult to assess because it was burnt quite recently. It appears to be managed as part of Lease 3114/950 and stock appear to have periodic access to it. There is a rubbish dump adjacent to it and it is likely that the frequent fires which are started in rubbish tips would have burnt into the bushland and caused changes in vegetation structure and composition. Consequently this area was rated as mostly in Good condition with small patches in Very Good condition.

The Seabird Road divides Lease 3114/950 into two parts. The eastern areas of both parts are largely cleared or at least modified by grazing. The small remnants within the clearings are mainly in Poor condition. A large remnant east of Seabird has been burnt recently but appears to be in Good condition although it is used for grazing. The northern part of this lease west of the rubbish dump is mainly Quindalup dunes, and these are in Good to Very Good condition with areas in Excellent condition. There is only minor weed invasion. Location 1741 is in similar condition to the northern part of the above lease, except a small area which has been totally cleared for a shack and stock. The coastal strip adjacent to Location 1741 and Lease 3114/950 appears to be in Good to Excellent condition.

5.0 CONSERVATION VALUES OF THE STUDY AREAS

5.1 Introduction

The Wilbinga and Breton Bay study areas undoubtedly have conservation value for flora and vegetation types. The extent of this value is a function of many variables that need to be taken into account when assessing the conservation value of an area for flora and vegetation. These variables are discussed below and then applied to the study areas in subsections 5.2 and 5.3 and section 6.

1) **the vegetation types and species of flora found there;** obviously an area has conservation value for those species or vegetation types that are found within it.

2) **how extensive the vegetation type is or how large the population sizes of a species of flora are (both in the area and elsewhere);** individual stands of vegetation types which exist nowhere else or rare flora will be considered to have higher conservation value than vegetation that is extensive or species that are very common over large areas. However it should be noted that this is a human value system that is being applied and that even populations of very common species or stands of common vegetation types still have intrinsic value. That is, common things (vegetation types, species) have conservation value, the underating of this value often leads to common things being poorly conserved because no-one has valued them.

3) **their distribution,** different vegetation types and individual flora species occur in different ways, for example as single blocks, as part of a recurring pattern or related to a specialised ecological situation such as the strand or wetlands.

4) **where in the distribution** of the vegetation type or the species the stand or population occurs. It is generally considered important to conserve a vegetation type or species over its range so that a representative sample of the variation is conserved and consequently stands or populations at the ends of the range of a vegetation type or flora species are considered to have higher conservation value.

5) how previous development has effected the extent of a vegetation type or how population sizes of flora species have been reduced by clearing and other development.

6) how well reserved the vegetation types or flora species are in secure conservation reserves. While the conservation value of a particular stand or population is from one point of view an intrinsic value, the perceived need to conserve a particular stand or population (i.e. part of the common useage of the term "conservation value") will vary depending on how well represented the vegetation type or species is in secure conservation reserves.

The factors listed above relate to the value of an area for the conservation of vegetation types or flora species for their continued existence rather than for use by man. An area of land can also have value through the conservation of the vegetation and flora on it from an anthropocentric point of view. For example, areas of land with native vegetation in an urban setting offer opportunities for education, enjoyment (bushwalking, observing native flora) and research that would not be possible on areas at a long distance from centres of population because of the distances involved in travel. Kings Park is an excellent example of such a reserve where there is widespread community acceptance that such values exceed the value of the land for development. Another anthropocentric viewpoint is an economic one where conservation value can be understood to exist because of a potential to find value in the flora of an area for economic purposes such as a source of wildflower species for cultivation for export, or as a source of drugs or alternative crops. Such value is extremely difficult to quantify because it is extremely difficult (if not impossible) to foresee the circumstances that will apply in the future to make a particular plant valuable.

Although this section is largely concerned with the conservation value for the protection of flora and vegetation brief comment will be made on the conservation value of the study area from other points of view (see subsections 5.4 & 5.5).

5.2 Conservation value for flora

The two study areas each have value for the conservation of the populations of those species known from it. That is they have value for the 220 native flora species known from Wilbinga and the 168 native species known from Breton Bay. In addition to this general value for all the species found in the two areas there is a particular value for those that are gazetted as rare flora, are restricted in distribution (either geographically or to a particular habitat), are not common or are poorly known, or are at or near the end of their range. Species of specific interest here include *Chorizema varium*, *Eucalyptus "petrea"*, *E. "argutifolia"* and *E. foecunda*, *Conostylis pauciflora* subspecies *euryhipis*, *Stylidium "maritima"* and *Alyogyne huegelii* ? var. *glabrescens*. The distribution of these species of particular interest between the two study sites is shown in table two. (See section 3.2 above for more details on individual species.)

Although on an individual basis the value for those species that are not of particular interest may be less than for those that are. Collectively it is probably at least as significant if not more so, as there are much fewer species of particular interest. It needs to be noted here that if common species are not adequately protected they will also become rare. For example, the study areas have significant value for the conservation of species such as *Lomandra maritima* and *Pimelea ferruginea* which are almost entirely restricted to the Quindalup dune system which is not adequately reserved except at the northern and southern ends of its range.

From table two it can be seen that many of the species of particular interest are at both Wilbinga and Breton Bay but that some are at one and not the other. From section 3 it can be seen that this also applies to the other species. From this it can be said that while the two areas have much similarity in their value for the conservation of flora that there are significant differences. However, given the range of species present, the number that are of particular interest and noting that many of the others are also not very abundant or very widespread, the conservation value for flora of both sites would have to be considered high. This would have to be qualified by saying that this does not include the areas that are cleared. The value of Wilbinga would be higher because its greater area of uncleared vegetation implies larger

Table two: Presence and absence of species of particular interest in the two study areas. Notes: 1. W = Wilbinga, BB = Breton Bay. 2. Presence or absence is as found in this survey, more detailed searching would probably show some populations were missed. 3. More detailed searching would probably locate other species of interest. 4. # sign indicates species restricted to near coastal areas.

Species	W core	W buffer	BB core	BB buffer
# <i>Conostylis bracteata</i>	X	-	-	-
<i>C. pauciflora</i> ssp. <i>euryhipis</i>	X	X	X	X
Restricted to Quindalup dunes Cervantes - Yanchep.				
<i>C. teretifolia</i> ssp. <i>planescens</i>	X	X	X	X
Uncommon Gingin - Yanchep - Wanneroo in <i>Banksia</i> woodland.				
<i>Conostylis bracteata</i> x <i>C. candicans</i>	X	X		
# <i>Chorizema varium</i>	-	-	X	-
Presumed extinct prior to this survey				
# <i>Eucalyptus</i> sp. (Yanchep)	-	-	-	B10
Declared rare flora. Yanchep - Lancelin				
<i>Banksia leptophylla</i>	-	-	-	X
Near southern end of range.				
# <i>Petrophile</i> aff. <i>brevifolia</i>	X	X	X	X
# <i>Petrophile</i> aff. <i>serruriae</i>	X	X	X	X
<i>Calandrinia bevipedata</i>	X	X	X	X
Northern extent of its range.				
# <i>Stenopetalum gracile</i>	X	X	X	X
Northern end of range.				
<i>Acacia idiomorpha</i>	-	-	X	-
Southern end of its range.				
<i>Acacia truncata</i>	X	X	X	X
Northern end of its range.				
<i>Nemcia reticulatum</i> var.	X	X	X	X
Not known in any conservation reserves south of Nambung.				
# <i>Diplolaena microcephala</i> aff. var. <i>microcephala</i>	X	X	X	X
Only known from a few collections made from Yanchep to Jurien.				
# <i>Alyogyne huegelii</i> ? var. <i>glabrescens</i>	X	X	X	X
Restricted, Yanchep to south of Dongara.				
# <i>Trymalium albicans</i>	X	X	X	X
# <i>Hibbertia spicata</i> ssp. <i>leptotheca</i>	X	X	X	X
# <i>Pimelea gilgiana</i> (Thymelaeaceae)	X	X	X	X
Southern end of range.				
# <i>Eucalyptus foecunda</i>	-	-	-	X
Priority 5, coastal endemic, south of Mandurah to north of Lancelin, not common.				
# <i>Eucalyptus "petrensis"</i>	-	-	-	X
Priority 3, restricted Yalgorup to Seabird.				
<i>Hydrocotyle diantha</i> N end of range	X	-	-	-
# <i>Astroloma microcalyx</i>	X	X	-	-
Poorly collected, Cervantes to Yalgorup.				
<i>Stylidium</i> sp. " <i>maritima</i> "	-	-	-	X
Northern end of range, populations not common				

overall populations of plants would be present and significantly more native flora species (52, see section 3) were recorded from there.

There are many taxa recorded for the study areas that are confined to near coastal areas on shallow sandy soils over limestone on the coastal plain these are indicated by a # sign. These taxa are poorly conserved as there are no coastal conservation reserves between the Perth Metropolitan area and Nambung National Park and only small and very small reserves in the Perth area. South of Perth the only large coastal reserve is Yalgorup and this only has small portions extending right to the coast. Some of these taxa extend north beyond Nambung but their southern populations are not conserved, eg. the Geraldton Wax, *Chamelaucium uncinatum*.

