Flora and Vegetation of the Leschenault Peninsula

THE LESCHENAULT PENINSULA — A FLORA AND VEGETATION SURVEY WITH AN ANALYSIS OF ITS CONSERVATION VALUE AND APPROPRIATE USES

M.E. TRUDGEN
Consultant Botanist
113 Park Street
Subiaco
Western Australia

Department of Conservation & Environment, Perth, Western Australia
Bulletin 157 June 1984

ISSN 0156-2983
ISBN 0 7244 6818 8

FRONT COVER

A typical view of vegetation of stabilised dunes on the Leschenault Peninsula showing its aesthetic appeal.

BACK COVER

1. Peppermint *(Agonis flexuosa)* Woodland, the understorey includes *Templetonia retusa* and *Rhagodia baccata*.

2. *Caladenia latifolia*. The only orchid common on the Peninsula.

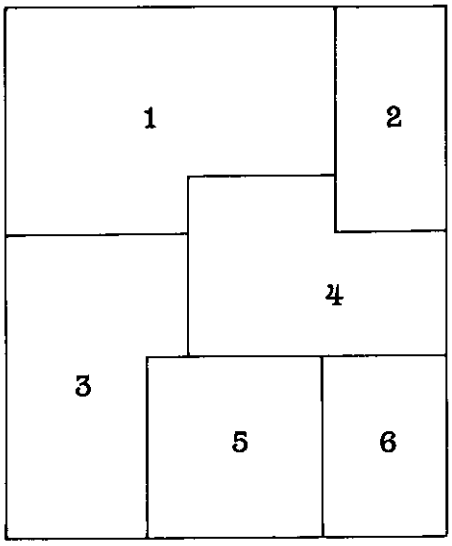
3. Tuart *(Eucalyptus gomphocephala)* Woodland. The understorey includes *Templetonia retusa, Rhagodia baccata* and *Acacia rostellifera*.

4. *Acacia rostellifera,* the most common shrub species on the Peninsula with *Hardenbergia comptoniana* (Native Wisteria), the commonest liane species.

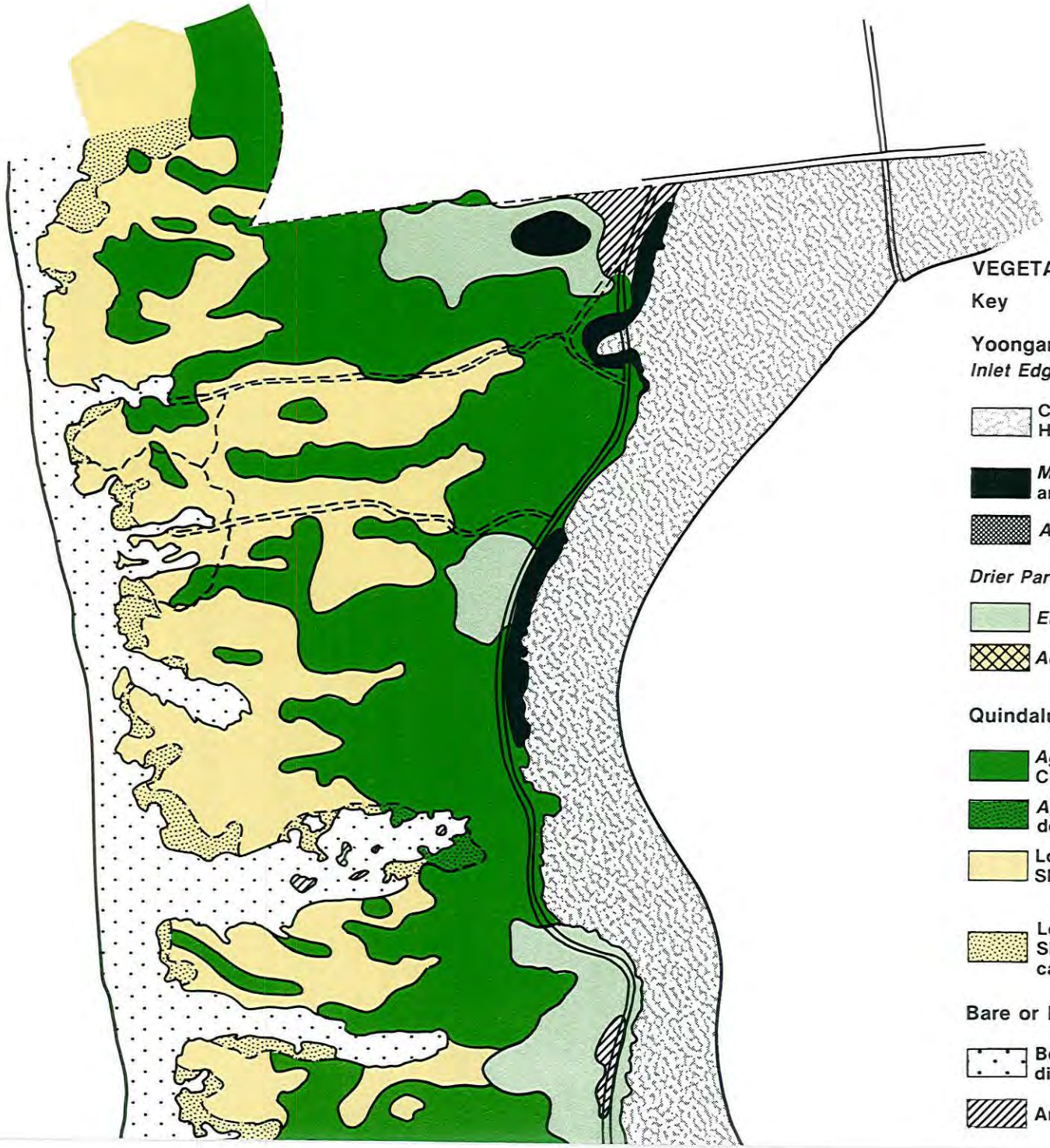
5. *Halosarcia halocnemoides*. Low Open Shrubland (in foreground) then *Sarcocornia quinqueflora* Closed Herbland and *Juncus kraussii* Closed Sedgeland on Inlet Edge.

6. *Templetonia retusa* (cockies tongue) one of the common shrub species is found under woodlands as well as in heaths.

Index to photograph captions



CONTENTS



VEGETATION OF THE LESCHENAULT PENINSULA

Key

Yoongarillup Plain

Inlet Edge

Closed Sedgelands, Closed Herblands and Low Open Heath

Melaleuca raphiophylla Low Open Forest to Closed Forest and *Melaleuca cuticularis* Low Open Forest

Avicennia marina Closed Scrub

Drier Parts of Plain

Eucalyptus gomphocephala (Tuart) Woodland

Acacia cochlearis, Acacia rostellifera Closed Scrub

Quindalup Sand Dunes and Plains

Agonis flexuosa Woodland Low Open Forest to Low Closed Forest

Agonis flexuosa with damage caused by erosion or deposition of sand

Low Shrubland, Low Open Shrubland, High Open Shrubland to High Shrubland, Closed Heath