5.3 Conservation Value for Vegetation

It is clear that both sites have examples of a wide range of vegetation types on both Quindalup and Spearwood dunes. These vegetation types are restricted to coastal and near coastal areas in the South West of Western Australia and are not adequately reserved. Of importance here is that many of the stands of these vegetation types in the study areas are in Good to Excellent condition. The vegetation of the Quindalup dune system is moderately well conserved at the extremes of its distribution in Yalgorup National Park (south of Mandurah) and in Nambung National Park and the adjoining Wanagaran Nature Reserve (both north of Lancelin). However, it is not conserved in the middle of its distribution. As a consequence, the study areas and some other uncleared areas between the Yanchep area (e.g. Alkimos and Ningana) and Lancelin have very significant conservation value for the vegetation of the Quindalup dunes. The degree of this significance is increased by the following points:

1. There are changes in the vegetation of the Quindalup dunes from north to south caused by the gradient of climatic change from north to south over the distribution of the dune systems.
2. Due to the discontinuous distribution of the Quindalup dunes and disturbance by urban development and agriculture there is no significant

opportunity to reserve this vegetation complex just south of Wilbinga (i.e. the Ningana/Alkimos general area) and Mandurah.

3. The Quindalup dune system is not represented in Neerabup National Park and there are only a few hectares of the system in Yanchep National Park.

The Spearwood dune system has a similar pattern of distribution to that of the Quindalup dune system, except that it is more continuous and broader. It is generally not well represented in conservation reserves, especially south of Perth (where it is largely cleared) but has moderate representation in Yalgorup National Park (south of Mandurah) and in Nambung National Park and the adjoining Wanagaran Nature Reserve (both north of Lancelin). However, unlike the Quindalup dune system, the Spearwood dune system has significant representation in conservation reserves in the metropolitan area (in Neerabup and Yanchep National Parks and some other smaller conservation reserves) although this should not be viewed as adequate to fully represent the full range of the system. Consequently, the areas of the Spearwood dunes in the study areas and on other uncleared land between the Yanchep area and Lancelin have significant conservation value. The degree of this significance is increased by the following points:

1. There are changes in the vegetation on this dune system (both the deep sand and shallow sand/limestone surface types) from north to south and from east to west (Trudgen, 1988, 1987) and the areas of the system in the study areas include significant amounts of the westernmost portion of the system, which is poorly represented in the metropolitan reserves.
2. Even though this system is better represented in reserves than the Quindalup system, it is still not well represented.
3. The vegetation of the Spearwood dunes is more diverse than that of the Quindalup dunes and this means that to adequately conserve this variation

larger areas are required.

Table 1 shows that the Wilbinga site, especially the buffer, contains a greater diversity of vegetation than the Breton Bay site but that neither sites include the full range of vegetation units recognised during this study. Wilbinga does not have vegetation units E and Fp and only has small amounts of units CuMa and AMa. On the other hand Breton Bay has very little area of the deeper sands of the Spearwood Dunes and some vegetation types of these soils (e.g. units BEp and Bi) are totally absent. The most important points relating to the conservation value of the vegetation found on the two sites are summarised below.

Wilbinga

Probably the most important feature of the Wilbinga site is its diversity of vegetation in good condition in a more or less single block. Of the approximate 10,000 ha less than 2,000ha has been cleared. The size of the uncleared area means there is a high chance of long term viability for the vegetation types. This area contains most of the vegetation types represented on both the Quindalup and Spearwood dunes in this study. It is thus an extremely valuable resource, given that most reserved land in the metropolitan area contains only parts of only one of the major geomorphological units.

The proposed core contains good examples of vegetation growing on extensive areas of exposed limestone and shallow sand over limestone. These are poorly represented in the adjoining Caraban Management Priority Area (whose purpose is conservation). Within the core are stands of *Melaleuca cardiophylla* which is close to its southern limit of distribution and is poorly represented in conservation reserves in the area. Particularly valuable are the near coastal areas which again are not well conserved.

The coastal portions of the proposed buffer contain a wide range of Quindalup dunes, mostly of the older Q1 and Q2 groups. Transgression of the Quindalup dunes over the Spearwood dunes has created a wide range of soil types to which many species

appear to be responding in their distribution and abundance. The eastern portion of the buffer, essentially Caraban MPA, is valuable for its range of different woodlands growing on Spearwood dunes. These were once extensive on the Swan Coastal Plain but have been greatly reduced in area by clearing for various activities. Included in this is perhaps the northern most remnant of Tuart (*Eucalyptus gomphocephala*) woodland. Other stands of Tuart further north are generally quite small and their under-storey is more representative of surrounding vegetation than of Tuart woodlands. The occurrence within these *Banksia* and Tuart woodlands of limestone capped hills and rises adds to the diversity of this part of the proposed buffer. Caraban MPA represents a range of *Banksia* woodlands which are near the northern limit of their distribution.

Location 1688, the subject of the System Six redbook recommendation M1, borders the Caraban MPA. However, its potential to compliment Caraban has been diminished since its area of Quindalup Dunes, are either cleared or in a poor condition. It has, however, areas of shallow Spearwood dunes not well represented in Caraban and still retains considerable conservation value.

Given the range of vegetation types present at Wilbinga, the overall good condition of the study area, the size of the site and the strategic location of the site (see section 6) it must be rated as having very high to extremely high value for the conservation of vegetation types.

Breton Bay

The native vegetation in the Breton Bay site is also diverse but as mentioned above only includes the vegetation of the Quindalup dunes and of the shallower soils of the Spearwood dunes. Most of the vegetation types recognised in the study for these soil types were at the Breton Bay site. While uncleared vegetation growing on a wide range of Quindalup dunes units is represented at the Breton Bay site, the relative importance of younger and older type dunes appears to be different from that at Wilbinga. Of particular note is the sizable area of steeper (and presumably younger) dunes in the northern part of the Breton Bay buffer.

Given the number of vegetation types present at Breton Bay, and the size of the site it must have value for the conservation of vegetation types. However, given the fragmented nature of the vegetation due to clearing it can only be rated as high value, except possibly for the largest uncleared block which could be rated as very high. Clearly however, the Breton Bay study area has somewhat less overall value than the Wilbinga study area.

The occurrences of several vegetation units are of particular merit. The *Melaleuca cardiophylla* (Mc) heaths right on the coast is uncommon both at the Breton Bay site and elsewhere. This vegetation apparently does not occur so close to the coast in Wanagarren Nature Reserve or Nambung National Park. Breton Bay also has one of the few areas known where vegetation dominated by two rare mallee eucalypts (*Eucalyptus argutifolia* and *Eucalyptus petrensis*) are known to occur.

Unfortunately for the long term viability of the vegetation in the Breton Bay study area the uncleared areas are scattered through a matrix of cleared and partially cleared land. The largest uncleared patch is between 3,000 and 4,000 ha. This contains many, but not all, of the vegetation units found in the Breton Bay site.

It appears to have been a relatively long period since much of the vegetation at Breton Bay was last burnt. Such areas are particularly valuable for research as they are relatively uncommon. The fragmentation of the native vegetation at Breton Bay has probably been responsible for it not having been regularly burnt.

5.4 Conservation Value for Landforms

The study areas also have value for the conservation of landforms. These include beaches, several ages of Quindalup dunes and areas of the shallow sand/limestone and deep sand surfaces (including several of the units of McArthur and Bartle 1980) of the Spearwood dune system. In a similar fashion to the vegetation and flora of the Quindalup dunes these features are in conservation reserves towards the limits of their distribution but are not adequately reserved in the centre of their range.

5.5 Value for education and research

The study areas have considerable potential value for educational use, for example:

- the study of the succession of the plants from the shore through the heaths of the Quindalup dunes to the woodlands and forests of the Spearwood dunes.
- the relationship of the different vegetation types developed to the soils that they grow on.
- the geomorphological processes that led to the formation of the dune systems.

These could be studied at various levels of understanding from primary school through to university study. Obviously the Wilbinga area is closer to the Metropolitan area and so would be more available for the realisation of such values. Similarly, the areas have potential for research into a variety of aspects of their botany and geomorphology, for example:

- the role of different factors such as fire and soil nutrients in the development of the different vegetation types found in the study area.
- the taxonomy of the less well known species found in the area.
- the ecological adaptation of the dune species to their environment and the dynamics of their populations.
- the development of the Quindalup dunes and the climatic conditions (much more arid than today) that prevailed when the older ones developed.

5.6 Values for recreation and tourism

The two study areas have beaches with high value for recreation and the proximity of Wilbinga to the Metropolitan area must mean that it has very high value for beach based and other recreational activities based on natural areas.

6.0 REGIONAL CONSERVATION ISSUES AFFECTING THE CONSERVATION VALUES OF THE STUDY AREAS

The regional issues affecting the conservation values of the Wilbinga and Breton Bay study areas are:

1) the very extensive clearing of the native vegetation of the Swan Coastal Plain on which the Wilbinga and Breton Bay study areas are located

Beard and Sprenger (1984) gives figures for alienation (which they equate with clearing, although there are remnants in private ownership) of the Plain as 78% overall, with south of Perth virtually 100%. This means that many species of plants found on the Plain have had their populations and ranges decimated and many vegetation types have been lost or reduced to fragmentary remains, particularly south of Perth. It also means that the areas of vegetation remaining have greatly increased significance for conservation because of the reduced opportunities for conservation.

It should be noted that Beard and Sprenger's figures are now six years old and that some of the data (particularly aerial photography) they were based on could be older than that.

2) the low reservation of native vegetation near the metropolitan area

The area of vegetation in reserves in or close to the Metropolitan area is quite low, especially considering that the demand for access to natural areas for recreation and other activities will largely come from the population centres. Significant areas have been recommended for reservation as reserves and regional parks in the areas in and surrounding the Perth Metropolitan area through the "System Six" process (EPA 1983). However, many of these have not been implemented, including a significant number of proposed reserves that have unfortunately been cleared or degraded since the System Six reports were released. Wilbinga is close to the urbanised zone whereas Breton Bay is at some distance. Some of vegetation types and flora species found at Wilbinga are represented in Neerabup and Yanchep National Parks but neither of

these has significant areas of Quindalup dunes (Yanchep has a few hectares and Neerabup none).

Areas containing Quindalup Dunes in the northern metropolitan area recommended for reservation in the System Six study (EPA 1983) were:

- M1 - Two Rocks Open Space,
- M2 - Coastal Strip from Two Rocks to Burns Beach,
- M6 - Additions to Neerabup National Park, and
- M46 - Swanbourne Beach and Rifle Range.

None of these areas have been implemented and the coastal vegetation of the Fremantle to Lancelin area is very poorly represented in Conservation Reserves. The only ones which cover any part of either the Quindalup or Spearwood Dunes in this area are two National Parks (Yanchep and Neerabup), one Management Priority Area (Caraban) and some small recreation reserves (Bold Park, Trigg Dunes Open Space and Star Swamp). There are no Nature Reserves. The representation of Quindalup dunes in the current reserves is especially low.

North of Lancelin a higher proportion of the Quindalup and Spearwood Dunes are in conservation reserves (eg. Nambung National Park and Wanagarran Nature Reserve). The rate of species turnover in this part of the Swan Coastal Plain (Griffin and Keighery, 1989) suggest these reserves would be more similar to Breton Bay than to Wilbinga in conservation value but that there would still be differences in species composition.

This would mean that in general the Wilbinga area would represent vegetation types and flora populations that are less well protected than those at Breton Bay, although there is no data available from Nambung National Park or Wanagarran Nature Reserve to quantify the degree of similarity to Breton Bay.

3) the desirability of a coastal reserve close to Perth

There is no significant reservation for conservation of the Quindalup dune system in or close to the metropolitan region and in fact no significant reservation of a coastal area. Protection of the Wilbinga area would largely remedy this problem although it should be balanced by the reservation of areas to the south of the Metropolitan area. Connecting Wilbinga to areas to the east of it would have the added advantage of securing a continuous sequence of the Quindalup and Spearwood dune systems. Connection to Yanchep National Park would realise potential for an outstanding National Park.

7.0 INTEGRATING MAINTENANCE OF CONSERVATION VALUE WITH DEVELOPMENT

There are practical limits to the successful integration of development and conservation as development brings with it not only the removal of the vegetation of the areas actually developed but, also disturbance to adjoining areas both during and after the actual development. This includes:

- physical disturbance by vehicles, including earthworking vehicles as well as cars and trucks
- the introduction of weeds, resulting in displacement of native species and changes to vegetation structure (and often increased flamability).
- changes to fire regimes (usually in Western Australia this means increased frequency of fire to protect valuable property such as buildings but arson can also be a problem) which results in changes to species composition and in time degradation of the vegetation
- changes to other environmental parameters caused by activities associated with the development can also affect the vegetation and flora. For example: increases in nutrient levels through the use of fertilisers in areas with very nutrient deficient soils such as the Quindalup dune system could result in significant changes in species composition and could very significantly increase the degree of weed invasion; drawdown of water tables can lead to the death of some species, as can increases in water tables caused by clearing of vegetation.

The most obvious step in integrating development with the maintenance of the conservation values found in either of the study areas would be to confine as much as possible of the development to those areas that are currently either cleared or badly disturbed. Complimentary to this would be a management plan designed to maintain the condition of the areas of native vegetation. The management plan would:

- designate areas to remain free of development (protected zones).
- designate areas where further development would be allowed and the scale and type of further developments allowed.
- contain prescriptions for routine management procedures such as fire regimes, wildfire fighting procedures, weed control, access control, allowable uses and rehabilitation procedures to be used for areas within protected zones that have been disturbed.

The management plan would have to have some form of security to ensure its effectiveness, otherwise a situation would develop where the plan would exist but a lack of commitment to it would lead to the gradual deterioration of the environmental quality it would seek to protect. A form of regular monitoring of adherence to the management plan would be ideal with assistance from an appropriate Government department such as the Department of Conservation and Land Management to provide biological expertise.

Such a degree of integration of protection of the environment with development would make a significant contribution to the conservation of flora species and vegetation types. It is very obvious however, that the scale of development entailed in the proposal for a heavy industrial area would be very difficult to reconcile with the relatively limited area of cleared and degraded land at Wilbinga. The Breton Bay site has much more land that is already cleared but the proposed core has significant areas that have conservation values. Especially the area of limestone at the coast with the population of *Chorizema varium* but also the large uncleared area of the shallow soil variant of the Spearwood dunes. This means that integration of development with the maintenance of conservation values at Breton Bay would involve considerable rearrangement of the design of the proposal.

It would also be desirable to avoid concentration of development on the coastal strip as this is most vulnerable to soil erosion.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

- the Wilbinga and Breton Bay study areas both have considerable conservation value for flora (including the presence of rare and restricted flora), vegetation and geomorphological types.

- the strategic position of the Wilbinga study area for the conservation of flora and vegetation coupled with its greater area of vegetation in a less disturbed state mean that it has significantly higher value for conservation than the Breton Bay study area.

- the value of Wilbinga and Breton Bay has not previously been recognised because of inadequate knowledge of the flora and vegetation of the Swan Coastal Plain, although in a general sense it has been well known (at least to biologists) that the coastal zone flora and vegetation is inadequately represented in conservation reserves.

- the protection, or realisation, of these values has not occurred because of inadequate weighting for the conservation of natural areas in the planning process and the inadequacy of the "System Six" report (EPA 1980) as a basis for the conservation of natural areas on the coastal plain.

8.2 Recommendations

- The value of the Wilbinga study area for the conservation of flora and vegetation should be accepted as sufficiently high for it not to be considered for the site of the proposed industrial area.

- The values of the Breton Bay study area for conservation should be more fully defined before detailed planning for the development of an industrial site at that location and such planning should fully take these values into account. (The rediscovery of *Chorizema varium* at Breton Bay, the recognition of *Diplolaena microcephala* aff. var. *microcephala* as a distinct variety and the extensions of the

known ranges of several species to the Breton Bay study area illustrates how poorly known the area is and the need for a detailed botanical survey of the area.)

- Unfortunately, the highest conservation values of the Breton Bay site are concentrated within the proposed core. These should be preserved by a modification of the plans to shift as much as possible of the intensive development to existing cleared areas within the study area.

- Particular emphasis should be placed on the protection of the population of *Chorizema varifolium* located at the south end of Breton Bay by setting aside an area around it. The size of this area should be set after discussions with the Department of Conservation and Land Management (CALM) however, an area of 400-500 ha may be necessary for long term maintenance of the population. The passage of services, clearing or other development should be excluded from this area. Other rare flora should also be specially protected.

- To ensure balance between development and conservation on the coastal strip north of Perth the setting aside of an industrial site in the region should be linked to proper allowance for conservation in the region by protection of the Wilbinga area.

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APPENDIX ONE: Flora recorded for the Wilbinga and Breton Bay study areas

Species recorded from the Wilbinga study area are indicated in the right hand column by the letters Wc (core) and Wb (buffer). Species from the Breton Bay study area are indicated by the letters Bc (core) and Bb (buffer). To allow comparison to other coastal areas on the Swan Coastal Plain species recorded from the Leschenault Peninsula (Trudgen 1984), the coast of the Shire of Mandurah (Trudgen 1988) and the Alkimos and Ningana areas (Trudgen 1989) just south of Wilbinga have been included and are indicated by the letters LP, MC, A and N respectively. An asterix (*) before a species indicates it is introduced to Western Australia.