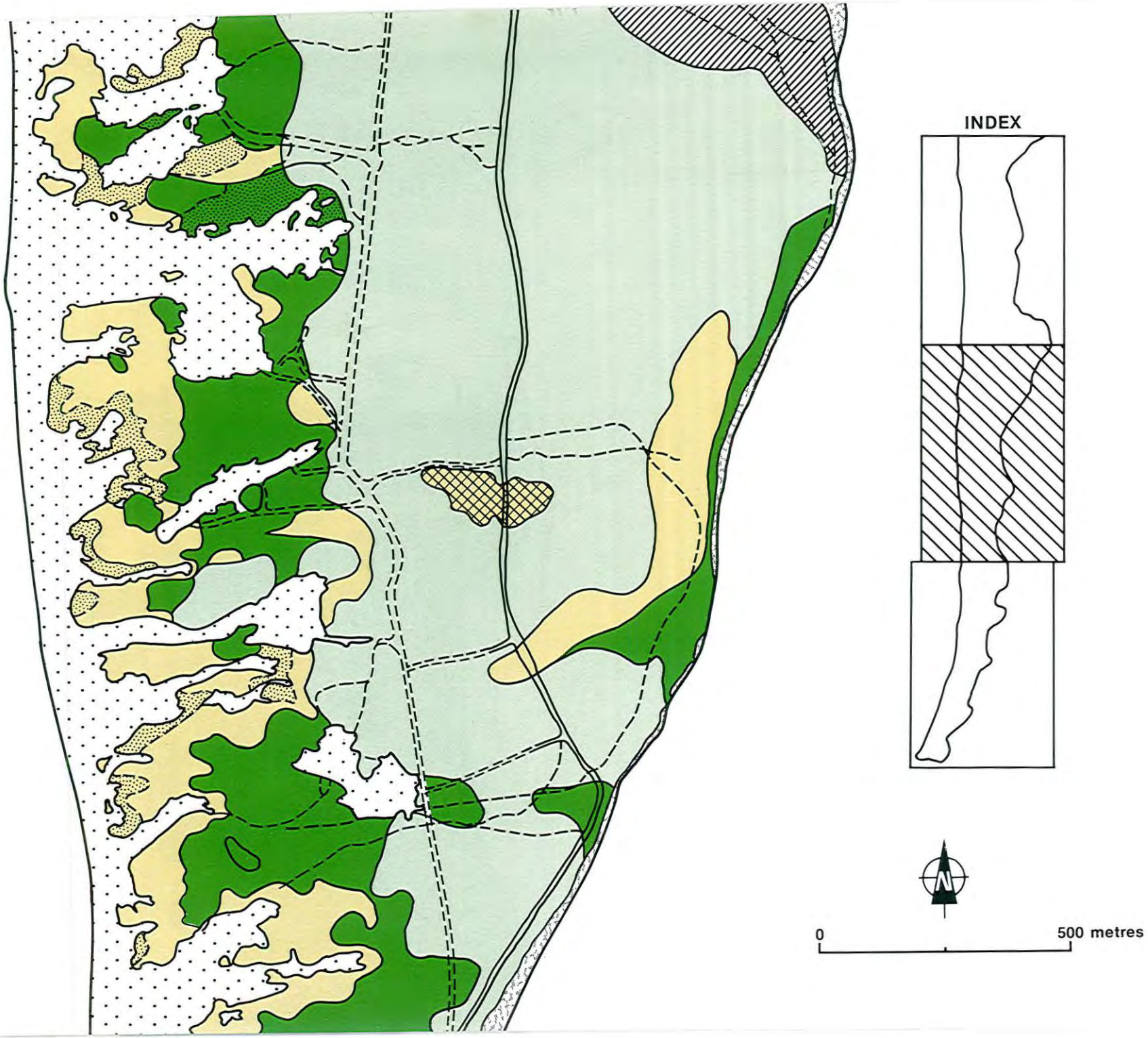
Low Shrubland, Low Open Shrubland, High Open Shrubland to High Shrubland, Closed Heath with damage caused by erosion or depositon of sand.

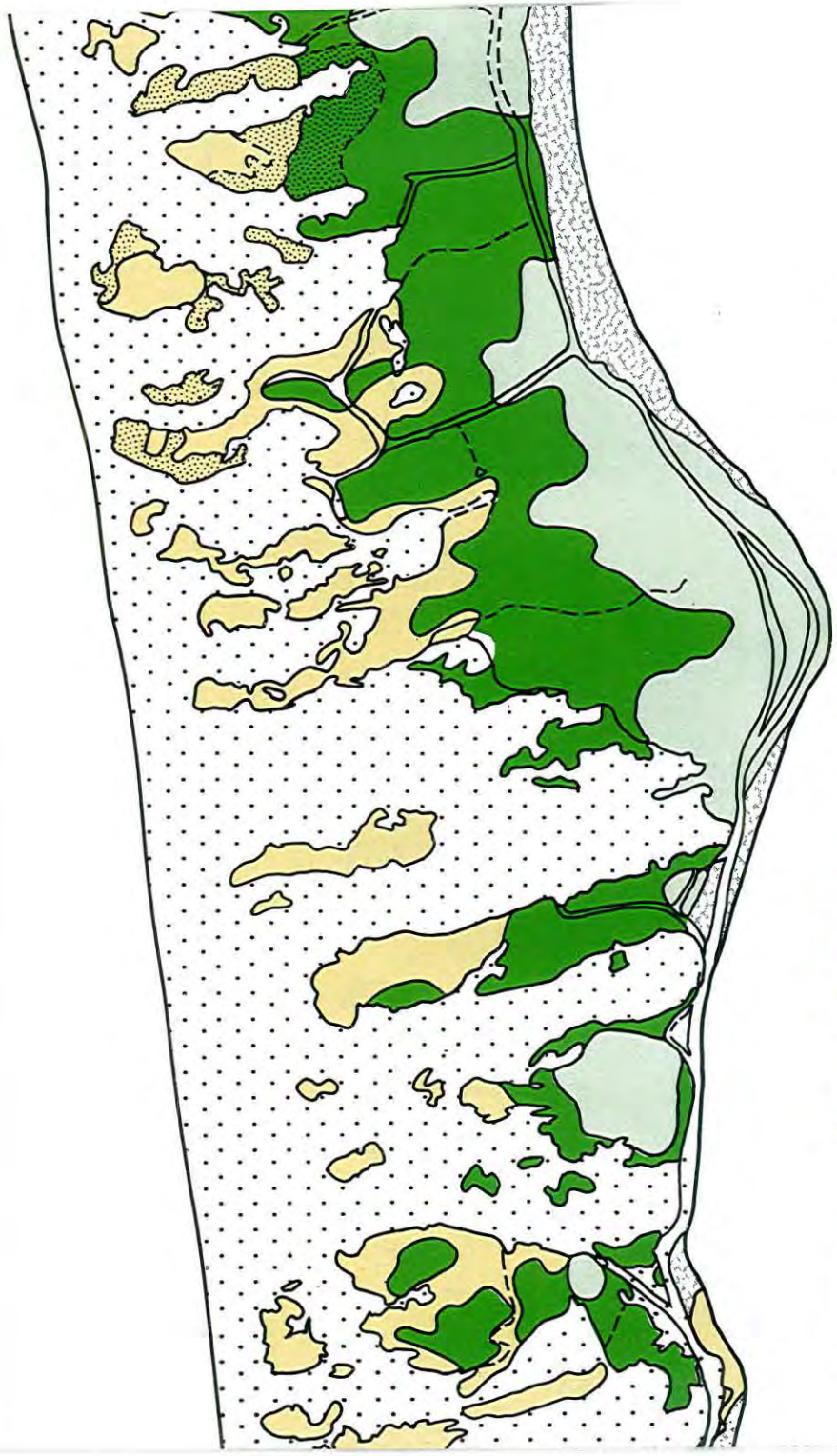
Bare or Disturbed Areas

Beach, Mobile Dunes, Poorly stabilised Dunes and areas disturbed by Waste Disposal

Areas disturbed by Agriculture


INDEX
N
0
500 metres


INDEX
0
500 metres



VEGETATION OF THE LESCHENAULT PENINSULA

Key

Yoongarillup Plain

Inlet Edge

Closed Sedgelands, Closed Herblands and Low Open Heath

Melaleuca raphiophylla Low Open Forest to Closed Forest and ***Melaleuca cuticularis*** Low Open Forest

Avicennia marina Closed Scrub

Drier Parts of Plain

Eucalyptus gomphocephala (Tuart) Woodland

Acacia cochlearis, Acacia rostellifera Closed Scrub

Quindalup Sand Dunes and Plains

Agonis flexuosa Woodland Low Open Forest to Low Closed Forest

Agonis flexuosa with damage caused by erosion or deposition of sand

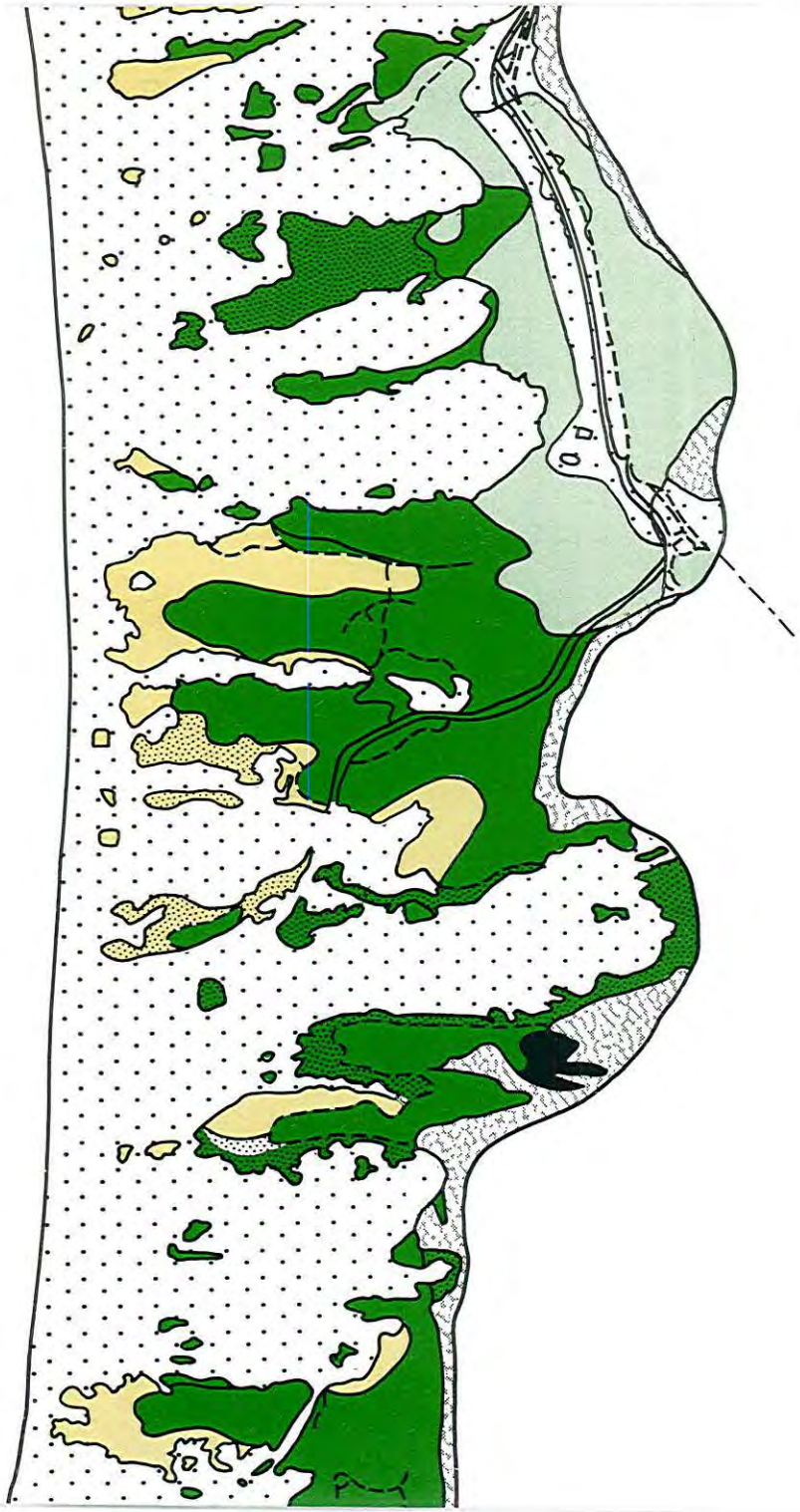
Low Shrubland, Low Open Shrubland, High Open Shrubland to High Shrubland, Closed Heath

Low Shrubland, Low Open Shrubland, High Open Shrubland to High Shrubland, Closed Heath with damage caused by erosion or depositon of sand.

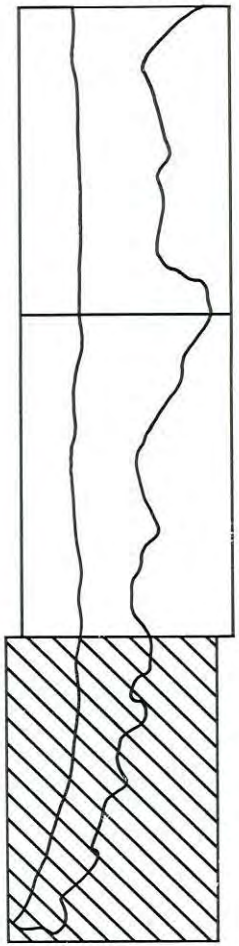
Bare or Disturbed Areas

Beach, Mobile Dunes, Poorly stabilised Dunes and areas disturbed by Waste Disposal

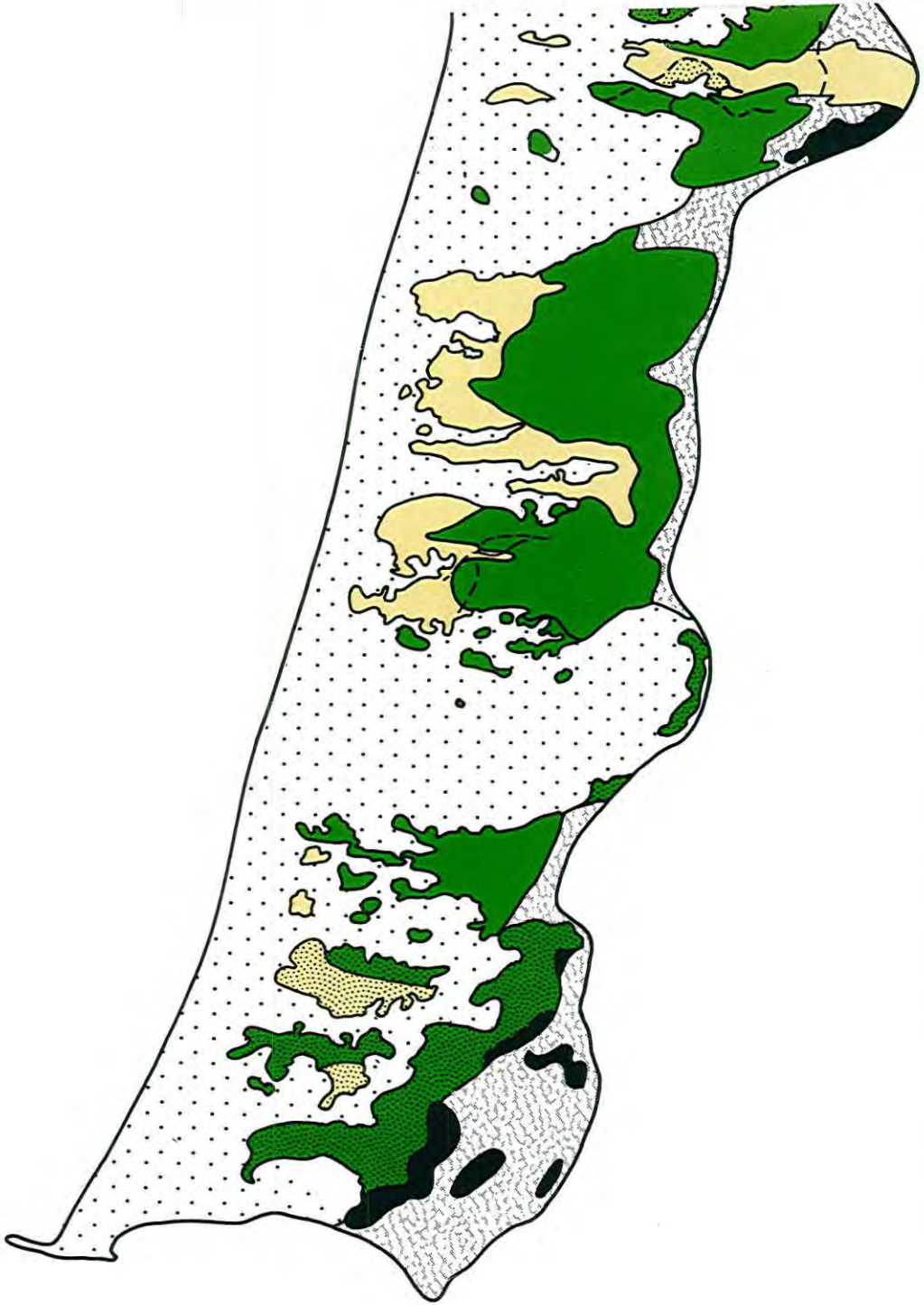
Areas disturbed by Agriculture



INDEX



0 500 metres



VEGETATION OF THE LESCHENAULT PENINSULA

Key

Yoongarillup Plain

Inlet Edge

- Closed Sedgelands, Closed Herblands and Low Open Heath
- *Melaleuca raphiophylla* Low Open Forest to Closed Forest and *Melaleuca cuticularis* Low Open Forest
- *Avicennia marina* Closed Scrub