PTERIDOPHYTA (ferns)**DENNSTAEDTIACEAE**

Pteridium aquilinum LP

GYMNOPHYTA**ZAMIACEAE**

Macrozamia reidleyi MC A/N Wb,Wc

ANGIOSPERMAE (flowering plants)**MONOCOTYLEDONS****RUPPIACEAE**

Ruppia megacarpa LP

JUNCAGINACEAE

Triglochin calcitrapa LP Wb /Bb

Triglochin centrocarpa MC

Triglochin mucronata LP MC

Triglochin striata LP

Triglochin trichophora LP Bb,Bc

POACEAE

**Agropyron racemosum* A/N

**Aira caryophyllea* LP

**Aira cupaniana* A/N

**Ammophila arenaria* LP MC

Amphipogon turbinatus A/N Wb,Wc

Arundo donax LP

**Avena fatua* LP MC A/N

**Briza maxima* LP A/N Wb,Wc

**Briza minor* LP A/N

**Bromus madritensis* MC

**Bromus diandrus* A/N Wc

**Catapodium ridgidum* A/N

* <i>Cynodon dactylon</i>	LP				
<i>Danthonia acerosa</i>			A/N		
<i>Danthonia caespitosa</i>			A/N		
<i>Danthonia setacea</i>		MC			
<i>Danthonia occidentalis</i>			A/N		
* <i>Ehrharta calycina</i>			A/N		
* <i>Ehrharta longiflora</i>	LP	MC	A/N		
* <i>Lolium multiflora</i>		MC			
<i>Microlaena stipoides</i>			N		
<i>Neurachne alopecuroidea</i>					Wb
* <i>Poa annua</i>	LP				
<i>Poa drummondiana</i>	LP	MC	A/N		
<i>Poa porphyrocladus</i>			A/N		Bc
<i>Poa poiformis</i>		MC			
<i>Poa sp.</i>					Bc
<i>Spinifex hirsutus</i>	LP	MC	A/N	Wb,Wc	
<i>Spinifex longifolius</i>	LP	MC	A/N	Wb,Wc/Bb,Bc	
<i>Sporobolus virginicus</i>		MC			Bc
<i>Stipa campylachne</i>		MC			
<i>Stipa compressa</i>		MC	A/N		
<i>Stipa flavescens</i>		MC	A/N	Wb,Wc	
<i>Stipa ? variabilis</i>	LP	MC			
* <i>Vulpia membranacea</i>		MC			Wb,Wc
* <i>Vulpia myuros</i>	LP				
CYPERACEAE					
<i>Baumea juncea</i>	LP	MC	N		Wb
<i>Bulboschoenus caldwelli</i>	LP	MC			
<i>Caustis dioica</i>					Wb
<i>Carex preissii</i>	LP	MC	N		
* <i>Cyperus laevigatus</i>		MC			
<i>Cyperus tenellus</i>	LP				
<i>Cyperus tenuiflorus</i>	LP				
<i>Gahnia trifida</i>	LP	MC			
<i>Isolepis cernua</i>			A/N		Wb,Wc/Bb,Bc
<i>Isolepis marginata</i>		MC			
<i>Isolepis nodosa</i>	LP	MC	A/N		Wb,Wc/Bb,Bc
<i>Isolepis sp.</i>	LP				
<i>Lepidosperma angustatum</i>	LP	MC			Wb,Wc/Bb,Bc
<i>Lepidosperma costale</i>			A		
<i>Lepidosperma ? costale</i>		MC			
<i>Lepidosperma gladiatum</i>	LP	MC	A/N		Wb,Wc/Bb,Bc
<i>Lepidosperma ? gracile</i>		MC			
<i>Lepidosperma longitudinale</i>	LP				
<i>Lepidosperma squamatum</i>			A		
<i>Lepidosperma scabrum</i>			A		Wb
<i>Lepidosperma sp. (B)</i>		MC			
<i>Schoenus clandestinius</i>			A		?Wc
<i>Mesomelaena stygia</i>			A/N		Wb,Wc/Bb,Bc
<i>Schoenus curviflorus</i>		MC	A		Wb,Wc
<i>Schoenus grandiflorus</i>		MC	A/N		Wb,Wc/Bb,Bc

Schoenus lanatus		MC -		
Schoenus latitans				Wb
Schoenus nanus		MC		
Schoenus pedicellatus				Wb
Schoenus subbartus			A/N	
Schoenus sp.		MC		
Schoenus sp.		MC		
? Tetragia octandra				Wc
ARACEAE				
*Zantedeschia aethiopica	LP			
RESTIONACEAE				
Alexgeorgia nitens			A	Wb
Hypolaena exsulca			A	?Wb
Lepidobolus chaetocephalus				Wb,Wc/Bb
Loxocarya cinerea		MC		
Loxocarya flexuosa		MC	A/N	Wb,Wc/Bb,Bc
Loxocarya pubescens	LP			
Loxocarya sp. (B)		MC		
Loxocarya sp.				Wb
Lyginia barbata		MC	A	Wb
Restio scariosus		MC (male & female)		Wb
Restio sp.				Wb
CENTROLEPIDACEAE				
Centrolepis drummondii	LP	MC	N	
JUNCACEAE				
*Juncus bufonius	LP			
Juncus kraussii ssp. australis	LP	MC		
Luzula meridionalis		MC		
DASYPOGONACEAE				
Acanthocarpus preissi	LP	MC	A/N	Wb,Wc/Bb,Bc
Calectasia cyanea		MC		
Lomandra caespitosa			A	Wb
Lomandra hermaphrodita				Wb
Lomandra maritima		MC	A/N	Wb,Wc/Bb,Bc
Lomandra micrantha		MC		
Lomandra purpurea		MC		
Lomandra ? sericea				Wb
Lomandra suaveolens		MC	A	M6
Lomandra sp.	LP			
XANTHORRHOEACEAE				
Xanthorrhoea brunonis ssp. semibarbata		MC		
Xanthorrhoea preissii		MC	A/N	Wb,Wc/Bb,Bc
PHORMIACEAE				
Dianella divaricata		MC	A/N	Wb,Wc/Bb,Bc

ANTHERICAEAE

<i>Arthropodium capillipes</i>		MC		
<i>Caesia parviflora</i>		MC		
<i>Chamaescilla corymbosa</i>		MC		
<i>Corynotheca micrantha</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Laxmania sessiliflora</i> ssp <i>australis</i>			A	
<i>Sowerbaea laxiflora</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Thysanotus arenarius</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Thysanotus patersonii</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Thysanotus sparteus</i>		MC		
<i>Thysanotus triandrus</i>			A/N	
<i>Tricoryne elatior</i>	LP	MC	A/N	Wc /Bb,Bc

ASPHODELACEAE

* <i>Asphodelus fistulosus</i>		LP	(probably a mis-identification of <i>Trachyandra divaricata</i>)	
<i>Bulbine semibarbata</i>		LP		
* <i>Trachyandra divaricata</i>		MC	A/N	Wb,Wc/Bb,Bc

COLCHICACEAE

<i>Burchardia umbellata</i>		MC	A/N	Wb
<i>Wurmbea monantha</i>	LP	MC		
<i>Wurmbea pygmaea</i>		MC		

HAEMODORACEAE

<i>Anigozanthos humilis</i>		MC	A	Wb,Wc/Bb,Bc
<i>Anigozanthos manglesii</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Conostylis aculeata</i> ssp. <i>aculeata</i>	LP	MC	A/N	
<i>Conostylis bracteata</i>				Wb
<i>Conostylis candicans</i> ssp. <i>calcicola</i>		MC	A/N	
<i>Conostylis pauciflora</i> ssp. <i>euryhipis</i>		MC	A/N	Wc/Bb,Bc
<i>Conostylis teretifolia</i> ssp. <i>planescens</i>			A	Wb,Wc/Bb,Bc
<i>Conostylis pauciflora</i> X <i>candicans</i>		MC		
<i>Conostylis bracteata</i> X <i>candicans</i>				Wb,Wc
<i>Haemodorum laxum</i>			A	Wb
<i>Haemodorum spicatum</i>			A	
<i>Haemodorum paniculatum</i>			A/N	

IRIDACEAE

* <i>Gladiolus cayophyllaceus</i>		MC	A/N	Bb,Bc
<i>Orthrosanthos laxus</i>		MC	A	Bb
<i>Patersonia occidentalis</i>		MC		Wb,Wc
* <i>Romulea rosea</i>			A/N	

ORCHIDACEAE

<i>Acianthus reniformis</i> var. <i>huegelii</i>		MC		
<i>Caladenia exilis</i> (MS)		MC		
<i>Caladenia flava</i>		MC		Bb,Bc
<i>Caladenia latifolia</i>	LP	MC		Wc/Bb,Bc
<i>Caladenia longicauda</i>		MC		Wb,Wc

<i>Caladenia menziesii</i>	LP	MC		
<i>Caladenia pectinata</i>		MC		
<i>Diuris longifolia</i>				Wb,Wc
<i>Elythranthera brunonis</i>		MC		
<i>Eriochilus dilatatus</i>	LP	MC		
<i>Lypreanthus nigicans</i>				Wb
<i>Microtis unifolia</i>			A/N	
<i>Microtis</i> sp. (material inadequate)		MC		
<i>Prasophyllum elatum</i>		MC		
<i>Prasophyllum giganteum</i>		MC		
<i>Prasophyllum hians</i>		MC		
<i>Prasophyllum macrostachyum</i> ssp. nov.		MC		
<i>Pterostylis vittata</i>		MC		Bc

DICOTYLEDONS

URTICACEAE

<i>Parietaria debilis</i>	LP	MC	A/N	
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CASUARINACEAE

<i>Allocasuarina fraseriana</i>		MC	A/N	Wb
<i>Allocasuarina humilis</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Allocasuarina lehmanniana</i>				Wb
<i>Casuarina obesa</i>		MC		