Drier Parts of Plain

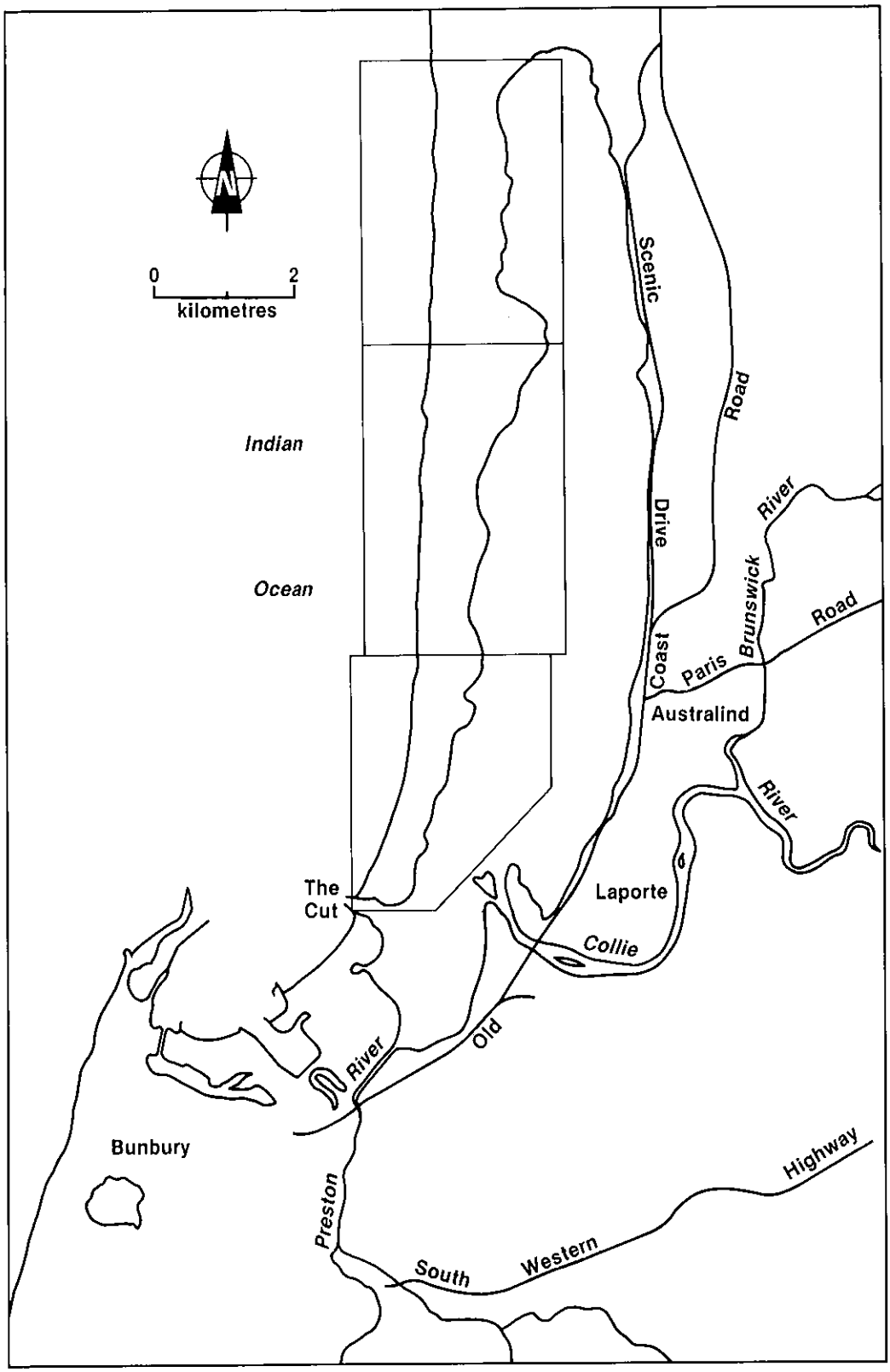
- *Eucalyptus gomphocephala* (Tuart) Woodland
- *Acacia cochlearis, Acacia rostellifera* Closed Scrub

Quindalup Sand Dunes and Plains

- *Agonis flexuosa* Woodland Low Open Forest to Low Closed Forest
- *Agonis flexuosa* with damage caused by erosion or deposition of sand
- Low Shrubland, Low Open Shrubland, High Open Shrubland to High Shrubland, Closed Heath
- Low Shrubland, Low Open Shrubland, High Open Shrubland to High Shrubland, Closed Heath with damage caused by erosion or depositon of sand.

Bare or Disturbed Areas

- Beach, Mobile Dunes, Poorly stabilised Dunes and areas disturbed by Waste Disposal
- Areas disturbed by Agriculture



Map 1 Location of Study Area and Map 2. Adapted from Public Works Department (undated).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Leschenault Peninsula has a flora of mainly coastal and near coastal species and in addition, a suite of species typical of saline mud flats (marshes). One hundred and twenty-two native species of flowering plants are known for the Peninsula, many of which have had their original populations considerably reduced by clearing for agriculture, urban areas and mining. Of these one hundred and twenty-two species, forty-one are not represented in the nearest coastal National Park (Yalgorup). Of special interest is the occurrence of the White Mangrove *(Avicennia marina)*, the only Mangrove population in the South West Botanical Province south of Shark Bay.
2. The vegetation of the Peninsula contains a range of plant communities representative of the vegetation of the unconsolidated sand dunes, salt marshes and plains of the Busselton to Mandurah coastal strip. The coastal dune types present are not well represented in secure conservation reserves. Tuart *(Eucalyptus gomphocephala)* woodlands which occur on the plains are inadequately represented in National Parks. The high value of the salt marshes of the Inlet edge sequence for conservation is widely recognised.
3. The Peninsula has a high potential as a resource for the conservation of flora, vegetation, fauna, landscape and geological features. In addition it has high potential value as a resource for education, scientific research, recreation and tourism.
4. The Peninsula is the most outstanding area of coastal and near coastal natural terrestrial environment remaining within the Bunbury region. As the Bunbury population is expected to increase greatly during the next 25 years, the Peninsula is ideally placed to play a unique role in the recreational pursuits of Bunbury residents.
5. The Peninsula has the potential to make a long term contribution to the economy of the Bunbury region through a role as a recreation and tourism destination in its own right.
6. The disposal of effluent on the Peninsula involves destruction of areas of high conservation value, has a significant impact on the terrestrial biota and precludes more appropriate land uses. Although effluent disposal is not the only cause of vegetation destruction on the Peninsula, it is an inappropriate land use for a fragile coastal environment.
7. The current use of Leschenault Peninsula for effluent disposal conflicts heavily with the guidelines for sound land use of the Quindalup Dune systems and with the Environmental Protection Authority criteria for disposal of effluent onto land.
8. Development of the Peninsula for agricultural purposes is also regarded as an inappropriate land use because of the conservation value of the Peninsula.
9. If coastal retreat and the mobile dunes are not controlled, in the long term, mobile dunes will invade Leschenault Inlet (several are already at or very near to its edge).

Recommendations

1. Effluent disposal on the Peninsula should cease as soon as possible. It is acknowledged that the current disposal practices would need to be continued, pending the adoption of a more environmentally acceptable long-term disposal option. However, this should not involve significant further destruction of vegetation. Use of the relatively undisturbed northern areas of the Peninsula should be avoided.
2. The status of the Peninsula should be changed, as soon as possible, to reflect its conservation values. The recommendations of the System Six Study for the area to be acquired as a reserve for recreation and conservation is endorsed.
3. A comprehensive management plan should be prepared for Leschenault Peninsula as a matter of urgency. Such a plan will need to have due regard to the dynamic nature of this coastal environment. The findings of this flora and vegetation survey should be an important element in the development of the management plan. There is a need for a survey of the Peninsula's fauna before the plan is drawn up.

4. The government should implement a comprehensive dune stabilisation and rehabilitation programme for Leschenault Peninsula, using ecologically sound stabilisation and rehabilitation techniques to stabilise the mobile dunes. In recognition of the conservation value of the area only native species indigenous to the Peninsula should be used. Additional resources should be extended to the Soil Conservation Service, Department of Agriculture, to implement this programme as a matter of urgency.
5. The assessment of the economics of different options for the disposal of Laporte's effluent should include realistic allowance for potential forgone and rehabilation needed through further use of the Peninsula as a disposal site.
6. The advice of an appropriate expert should be sought to establish what options, if any, are available to control the erosion of the coastline as this would be effective in reducing the number of blowouts.

Access to the Peninsula along Buffaloe Road.

INTRODUCTION

The Peninsula

The Leschenault Peninsula (the Peninsula) is an elongate, fingerlike extension of the Swan Coastal Plain, some 12km long and between 0.8 to 1.5km wide. It lies directly north of Bunbury, the second largest city in Western Australia. It encloses Leschenault Inlet and consists of a series of vegetated and mobile dunes and some small woodland plains. Some of the dunes rise to 40 metres above sea level and the mobile dunes currently cover some 30% of the Peninsula (Semeniuk and Meagher, 1981).

The Leschenault Inlet is of considerable importance for water birds, is an important nursery area for commercial species of fish, the whole area (i.e. the Inlet and its surrounds) is used heavily for recreation and has a very high conservation value. (DCE, 1981). The Peninsula and the Inlet are obviously interdependent but detailed discussion of the latter is outside the scope of this report.

The Peninsula is owned partly privately and partly publicly. The privately owned sections are largely undeveloped, with the exception of 'Belvedere', a small farming property on Waterloo Head. The Public Works Department controls a significant proportion of the Peninsula and uses part of this to dispose of effluent from the Laporte titanium dioxide manufacturing plant (See map 1).

As the Peninsula is largely surrounded by water it has an almost island-like atmosphere. This is very significant as Bunbury has no offshore islands to offer that distinctive island appeal which can afford a complete break from the bustle of a city.

Terms of Reference

The current study was commissioned to provide a report on the flora and vegetation of the Leschenault Peninsula giving:

- a description of the vegetation with an accompanying map;
- a survey of the flora;
- an analysis of the regional and local value of the flora and vegetation from a conservation viewpoint;
- comments on the implications of the survey for present and future land use;
- conclusions and recommendations based on the study.

View along seashore of the Peninsula with Bunbury in the background.

PHYSICAL ENVIRONMENT

Climate

Description

The climate has recently been described by Semeniuk and Meagher (1981) from which the following account is taken.

"The climate of the area is typically Mediterranean with hot dry summers and mild wet winters. Annual precipitation is 881mm (average), falling mainly in April to November. Temperatures reach a mean maximum of 27.9°C in January. The corresponding mean maximum for winter occurs in August at 16.5°. The mean minimum temperature in winter is 8.3°."

There is a clear division between the summer and winter wind patterns with normal wind patterns being related to the position of the eastward travelling high and low pressure systems which control the weather.

"The winter period is characterised by storms with intervening relatively calm weather". "Two to four of these storms may be expected each winter, with minor storms occuring approximately every 2 weeks". These storms bring strong westerly to north-westerly winds.

"As summer approaches the high pressure systems move north and the regional wind conditions moderate. Sea breeze/land breeze systems then control the winds in the coastal area." "During the summer there is the possibility of tropical cyclones travelling through the area".

"Late summer to autumn is the calmest period of the year with light winds".

Affect of Climate on Vegetation Development

The long summer drought undoubtedly plays a significant role in determining the vegetation developed on the Peninsula, with the availability of water from seepage and protected aspects offering some escape from its restrictions. Close to the coast the strong breezes, laden with salt, are also obviously a very important factor, restricting tree growth and causing wind pruning of the Peppermint *(Agonis flexuosa)*.

Landform

Four geomorphic sub-units have been identified for the Peninsula by Semeniuk and Meagher (1981). These are:

- Beach, this is a narrow strip along the western edge of the Peninsula.
- Mobile dunes, these occur as elongate east-west trending active parabolic dune lobes which progressively engulf the established vegetation as they move east. They currently comprise about 30% of the Peninsula and begin as blowouts on vegetated older dunes close to the beach.
- Vegetated parabolic dunes, these are similar in shape to the mobile dunes, and have developed from earlier generations of mobile dunes which have become stabilised by plants. Currently the best examples of these are on the northern part of the Peninsula where they have been least disturbed. Four ages of these dunes are recognised, Q1 to Q4, with Q1 being the oldest and Q4 the youngest (McArthur and Bartle, 1980).
- Woodland Plain, this is a relatively flat surface located in the central and eastern areas of the Peninsula and is typically covered by groves of Tuart *(Eucalyptus gomphocephala)*, Peppermint *(Agonis flexuosa)*, Tuart/Peppermint or *Acacia* species. These plains are sheltered from the prevailing south-west winds.

To these should be added a fifth sub-unit.

- The saline flats of the Inlet edge of the Peninsula.

The vegetated dunes are part of the Quindalup Dune System, the westernmost and youngest of a series of sub parallel dune systems that occur on the Swan Coastal Plain. The mobile dunes represent a recent reworking of these vegetated dunes. The woodland plain forms part of the Yoongarillup Plain (McArthur and Bartle, 1980).

Geology and Geomorphological Processes

Geology

The dunes of the Peninsula consist of fine grained, unconsolidated dune sands, near the base of which there is a layer of kankarised calcarenite. Just above sea level the dune sands give way to fine grained littoral sands and shell beds, with medium grained littoral sands along the present beach. These are all members of the Safety Bay Sand Formation. On the ocean side of the Peninsula they overlay the Tamala Limestone and on the Inlet side of the Peninsula they overlie the slightly calcareous estuarine muds of the Leschenault Formation (from fig.3, DCE. 1983).

Geomorphological processes

The geomorphological agents (ocean waves and wind) which were responsible for the formation of the dune systems which make up the bulk of the Peninsula are still active. It is important to realise the effects that these physical agents are having and will continue to have, on the sands and vegetation of the Peninsula.

Wave action

(particularly from high-energy winter storm waves associated with high tide levels) This is causing coastal retreat (erosion) at the rate of approximately 1-2 metres per year (Semeniuk & Meagher, 1981). This has caused the removal of the low foredune with its colonising plants and the undercutting of the stabilised dunes.

As well as exposure of the dune sands to the wind by wave action there is now the physical disturbance associated with the disposal of Laporte's effluent, the death of vegetation caused by the effluent itself and from the indiscriminate use of four wheel drive vehicles and motorbikes along the beach front.

Wind Action

Once the vegetation has been disturbed and the soil of the stabilised dunes has been exposed, the wind starts to redistribute the sand as blowouts. Whole dunes have been and are being moved, slowly across the width of the Peninsula.

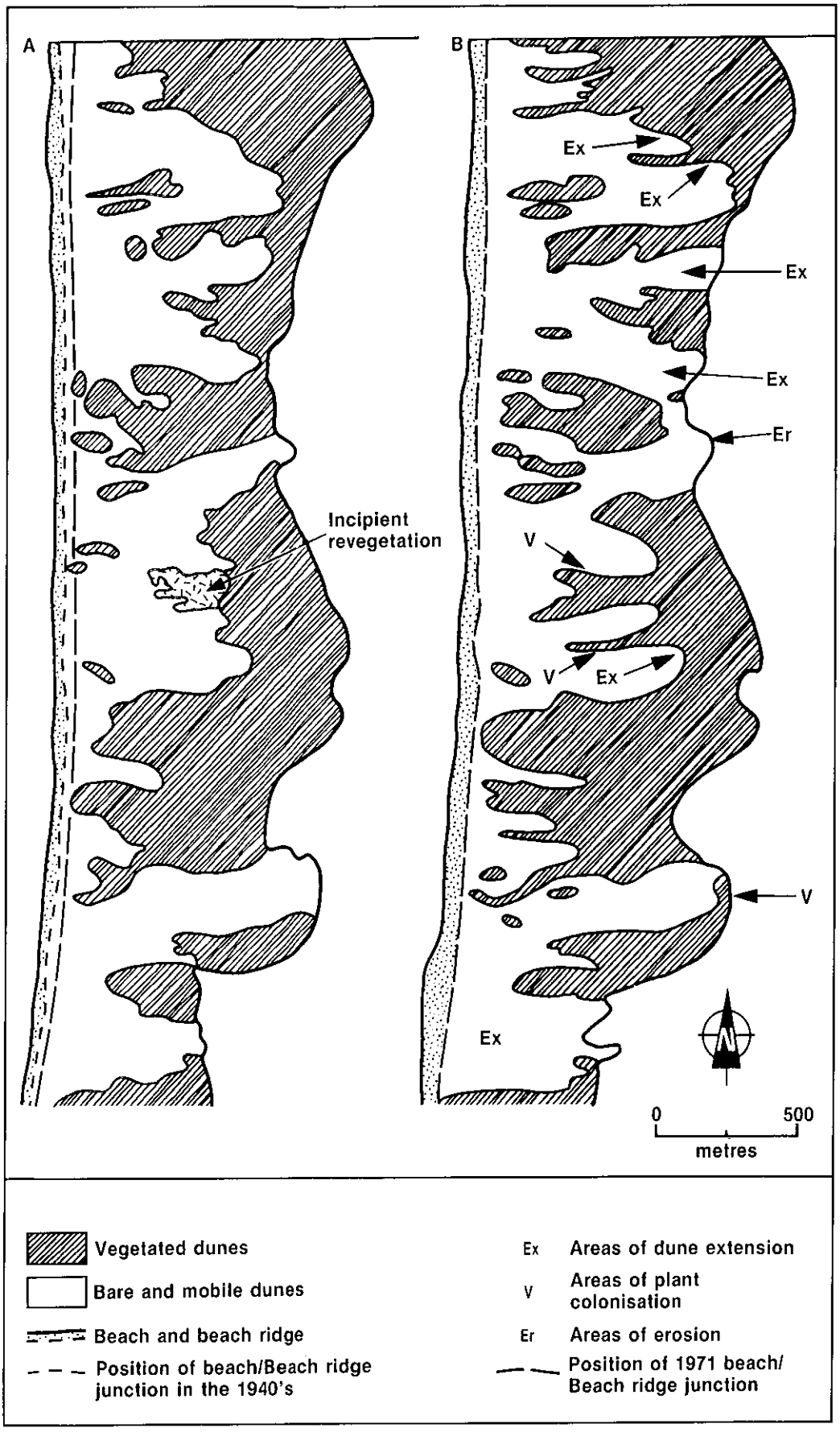
The strongest winds are associated with winter storms but at this time of year the sand is damp and so is not as susceptible to erosion. It is the strong sea breezes (speeds up to 15 metres per second), which occur in the dry summer, that are actually responsible for moving the sand (Semeniuk & Meagher, 1981). The movement of the dunes is staggered through time; while one area is becoming unstable another is being revegetated and stabilized (Semeniuk & Meagher, 1981). Dune movement appears to take place at varying speeds depending on the degree of disturbance and exposure to the wind. The subsurface calcrete layers present at some locations have effectively stopped erosion, until undercutting by wave action has taken place.