PROTEACEAE

<i>Adenanthos cygnorum</i>				N (only one plant seen)
<i>Banksia attenuata</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Banksia grandis</i>		MC	A/N	Wb
<i>Banksia ilicifolia</i>				Wb
<i>Banksia leptophylla</i>				Bb
<i>Banksia littoralis</i>		MC		
<i>Banksia menziesii</i>			A/N	Wb,Wc/Bb,Bc
<i>Banksia prionotes</i>				Wb, /Bb,Bc
<i>Conospermum canaliculatum</i>				Wb,Wc
<i>Conospermum incurvum</i>				Wb
<i>Conospermum stoechadis</i>				Wb,Wc/Bb,Bc
<i>Conospermum triplinervium</i>		MC	A/N	
<i>Dryandra nivea</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Dryandra sessilis</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Grevillea crithmifolia</i>		MC		Wb,Wc
<i>Grevillea thelemanniana</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Grevillea vestita</i>		MC	A/N	? Wc/Bb,Bc
<i>Hakea costata</i>			A/N	Wb,Wc/Bb,Bc
<i>Hakea lissocarpha</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Hakea prostrata</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Hakea ruscifolia</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Hakea trifurcata</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Hakes undulata</i>				Bb
<i>Hakea varia</i>		MC		
<i>Persoonia comata</i>			A/N	Wb,Wc

<i>Persoonia saccata</i>		MC	-		
<i>Petrophile brevifolia</i>			A		Wb,Wc/Bb,Bc
<i>Petrophile linearis</i>		MC	A		Wb,Wc
<i>Petrophile macrostachya</i>			A/N		Wb,Wc/Bb,Bc
<i>Petrophile serruriae</i>		MC	A/N		Wb,Wc/Bb,Bc
<i>Stirlingia latifolia</i>		MC	A		Wb,Wc
<i>Synaphea spinulosa</i>		MC			Wb,Wc/Bb,Bc
SANTALACEAE					
<i>Exocarpos sparteus</i>	LP	MC	A/N		Wb,Wc/Bb,Bc
<i>Leptomeria empetriformis</i>		MC			Wb,Wc/Bb
<i>Leptomeria lehmanii</i>		MC			
<i>Leptomeria preissiana</i>			N		
<i>Leptomeria spinosa</i>			N		
<i>Santalum acuminatum</i>	LP	MC			Wb,Wc/Bb,Bc
OLACACEAE					
<i>Olax benthamiana</i>					Wc
LORANTHACEAE					
<i>Amyema miquelii</i>		MC			
<i>Nuytsuia floribunda</i>		MC	A/N		Wb,Wc/Bb,Bc
POLYGONACEAE					
* <i>Emex australia</i>	LP	MC			
CHENOPODIACEAE					
<i>Atriplex cinerea</i>		MC			
<i>Atriplex hypoleuca</i>	LP	MC			
<i>Enchylaena tomentosa</i>					Wb,Wc/ Bc
<i>Halosarcia indica</i> ssp. <i>bidens</i>	LP	MC			
<i>Halosarcia halocnemoides</i>					
ssp. <i>halocnemoides</i>	LP	MC			
<i>Halosarcia syncarpa</i>		MC			
<i>Rhagodia baccata</i>	LP	MC	A/N		Wb,Wc/Bb,Bc
<i>Salsola kali</i>		MC			
<i>Sarcocornia blackiana</i>		MC			
<i>Sarcocornia quinqueflora</i>	LP	MC			
<i>Sarcocornia ?quinqueflora</i>					Bc
<i>Suaeda australis</i>	LP	MC			
<i>Threlkedia diffusa</i>	LP	MC			W48
AMARANTHACEAE					
<i>Ptilotus drummondii</i>		MC			
<i>Ptilotus polystachyus</i>			A		Bb
<i>Ptilotus manglesii</i>					Wb
<i>Ptilotus stirlingii</i>			A/N		
GYROSTEMONACEAE					
<i>Tersonia cyathifolia</i>		MC			Wb,Wc/Bb,Bc

AIZOACEAE

* <i>Carpobrotus edulis</i>			A/N	Wb,Wc/Bb,Bc
<i>Carpobrotus virescens</i>	LP	MC	A/N	
* <i>Tetragonia decumbens</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Tetragonia implexicoma</i>		MC		
<i>Tetragonia tetragonoides</i>			N	
<i>Threkeldia diffusa</i>			A	

MOLLUGINACEAE

<i>Macarthuria australis</i>				Wb,Wc
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PORTULACACEAE

<i>Calandrinia brevipedata</i>	LP			Wb,Wc/ Bc
<i>Calandrinia calyptrata</i>	LP	MC		
<i>Calandrinia corrigioloides</i>		MC		Wb,Wc/Bb,Bc
<i>Calandrinia granulifera</i>				Wb,Wc
<i>Calandrinia liniflora</i>		MC?	A/N	Bc

CARYOPHYLLACEAE

* <i>Cerastium ? diffusum</i>	LP			? Wc
* <i>Cerastium glomeratum</i>				Bb,Bc
* <i>Petrohagia velutina</i>	LP		A/N	
* <i>Polycarpon tetraphyllum</i>	LP			
* <i>Silene nocturna</i>		MC		

RANUNCULACEAE

<i>Clematis microphylla</i>	LP	MC	A/N	Wc
<i>Clematis pubescens</i>		MC		
<i>Ranunculus colonorum</i>	LP	MC		
* <i>Ranunculus muricatus</i>	LP	MC		

LAURACEAE

<i>Cassytha flava</i>			A/N	
<i>Cassytha glabella</i>		MC	N	Wc/Bb
<i>Cassytha pomiformis</i>			N	
<i>Cassytha racemosa</i>	LP	MC	A/N	Wb,Wc/Bb,Bc

FUMARIACEAE

* <i>Fumaria capreolata</i>	LP			
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BRASSICACEAE

* <i>Brassica tournefortii</i>	LP	MC		
* <i>Cakile maritima</i>	LP	MC	A/N	Wb,Wc
* <i>Heliophila pusilla</i>		MC	A/N	Wb /Bb,bc
* <i>Lepidium bonariense</i>			N	
<i>Stenopetalum lineare</i>				
<i>Stenopetalum gracilis</i> (previously <i>S. robustum</i>)				LP (probably misidentification of <i>S. robustum</i>)
				MC

DROSERACEAE

<i>Drosera erythorrhiza</i>		MC		Wb,Wc/Bb,Bc
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<i>Drosera glandulifera</i>		MC	-	Wb
<i>Drosera macrantha</i>		MC		Wb,Wc/Bb,Bc
<i>Drosera pallida</i>		MC	A	
<i>Drosera stolonifera</i>		MC		
CRASSULACEAE				
<i>Crassula colorata</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
* <i>Crassula decumbens</i>		MC		
<i>Crassula exserta</i>			A/N	
* <i>Crassula glomerata</i>		MC	A/N	Wb /Bb,Bc
<i>Crassula natans</i>	LP			Wc
<i>Crassula pedicellosa</i>	LP			Wb
PITTOSPORACEAE				
<i>Billardiera variifolia</i>		MC		
<i>Pittosporum phylliraeoides</i>				
var. <i>phylliraeoides</i>	LP	MC		
? <i>Pronaya fraseri</i>			N	Wc
MIMOSACEAE				
<i>Acacia alata</i>				Wc
<i>Acacia cochlearis</i>	LP	MC	A/N	Wb /Bb,Bc
<i>Acacia cyclops</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Acacia huegelii</i>			A	
<i>Acacia idiomorpha</i>				Bc
<i>Acacia lasiocarpa</i> var. <i>lasiocarpa</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Acacia pulchella</i> var. <i>glaberrima</i>		MC	A/N	Wb,Wc
<i>Acacia pulchella</i> var. <i>pulchella</i>		MC		Bc
<i>Acacia rostellifera</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Acacia saligna</i>	LP	MC	A/N	
<i>Acacia sessilis</i>				Wb /Bb
<i>Acacia spathulifolia</i>				Bb
<i>Acacia truncata</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Acacia wildenowiana</i>		MC		
<i>Acacia xanthina</i>				Bb,Bc
<i>Acacia rostellifera</i> x <i>saligna</i>			A	
PAPILIONACEAE				
<i>Bossiaea eriocarpa</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Burtonia conferta</i>		MC		
<i>Chorizema varium</i>				Bb
(Thought to be extinct prior to the current survey.)				
<i>Daviesia divaricata</i>		MC	N	Wb,Wc/Bb,Bc
<i>Daviesia decurrens</i>		MC		Wb,Wc/Bb,Bc
<i>Daviesia nudiflora</i>				Wb
<i>Daviesia physodes</i>		MC		
(D. <i>pectinata</i> = D. <i>decurrens</i>)				
<i>Gompholobium tomentosum</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Hardenbergia comptoniana</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Hovea pungens</i>		MC		Wb,Wc/Bb,Bc
<i>Hovea trisperma</i>		MC	A/N	Wb,Wc