Long Term Result

Map two shows the increase in bare soil and mobile dune for a portion of the Peninula between 1941 and 1971. While the increase further north on the Peninsula is less, the same processes are at work there. The degree of increase and the threat to the Peninsula and Inlet are significant. Semeniuk and Meagher (1981) have analysed the position with regard to the increase in the easterly migration of the sand dunes in the following way:

- "Although their movement is staggered it may be expected that ultimately the dunes will migrate across the inlet and abut the hinterland."
- "More importantly, the entire Leschenault Inlet sequence could be lost by marine erosion. Thus the variability present today from offshore to the hinterland would be reduced to a more simple west to east parallel sequence . . ."

Obviously Semeniuk and Meagher are referring to a long term outlook. However, it should be realised that blowouts are already encroaching on the inlet margin and significant damage could be caused even in the relatively short term.



Map 2. Change in area of bare soil and mobile dunes between 1941 (A) and 1971 (B) for part of the study area (from Semeniuk and Meagher, 1981). Comparison to 1981 aerial photography shows a small increase (for this section) in the area of bare soil since 1971, largely being clearing associated with effluent disposal.

FLORA

The flora of the Peninsula reflects its coastal and near coastal environment, with the addition of a number of species typical of moist (freshwater) habitats and saline mud flats.

Flowering plants make up the (visible) bulk of the vegetation. They are complemented by species of non flowering plants (fungi, lichens and mosses) which although smaller, or not readily visible to the naked eye (many fungi live in the soil, litter or dead or living wood with their fruiting bodies only appearing for short times) are still extremely important in the ecology of the area.

The occurrence of the White mangrove *(Avicennia marina)* is of particular importance.

Flowering Plants

One hundred and nineteen native species of flowering plants were recorded from the Peninsula during the study, a further three species not collected during this study were recorded by Blackwell (undated) bringing the total known for the Peninsula to one hundred and twenty-two species (Appendix 1).

None of these species are gazetted as rare, although one *(Atriplex hypolenca)* is an uncommon plant of restricted occurrence due to its habitat preference (P.G. Wilson, pers.comm.).

Although none of the species found on the Peninsula are rare, almost all have had their populations considerably reduced by clearing for agriculture elsewhere on the Swan Coastal Plain. As agricultural clearing, the expansion of urban areas and mining developments are ongoing processes it is not unreasonable to assume that in years to come many more species of the native flora of the Swan Coastal Plain will become rare or threatened. It is in this context the status of the Tuart *(Eucalyptus gomphocephala)* is of considerable interest.

The size of the populations of the different species present ranges enormously, with a few species being very abundant and others being observed only at one place. There are two major tree species, the Peppermint *(Agonis flexuosa)* and Tuart *(Eucalyptus gomphocephala)*, other tree species are *Melaleuca rhaphiophylla, M. cuticularis, M. aff. hamulosa* and the sweet Quandong *(Santalum acuminatum)*. The shrub layer is dominated by a small number of species with *Templetonia retusa, Spyridium globulosum, Diplolaena dampieri, Acacia rostellifera and Acacia cochlearis* being the most common.

Arctotheca calendula an introduced flowering plant species that grows along the front of the foredune.

A feature of the flora is the prominence of the liane species *Hardenbergia comptoniana* and *Clematis microphylla* which both occur in all the vegetation associations except the inlet edge sequence.

Of the one hundred and twenty-two species of native flowering plants recorded for the Peninsula, forty-one were not recorded from Yalgorup National Park (the nearest coastal National Park) by Fox et.al. (1980). As Yalgorup contains similar habitats to those found on the Peninsula (as well as others) this has two significant implications:

- firstly, as Yalgorup is the largest coastal National Park between Perth and Busselton, if one third of the species found on the Peninsula are not protected there (Yalgorup) then the adequacy of the conservation of the coastal flora of this region must be in doubt.
- secondly, the Peninsula has very high conservation value (potential) for the forty one species found there but not recorded for Yalgorup.

Ferns

One fern species, the bracken *(Pteridium aquilinum)* was recorded. This species is widespread and common in the south west of Western Australia.

Mosses

The moss flora of the Peninsula is not rich, but the species present are important in the ecology of the area as in many places they cover the soil surface and would undoubtedly help to prevent erosion. Five species were recorded, all are widespread in Australia.

Stoneworts

One species of *Chara* was collected from fresh water seepage pools.

Lichens

Eleven lichen species were collected, mainly from the trunks of individuals of *Santalum acuminatum* and *Hakea prostrata* which provide the richest habitat for lichens on the Peninsula. All are widespread in Australia.

Fungi

The present study was not initiated until after the main season for the fruiting of fungi (autumn) had passed. Even so, six fungi were collected. Of these one species, *Cyathus affinity stercoreus* may be new to science (R. Hilton pers. comm.)

In general the specimens collected were of above average size, which is apparently not unusual for coastal areas (R.Hilton, pers. comm.).

Panus fasciatus, one of the fungi collected from the Peninsula.

Alien (Introduced) Species

In addition to the one hundred and twenty two species of native flowering plants recorded, thirty nine alien flowering plant species were recorded during the field surveys.

Fortunately only one of these thirty nine species *(Asphodelus fistulosus)* is highly aggressive and in general the degree of invasion is not high. Certainly it is much less than at Kings Park for example.

VEGETATION OF THE PENINSULA

Introduction

The vegetation of the Leschenault Peninsula is of high interest. Its value lies in the good development of the vegetation types represented, its aesthetically pleasing nature, its potential as a resource, its role in stabilising the sand dunes of the Quindalup Dune System and the presence of the Tuart *(Eucalyptus gomphocephala)* woodlands, White Mangrove *(Avicennia marina)* closed scrub and the extensive halophytic areas.

The stabilising role of the dune vegetation is highly significant in protecting the Leschenault Inlet and inlet edge communities from invasion by sand dune blowouts.

Vegetation Description

Vegetation can be described on the basis of its structure (height, foliage cover, layers developed) or its floristics (which species are present) or a combination of these.

Table 1

Vegetation structural types found on the Leschenault Peninsula (Adapted from Aplin (1979))

Increasing height ↓		
	Herblands	closed Herblands closed sedgelands
	Low open heath	closed heath closed scrub
	Low open woodland	low closed forest
	Open woodland	closed forest

Increasing Foliage Cover →

The vegetation of the Peninsula includes the structural forms shown in Table 1. However, due to time restrictions and the diversity of communities developed on the Peninsula, the vegetation map has been simplified by grouping similar communities together in mapping units. The vegetation map gives significantly greater detail than has previously been available and is at a level that enables a meaningful overview of the vegetation to be gained.

The communities that can be described for the Peninsula can be split into two major groups on the basis of their floristics. These are the communities of the inlet edge and the communities of the shallow to deep sands which make up the bulk of the Peninsula. The former are part of the Yoongarillup Plain and the latter are the Quindalup Dune System and part of the Yoongarillup Plain as defined by McArthur and Bartle (1980).

Vegetation of the Yoongarillup Plain

The vegetation of the Yoongarillup Plain includes the communities of the Inlet edge which are related to water availability and quality (salinity) and the communities of the broader areas of the plain away from the Inlet edge. These are mostly dominated by Tuart *(Eucalyptus gomphocephala)* and Peppermint *(Agonis flexuosa)* but include also an occurrence of *Acacia cochlearis* and *A. rostellifera* Closed Scrub.