<i>Isotropis cuneifolia</i>		MC	A	Wb,Wc
<i>Jacksonia furcellata</i>	LP	MC	A/N	Wb
<i>Jacksonia sternbergiana</i>		MC	A/N	WB,Wc
<i>Jacksonia stricta</i>			A/N	Wb,Wc/Bb,Bc
<i>Kennedia coccinea</i>	LP	MC		
<i>Kennedia prostrata</i>		MC	A/N	Wb,Wc/Bb,Bc
* <i>Medicago ? lupulina</i>	LP			
* <i>Medicago polymorpha</i>			A/N	
* <i>Melilotis indica</i>			A/N	
<i>Mirbelia spinosa</i>				Bb,Bc
<i>Nemcia reticulatum</i> (<i>Oxylobium reticulatum</i> = <i>Nemcia reticulatum</i>)		MC	A/N	Wb,Wc/Bb,Bc
<i>Sphaerolobium medium</i>				Wb,Wc/Bb,Bc
<i>Sphaerolobium ?medium</i>			A/N	
<i>Sphaerolobium aff. macranthum</i>		MC		
<i>Templetonia retusa</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
* <i>Trifolium campestre</i>			A/N	
GERANIACEAE				
* <i>Erodium cicutarium</i>	LP	MC		Wb,Wc/Bb,Bc
* <i>Geranium molle</i>	LP (poss. misid. <i>G. solanderi</i>)N			
<i>Geranium solanderi</i>		MC	A/N	
* <i>Pelargonium capitatum</i>	LP	MC	A/N	
<i>Pelargonium littorale</i>		MC	A	
OXALIDACEAE				
* <i>Oxalis corniculata</i>	LP			
* <i>Oxalis pes-caprae</i>	LP			
ZYGOPHYLLACEAE				
<i>Zygophyllum fruticulosum</i>	LP	MC		Bc
<i>Zygophyllum simile</i>		MC		
RUTACEAE				
<i>Boronia alata</i>		MC		
<i>Boronia crenulata</i>		MC		
<i>Boronia ramosa</i>				
<i>Diplolaena dampieri</i>	LP	MC		
<i>Dipolaena microcephala</i> (? relationship to var. <i>drummondii</i>)				
<i>Dilolaena micrcephala</i> var <i>microcephala</i>				Wc/Bb,Bc
<i>Eriostemon spicatus</i>		MC		Wb,Wc/Bb,Bc
POLYGALACEAE				
<i>Comesperma calymega</i>			A	
<i>Comesperma confertum</i>		MC		
<i>Comesperma integerrimum</i>			A/N	Wc
<i>Comesperma virgatum</i>		MC		Wc/Bb,Bc
<i>Comesperma volubile</i>		MC	A	
EUPHORBACEAE				
<i>Adriana quadripartita</i>	LP	MC	A/N	Bb,Bc

* <i>Euphorbia peplus</i>	LP	MC	-	Bb, Bc
* <i>Euphorbia terracina</i>			N	
<i>Phyllanthus calycinus</i>	LP	MC	A/N	Wb, Wc/Bb, Bc
<i>Poranthera microphylla</i>	LP	MC		Wc/Bb
<i>Ricinocarpos glaucus</i>		MC	A	Bb, Bc
STACKHOUSIACEAE				
(<i>Stackhousia huegelii</i> = <i>Stackhousia monogyna</i>)			A/N	Wb, Wc/Bb
<i>Stackhousia monogyna</i>				Wb, Wc
<i>Triterococcus brunonis</i>				
SAPINDACEAE				
<i>Dodonaea aptera</i>			A	Wb, Wc/Bb, Bc
<i>Dodonaea ?</i>		MC		
<i>Diplopeltis huegelii</i>		MC	N	Wb /Bb, Bc
MALVACEAE				
<i>Alyogyne huegelii</i>		MC		
? var. <i>glabresens</i>			N	Wb, Wc/Bb, Bc
RHAMNACEAE				
<i>Cryptandra arbutiflora</i>		MC		
<i>Cryptandra mutila</i>		MC	N	Wb, Wc/Bb, Bc
<i>Cryptandra pungens</i>			A	Wc/Bb
<i>Spyridium globulosum</i>	LP	MC	A/N	Wb, Wc/Bb, Bc
<i>Spyridium tridentatum</i>			A/N	Bb, Bc
<i>Trymalium albicans</i>		MC	A/N	Wb, Wc/Bb, Bc
STERCULIACEAE				
<i>Guichenotia ledifolia</i>	LP	MC		
<i>Thomasia cognata</i>	LP	MC	A/N	
<i>Thomasia triphylla</i>		MC	A	Wb, Wc/Bb, Bc
<i>Lasiopetalum membranaceum</i>		MC		
DILLENACEAE				
<i>Hibbertia acerosa</i>		MC		Wc
<i>Hibbertia cuneiformis</i>	LP	MC		
<i>Hibbertia huegelii</i>				Wb
<i>Hibbertia hypericoides</i>		MC	A/N	Wb, Wc/Bb, Bc
<i>Hibbertia racemosa</i>		MC	A/N	Wb, Wc/Bb, Bc
<i>Hibbertia spicata</i> ssp. <i>leptotheca</i>			A	Wb, Wc/Bb
FRANKENIACEAE				
<i>Frankenia pauciflora</i>		MC		Bc
VIOLACEAE				
<i>Hybanthus calycinus</i>		MC	A	Wb, Wc/Bb, Bc
THYMELAEACEAE				
<i>Pimelea argentea</i>		MC		Wb

<i>Pimelea calcicola</i>		MC	A	Wb,Wc/Bb,Bc
<i>Pimelea ferruginea</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Pimelea gilgiana</i>				Wb,Wc/Bb,Bc
<i>Pimelea rosea</i>		MC		
<i>Pimelea sulphurea</i>				Wb
MYRTACEAE				
<i>Agonis flexuosa</i>	LP	MC		
<i>Baeckea robusta</i>				Wb
<i>Calothamnus quadrifidus</i>			A/N	
<i>Calothamnus sanguineus</i>				
<i>Calytrix angulata</i>			A	Wb
<i>Calytrix sp</i>				Bb
<i>Chamelaucium uncinatum</i>				Wb,Wc/Bb,Bc
<i>Eremaea pauciflora</i>			A	Wb
<i>Eremaea sp</i>				Wb,Wc
<i>Eucalyptus calophylla</i>		MC		
<i>Eucalyptus decipiens</i>		MC	A	Wb,Wc/Bb,Bc
<i>Eucalyptus foecunda</i>		MC		Wb M1 B36
<i>Eucalyptus gomphocephala</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Eucalyptus marginata</i>		MC	A/N	Wb
<i>Eucalyptus rudis</i>		MC		
<i>Eucalyptus todtiana</i>			A	Wb,Wc/Bb,Bc
<i>Eucalyptus "argutifolia" (MS) = M.I.H. Brooker 8608</i> (declared rare species)				Bb
<i>Eucalyptus "petrensis" (MS)</i> (priority species)				Bb
<i>Hypocalymma robustum</i>		MC		
<i>Kunzea ericifolia</i>				Wb
<i>Leptospermum spinescens</i>			A/N	Wb,Wc/Bb,Bc
<i>Leptospermum oligandrum</i>				Wb
<i>Melaleuca acerosa</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Melaleuca cardiophylla</i>			A/N	Wb,Wc/Bb,Bc
<i>Melaleuca cuticularis</i>	LP	MC		
<i>Melaleuca aff. hamulosa</i>	LP			
<i>Melaleuca huegelii</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Melaleuca scabra</i>				Wb
<i>Melaleuca raphiophylla</i>	LP	MC		
<i>Melaleuca trichophylla</i>			A	
<i>Melaleuca thymoides</i>		MC		
<i>Melaleuca uncinata</i>		MC		
<i>Melaleuca viminea</i>		MC		
<i>Scholtzia laxiflora</i>				Wb,Wc
<i>Verticordia ?penigera</i>				Bb
ONAGRACEAE				
<i>Epilobium billardierianum</i>		MC		
* <i>Oenothera drummondii</i>		MC		
HALORAGACEAE				
<i>Haloragis sp</i>				Wc

APIACEAE

<i>Apium annuum</i>	LP			
<i>Apium prostratum</i>				
ssp. <i>prostratum</i> var. <i>prostratum</i>		MC		
<i>Centella asiatica</i>	LP	MC		
<i>Daucus glochidiatus</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Eringium pinnatifidum</i>		MC	N	
<i>Homalosciadum homalocarpum</i>		MC	A/N	
<i>Hydrocotyle blepharocarpa</i>		MC		Bb,Bc
<i>Hydrocotyle diantha</i>	LP			Wc
<i>Hydrocotyle ? hispidula</i>	LP			
<i>Hydrocotyle pilifera</i>				Bb
<i>Hydrocotyle tetragonocarpa</i>	LP	MC		Wc
<i>Platysace</i> sp.		MC		
<i>Trachymene caerulea</i>	LP	MC		Wb
<i>Trachymene pilosa</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Trachymene</i> sp.				Bb,Bc
<i>Xanthosia huegelii</i>			A	
<i>Xanthosia pusilla</i>		MC		

EPACRIDACEAE

<i>Acrotriche cordata</i>		MC	A/N	Wb,Wc
<i>Astroloma ciliatum</i>		MC		Wc
<i>Astroloma microcalyx</i>		MC		Wb,Wc
<i>Astroloma pallidum</i>		MC	A/N	Wb,Wc/Bb
<i>Astroloma</i> sp.		MC		Wb,Wc
<i>Conostephium pendulum</i>			A	Wb
<i>Conostephium preissii</i>		MC		
<i>Leucopogon insularis</i>			A	
<i>Leucopogon parviflorus</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Leucopogon polymorphus</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Leucopogon aff. polymorphus</i>			A/N	
<i>Leucopogon propinquus</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Leucopogon racemulosus</i>		MC		
<i>Leucopogon</i> sp.				Wc
<i>Lysinema ciliatum</i>		MC	N	Wb,Wc/Bb,Bc