Communities of the Inlet edge

The communities of the Inlet edge range in structural form from herblands through low heaths to low woodland to forest. On the vegetation map the communities of the Inlet edge are represented by three units, the *Avicennia marina* Closed Scrub, the *Melaleuca cuticularis* and *Melaleuca rhaphiophylla* Low Open Forest to Closed Forest and a unit which groups the Sedgeland, Herbland, Aquatic Herbland and Low Open Heath communities ocurring on the Inlet edge. The sequence of communities found at any particular locality along the Inlet shore is dependent on the topography, water level and quality there. Bearing this in mind parts of two 'idealised' sequences may be present.

(i) First inlet edge sequence (Fig.1A).
This sequences is the least common and consists of two floristically quite simple communities. These are:

***Avicennia marina* Closed Scrub:** A community which has a dense cover of the White Mangrove *(Avicennia marina)* with only a few straggly *Sarcocornia quinqueflora* 'shrubs' and occasional individuals of *Lobelia alata* as an understorey.

***Bulboschoenus caldwellii* Closed Sedgeland:** A community which occurs immediately inland of the *Avicennia marina* community, is dominated by *Bulboschoenus caldwellii* with *Suaeda australis* as a minor constituent. It has been very heavily invaded by couch grass *(Cynodon dactylon)*. The *Bulboschoenus* sedgeland can abut the Inlet directly.

This sequence was only observed at one locality (just north of 'Belvedere') where it is threatened by a poorly stablilised dune. Prior to the invasion of the inlet edge by this dune the *Avicennia* and *Bulboschoenus* communities were probably adjacent to communities of the second inlet edge sequence.

(ii) Second Inlet edge sequence (Fig.1B).
This sequence is more complex with a greater number of communities, but again some of them are very simple floristically with few species, and at any locality not all will necessarily be present. Two of the communities occur twice in the sequence.

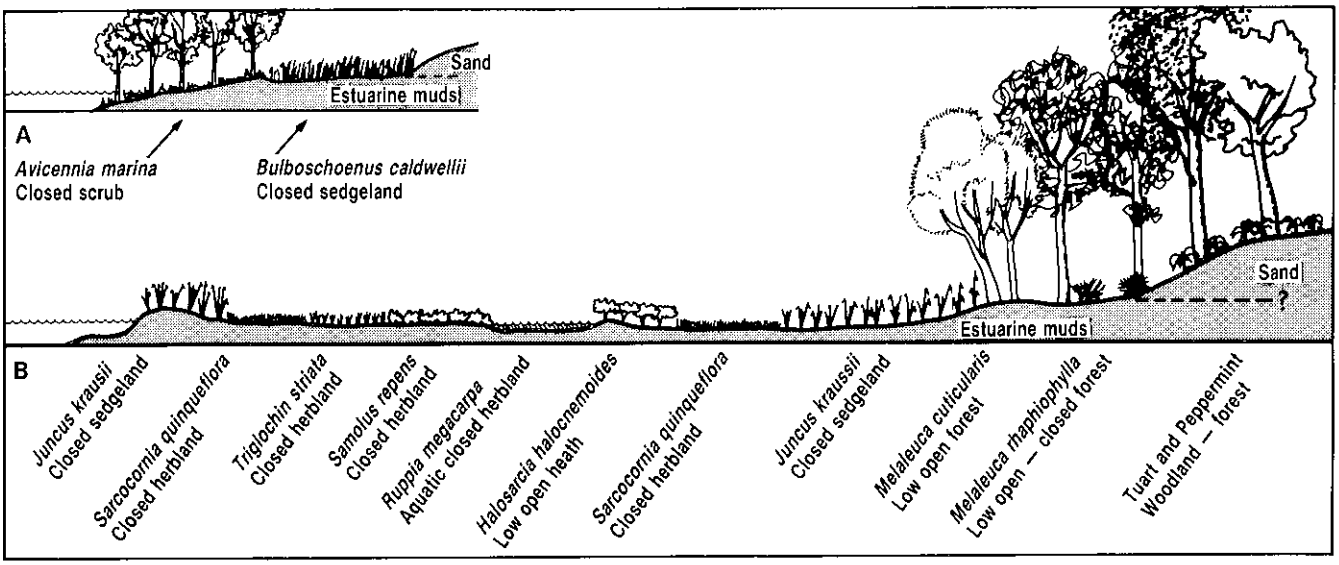


Figure 1: Inlet edge sequences with boundary to the Quindalup Sandune — Yoongarillup Plain sequence.
A: Sequence with White Mangrove *(Aucennia marina)* and *Bulboschoenus caldwellii* communities.
B: Sequence with *Juncus, Triglochin, Sarcocornia, Samolus, Ruppia, Halosarcia* and *Melaleuca* communities.

Starting at the Inlet shore the sequence is as follows:

***Juncus kraussii* Closed Sedgeland:** A dense sedgeland with *Sarcocornia quinqueflora* and *Suaeda australis* as minor constituents. Where developed on the outside of the sequence, this community occurs as a narrow fringe only. The same community occurs further up the sequence where it is quite extensive.

***Sarcocornia quinqueflora* Closed Herbland:** A community which typically occurs as Monospecific stands of the *Sarcocornia*.

***Triglochin striata* Closed Herbland:** Typically a monospecific stand of the *Triglochin*.

As well as the pure *Sarcocornia* and *Triglochin* communities there are areas where the communities intergrade.

***Samolus repens* Closed Herbland:** Occurs as monospecific stands or with *Sarcocornia quinqueflora* as a minor constituent. This *Samolus* community in-

tergrades with both of the two preceding communities.

***Ruppia megacarpa* Aquatic Closed Herbland:** This aquatic species occurs in ponds, very slow flowing drainage lines within the sequence and soaks in the *Juncus kraussii* community.

***Halosarcia halocnemoides* Low Open Heath:** monospecific stands or with an understorey of *Sarcocornia* and *Samolus* and *Suaeda* as minor constituents.

***Sarcocornia quinqueflora* Closed Herbland:** (see above)

***Juncus kraussii* Closed Sedgeland:** This community occurs at the beginning of the sequence on the edge of the Inlet and again at this stage where it is much better developed. At its upper edge there is a band where additional species including *Baumea juncea* and *Atriplex hypoleuca* occur.

***Melaleuca cuticularis* Low Open Forest:** Observed as a thin belt with a *Sarcocornia quinqueflora* understorey. *M. cuticularis* is tolerant of higher salinity levels than the dominant of the next community *(M. rhaphiophylla).*

***Melaleuca rhaphiophylla* Low Open Forest to Closed Forest:** This community can have a lower stratum of *Melaleuca aff. hamulosa* and various understoreys depending on the particular site. Understorey species include *Halosarcia indica ssp. bidens, Sarcocornia quinqueflora* and *Gahnia trifida*. This community also occurs as a swamp just inland from the Inlet margin at the northern end of the Peninsula. *M. rhaphiophylla* is tolerant of only mildly brackish salinity levels.

***Chara sp.* Aquatic Closed Herbland:** This community occurs in brackish soaks within the *Melaleuca raphiophylla* communities.

Mixed Herbland: This community is only well developed at one location which seems to be an old beach (? from a period of higher water level). It has been moderately heavily invaded by couch grass *(Cynodon dactylon)* and *Dittrichia graveolens*.

Where channels have been cut in the sequence or where there is drainage from soaks the particular development of the sequence is distorted, in a logical fashion, as the occurrence of the communities is closely related to soil moisture conditions (salinity levels may also be important).

Vegetation of the Drier Parts of the Yoongarillup Plain (Fig. 2)

***Eucalyptus gomphocephala* Woodland:** On this plain the most widespread vegetation unit is Tuart *(Eucalyptus gomphocephala)* woodland. It has a very variable understorey that is determined by the depth of the irregular sand banks that occur on it. The Peppermint occurs as a second tree stratum and understorey species include *Olearia axillaris, Templetonia retusa, Exocarpus sparteus, Hakea prostrata, Spyridium globulosum* and *Diplolaena dampieri.*

One small area of *Acacia cochlearis, Acacia rostellifera* Closed Scrub occurs on the Yoongarillup Plain about 1km south west of 'Belvedere'.

These two communities are shown seperately on the vegetation map.

Vegetation of the Quindalup Sand Dunes and Plains (Fig.2).

The communities of the Quindalup Dunes and Plains range in structural form from grasslands through heaths and shrublands to woodlands and forests. The community developed depends on the interaction of several factors; distance from the sea, aspect and depth of sand, as well as the age of the individual dunes involved.

These communities are grouped into two units on the vegetation map. The first groups the grasslands, heaths and shrublands together and the second groups the *Agonis flexuosa* woodlands and forests.