PRIMULACEAE

* <i>Anagallis arvensis</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Samolus junceus</i>		MC		
<i>Samolus repens</i>	LP	MC		

GENTIANACEAE

* <i>Centaurium erythraea</i>			A/N	
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LOGANIACEAE

<i>Logania vaginalis</i>	LP	MC		
<i>Mitrasacme paradoxa</i>		MC		Bb,Bc

APOCYNACEAE

<i>Alyxia buxifolia</i>	LP	MC		
CONVOLVULACEAE				
* <i>Convolvulus arvensis</i>	LP			
* <i>Cuscuta epithymum</i>		MC		
<i>Dichondra repens</i>	LP	MC		
<i>Wilsonia backhousei</i>		MC		
<i>Wilsonia humilis</i>		MC		
AVICENNIACEAE				
<i>Avicennia marina</i>	LP			
LAMIACEAE				
<i>Hemiandra pungens</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Westringia dampieri</i>				Wc
SOLANACEAE				
<i>Anthocercis ilicifolia</i> ssp. <i>ilicifolia</i>		MC		Wb,Wc/Bb,Bc
<i>Anthocercis littorea</i>	LP	MC	A/N	Wb,Wc
* <i>Solanum nigrum</i>	LP	MC	A/N	Wb,Wc
<i>Solanum simile</i>	LP			
* <i>Solanum sodomaeum</i>		MC	A/N	Wb,Wc
<i>Solanum symonii</i>		MC		
SCROPHULARIACEAE				
* <i>Bellardia trixago</i>	LP	MC		
* <i>Dischisma arenarium</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
* <i>Parentucellia latifolia</i>		MC		Bb
<i>Veronica aff. calycina</i>		MC	A	
OROBANCHACEAE				
<i>Orobanche australiana</i>				
* <i>Orobanche minor</i>		MC	N	
MYOPORACEAE				
<i>Eremophila glabra</i>	LP	MC	N	Wb,Wc/Bb,Bc
<i>Myoporum caprarioides</i>		MC		
<i>Myoporum insulare</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Myoporum tetrandrum</i>	LP			(Probably mis-identification of <i>E. caprarioides</i>)
PLANTAGINACEAE				
<i>Plantago exilis</i>		MC		
* <i>Plantago lanceolata</i>	LP			
<i>Plantago sp.</i>				Bb,Bc
RUBIACEAE				
* <i>Galium murale</i>	LP			Bb
<i>Galium sp.</i>	LP			
<i>Opercularia hispidula</i>		MC		
<i>Opercularia vaginata</i>	L	MC	A/N	Wb,Wc/Bb,Bc

* <i>Sherardia arvensis</i>	LP			
CUCURBITACEAE				
* <i>Cucurbita pepo</i>			N	Wb,Wc
CAMPANULACEAE				
* <i>Wahlenbergia capensis</i>			A	Bb
<i>Wahlenbergia ? gracilentia</i>	MC			
LOBELIACEAE				
<i>Grammatotheca bergiana</i>	LP			
<i>Lobelia alata</i>	LP	MC		
<i>Lobelia heterophylla</i>			N	
<i>Lobelia ? heterophylla</i>	LP			
<i>Lobelia tenuior</i>		MC	A/N	
<i>Isotoma hypocrateriformis</i>		MC	A/N	Bc
GOODENIACEAE				
<i>Dampiera linearis</i>		MC		Wb,Wc/Bb,Bc
<i>Lechenaultia linarioides</i>			A/N	Wc
<i>Scaevola canescens</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Scaevola crassifolia</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Scaevola globulifera</i>		MC		
<i>Scaevola holosericea</i>		MC	N	
<i>Scaevola paludosa</i>			A	Wb,Wc
<i>Scaevola phlebopetala</i>				Bb
<i>Scaevola nitida</i>		MC	A/N	Wb,Wc
<i>Scaevola thesioides</i>		MC	A/N	Bb,Bc
<i>Verreauxia reinwardtii</i>			A	
STYLIDIACEAE				
<i>Levenhookia stipitata</i>			A/N	
<i>Stylidium brunonianum</i>			A/N	Wc
<i>Stylidium calcaratum</i>			A/N	
<i>Stylidium bulbiferum</i>		MC		
<i>Stylidium junceum</i>		MC	A/N	Bc
<i>Stylidium piliferum</i>		MC	A	Wb
<i>Stylidium schoenoides</i>		MC		
<i>Stylidium repens</i>				Wb,Wc
<i>Stylidium aff. repens</i>			A	
<i>Stylidium sp. (S. maritima M. S.)</i>		MC	A/N	Bb
ASTERACEAE				
<i>Asteridea pulverulenta</i>		MC		
<i>Angianthus tomentosus</i>		MC		
* <i>Arctotheca calendula</i>	LP	MC		Wb,Wc/Bb,Bc
* <i>Arctotheca populifolia</i>	LP	MC		Wb,Wc
<i>Brachycome bellidioides</i>		MC		
<i>Brachycome iberidifolia</i>		MC		Wc/Bb,Bc
<i>Calocephalus brownii</i>	LP	MC		Wb,Wc/Bb,Bc
* <i>Carduus pycnocephalus</i>	LP			

<i>Cotula australis</i>	LP			Bc
<i>Colula cotuloides</i>	LP			
<i>Cotula coronopifolia</i>	LP	MC		
* <i>Dittrichia graveolens</i>	LP			Wb,Wc/Bb,Bc
<i>Gnaphalium sphaericum</i>			A/N	
<i>Helichrysum cordatum</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Helipterum corymbosum</i>			Wb	/Bb,Bc
<i>Hyalospermum cotula</i>		MC		Bb,Bc
* <i>Hypochoeris glabra</i>			A/N	Wb,Wc/Bb,Bc
<i>Ixiolaena viscosa</i>		MC		
<i>Lagenifera hugelii</i>	LP	MC	A	Wb,Wc/Bb,Bc
<i>Leptorhyncuos scabrus</i>		MC	A/N	
<i>Millotia tenuifolia</i>	L	MC	A/N	Wc,Wb
<i>Olearia axillaris</i>	LP	MC	A/N	Wb,Wc/Bb,Bc
<i>Olearia rudis</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Pithocarpa pulchella</i>		MC		Bc
<i>Podolepis canescens</i>			A	
<i>Podolepis gracilis</i>		MC	A/N	
<i>Podolepis lessonii</i>		MC		
<i>Podotheca angustifolia</i>		MC	A/N	Wb,Wc
<i>Podotheca chrysantha</i>		MC		
<i>Podotheca gnaphalioides</i>			A/N	Wc
<i>Quinetia urvillei</i>		MC	A/N	Wb,Wc/Bb,Bc
<i>Senecio lautus</i>	LP	MC	A/N	
<i>ssp. maritimus</i>				Wb,Wc/Bb,Bc
<i>Senecio ramosissimus</i>		MC		
<i>Siloxerus humifusus</i>			A/N	
* <i>Sonchus oleraceus</i>	LP	MC		Wb,Wc/Bb,Bc
* <i>Urospermum picroides</i>			N	
* <i>Ursinia anthemoides</i>			A/N	Wb,Wc/Bb,Bc
<i>Waitzia citrina</i>	LP			Wb
<i>Waitzia suaevoleons</i>		MC	A/N	

APPENDIX 2: CONDITION SCALE

E = Excellent. Pristine or nearly so, no obvious signs of damage caused by the activities of European man.

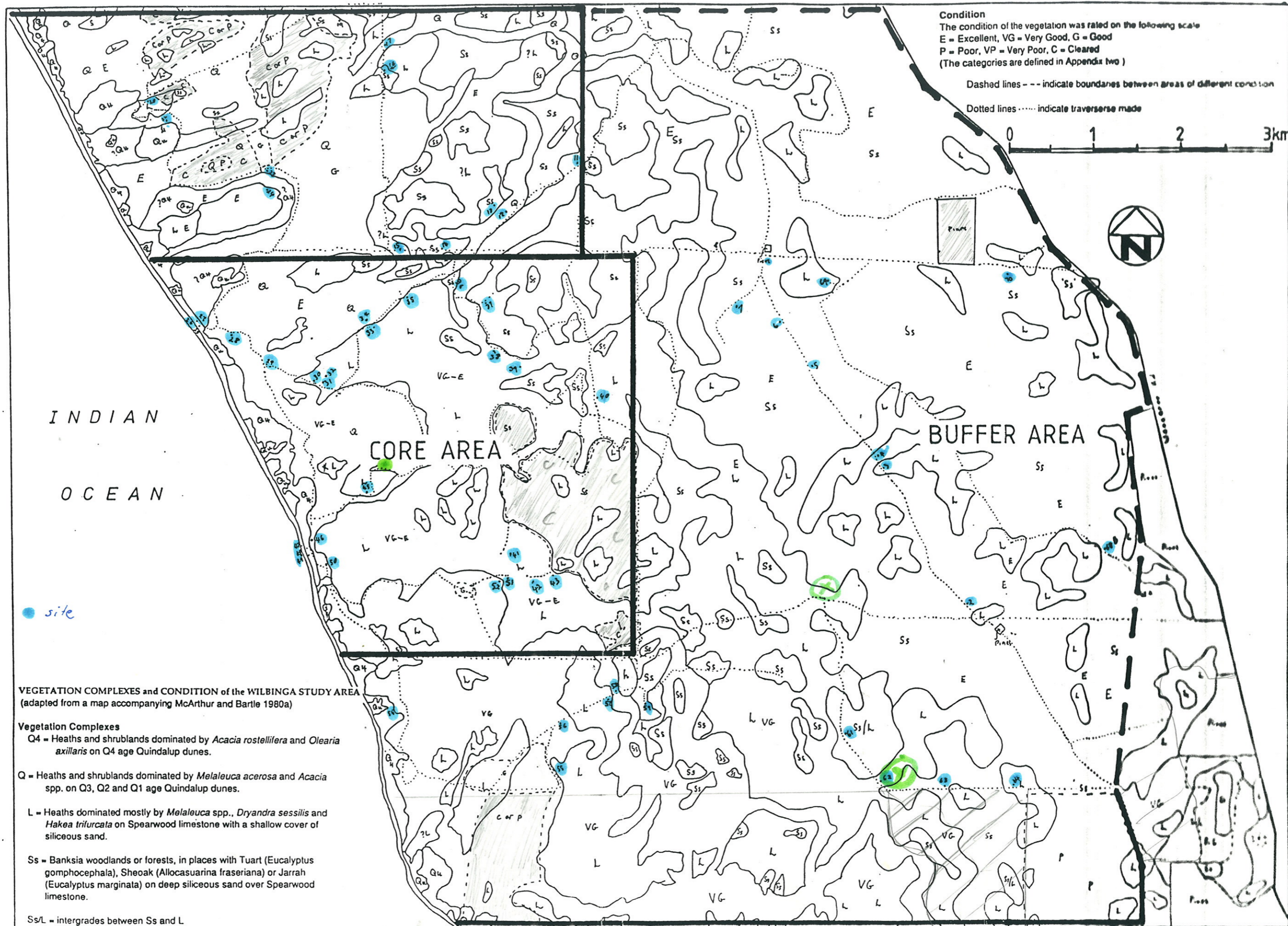
VG = Very good. Some relatively slight signs of damage caused by the activities of European man. E.g. some signs of damage to tree trunks caused by repeated fire and the presence of some relatively non-aggressive weeds such as Ursinia anthemoides or Briza spp., or occasional vehicle tracks.

G = Good. More obvious signs of damage caused by the activities of European man, including some obvious impact on the vegetation structure such as caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones.

P = Poor. Still retains basic vegetation structure or ability to regenerate to it after very obvious impacts of activities of European man such as grazing or partial clearing (chaining) or very frequent fires. Weeds as above, probably plus some more aggressive ones such as *Ehrharta* spp.

VP = Very poor. Severely impacted by grazing, fire, clearing or a combination of these activities. Scope for some regeneration but, not to a state approaching good condition without intensive management. Usually with a number of weed species including aggressive species.

D = Completely degraded. Areas that are completely or almost completely without native species in the structure of their vegetation. I.e. areas that are cleared or "parkland cleared" with their flora comprising weed or crop species with isolated native trees or shrubs.



Condition
 The condition of the vegetation was rated on the following scale
 E = Excellent, VG = Very Good, G = Good
 P = Poor, VP = Very Poor, C = Cleared
 (The categories are defined in Appendix two)

Dashed lines --- indicate boundaries between areas of different condition

Dotted lines indicate traverse made



INDIAN
OCEAN

CORE AREA

BUFFER AREA

● site

VEGETATION COMPLEXES and CONDITION of the WILBINGA STUDY AREA
 (adapted from a map accompanying McArthur and Bartle 1980a)

Vegetation Complexes

Q4 = Heaths and shrublands dominated by *Acacia rostellifera* and *Olearia axillaris* on Q4 age Quindalup dunes.

Q = Heaths and shrublands dominated by *Melaleuca acerosa* and *Acacia* spp. on Q3, Q2 and Q1 age Quindalup dunes.

L = Heaths dominated mostly by *Melaleuca* spp., *Dryandra sessilis* and *Hakea trilurcata* on Spearwood limestone with a shallow cover of siliceous sand.

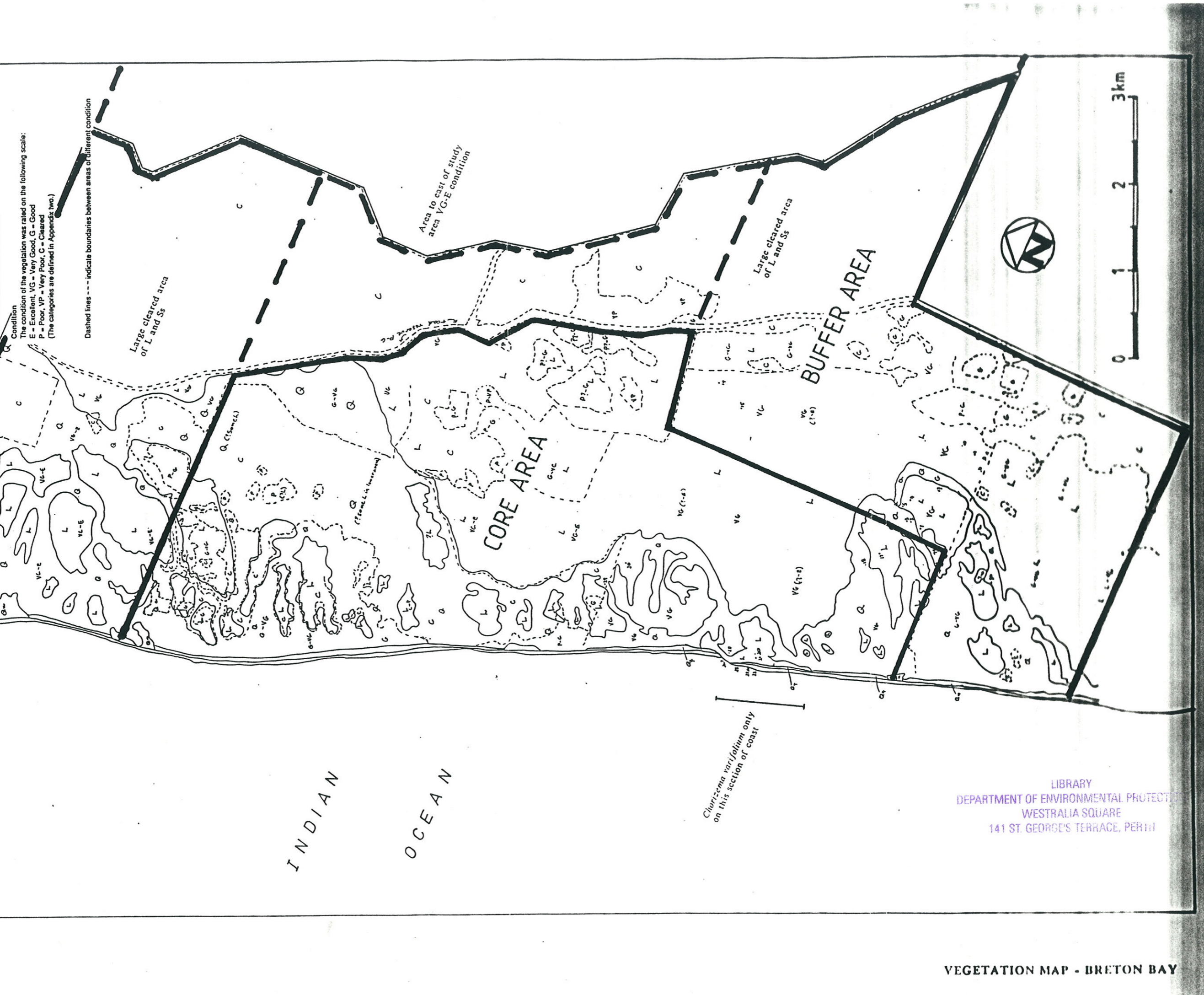
Ss = Banksia woodlands or forests, in places with Tuart (*Eucalyptus gomphocephala*), Sheoak (*Allocasuarina fraseriana*) or Jarrah (*Eucalyptus marginata*) on deep siliceous sand over Spearwood limestone.

Ss/L = intergrades between Ss and L

VEGETATION COMPLEXES
 Q4 - Heaths and shrublands dominated by *Acacia rostellifera* and *Cladonia* spp. on Q4 age Quindalup dunes.
 Q - Heaths and shrublands dominated by *Melaleuca acerosa* and *Acacia* spp. on Q3, Q2 and Q1 age Quindalup dunes.
 L - Heaths dominated mostly by *Melaleuca* spp., *Dryandra sessilis* and *Hakea trifurcata* on Spearwood limestone with a shallow cover of siliceous sand.
 Ss - Banksia woodlands or forests, in places with Tuart (Eucalyptus gomphocaphala), Sheoak (*Allocasuarina fraseriana*) or Jarrah (*Eucalyptus marginata*) on deep siliceous sand over Spearwood limestone.
 SsL - intergrades between Ss and L

CONDITION
 The condition of the vegetation was rated on the following scale:
 E - Excellent, VG - Very Good, G - Good
 P - Poor, VP - Very Poor, C - Cleared
 (The categories are defined in Appendix two.)

Dashed lines --- indicate boundaries between areas of different condition



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