Sand Dunes Closest to Beach (Q4) (first stabilised dunes)

The typical foredune, swale, stabilised dune system has been truncated by erosion of the beach. The plants typically found on the foredune can now be found on the disturbed front of the first stabilised dunes that remain, or in scattered patches on the mobilised dunes (blowouts) where what was the first stabilised dune

has been destabilised and moved inland. The following sequence is now found on the remainder of the first stabilised dunes.

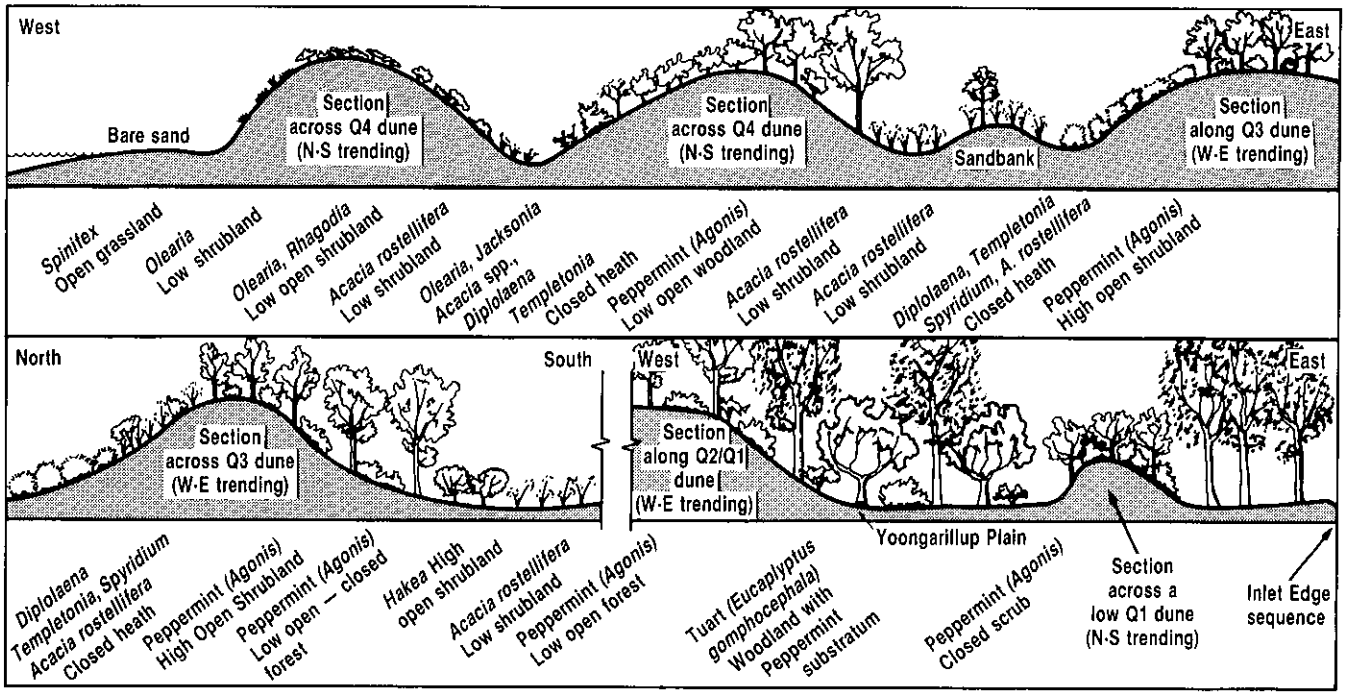


Figure 2: Transect from beach through Quindalup Dunes and Yoongarillup Plain to Inlet Edge.
Note: The transect is not a simple W—E one, but W—E, then N—S then W—E again.

Seaward face of Dune:
***Spinifex hirsutus, S. longifolius* Open Grassland:** Has scattered individuals of *Carpobrotus virescens, Scirpus nodosus, Cakile maritima, Olearia axillaris* and *Tetragonia decumbens*.

Crest of Dune:
***Olearia axillaris* Low Shrubland:** This has a prominent understorey of *Scaevola crassifolia* and *Alyxia buxifolia*. Others species present include *Acanthocarpus preissii, Acacia rostellifera, Hardenbergia comptoniana* and *Cassytha glabella*.

Landward Face of Dune:
***Olearia axillaris, Rhagodia baccata* Low Open Shrubland:** Occurs with *Acacia rostellifera* and *Lepidosperma gladiatum* as additional species.

A common variant has wind pruned *Agonis flexuosa* on the dune crest and the same species as a tree on the landward side of the dune.

Deflation Basin (Interdune):
***Acacia rostellifera* Low Shrubland:** Other species include *Rhagodia radiata* and *Suaeda maritima*. This community is repeated later in the sequence where it is generally better developed (see below).

Second Stabilised Dune — where this is also Q4 in age.
Seaward face:
***Olearia axillaris, Jacksonia furcellata, Acacia cochlearis, Acacia rostellifera, Diplolaena dampieri, Templetonia retusa* Closed Heath.** Other species include *Acanthocarpus preissii, Rhagodia baccata, Hardenbergia comptoniana* and *Clematis microphylla*.

Landward face of Second Dune:
***Agonis flexuosa* Low Open Forest:** Occurs with an *Acacia rostellifera, Diplolaena dampieri, Templetonia retusa, Rhagodia baccata* understorey.

Parabolic Dune typically at right angles to the coast.
These are Q3 age dunes, and show a very strongly marked aspect effect. That is, the vegetation on the north facing side is significantly different to that on the south

facing side, with a transition over the crest. The difference apparently being caused by the different amounts of sunlight received.

North facing side:

***Diplolaena dampieri, Templetonia retusa, Spyridium globulosum, Acacia rostellifera* Closed Heath:** Additional species include *Phyllanthus calycinus, Leucopogon parviflorus* and *Acanthocarpus preissi*.

Towards the crest:

***Agonis Flexuosa* High Open Shrubland to High Shrubland:** The Peppermint *(Agonis flexuosa)* usually appears as a mallee or several stemmed form over an understorey similar to the heath downslope on the northern aspect, though in places a variant occurs in which the heath is dominated by *Guichenotia ledifolia*.

South facing side:

***Agonis flexuosa* Low Open Forest to Low Closed Forest:** This occurs immediately over the crest. It has an open understorey of *Templetonia* and *Spyridium*. At the base the *Agonis* is typically taller and denser and is properly classified as closed forest.

Deflation hollows left by advancing Parabolic Dune Lobes

The vegetation of these narrow elongate plains has the following communities and similar sites occur between the Q4 dunes (see above).

***Acacia rostellifera* Low Shrubland:** This occurs on the lowest parts, other species present include *Rhagodia baccata, Suaeda maritima, Zygophyllum fruticulosum, Clematis microphylla and Tetragonia decumbens*. These areas have been heavily invaded by Onion weed *(Asphodelus fistulosus)*. Where this has not occurred displays of the annual *Senecio lautus* occur.

***Hakea prostrata* High Open Shrubland to Shrubland:** This community occurs as an irregular belt around the preceding community and is quite variable in density and species composition.

Other species in the community include *Exocarpos sparteus, Spyridium globulosum and Acacia rostellifera*.

***Acacia rostellifera* Low Open Woodland to Low Woodland:** This community occurs on small sand banks in the deflation basins and is interesting, because *Acacia rostellifera* in other communities usually occurs as a shrub and mostly dies out at about 2m tall, yet here occurs to 5m as the dominant. The same community can also occur between the Q4 and Q3 dunes, as shown on Figure 2.

Q2 and Q1 Dunes and Interdunes

***Agonis flexuosa* Woodland to Forest:** A range of communities dominated by *Agonis flexuosa* occurs on these dunes. The community developed at any location depends on the depth of soil and the aspect. The major understorey species are *Templetonia retusa, Diplolaena dampieri, Spyridium globulosum* and *Hibbertia cuneiformis*. The liane *Hardenbergia comptoniana* is common, often with stems 2cm or more thick.

Q2 dunes typically have *Agonis flexuosa* woodland or low open forest to open forest. Q1 dunes have these but also occasionally have Tuart *(Eucalyptus gomphocephala)* woodland where they abut parts of the Yoongarillup Plain. Low Q1 dunes that have invaded the Yoongarillup Plain have a distinctive *Agonis flexuosa* closed scrub on them. One such dune which has turned parallel to the inlet shore, has a narrow belt of *Acacia cyclops* low open woodland developed along the side facing the inlet.

Boundary of Inlet Edge Sequence with Quindalup Sandunes or Drier Parts of the Yoongarillup Plain.

This boundary is very abrupt, with little overlap between the Inlet edge sequence and the Peppermint *(Agonis flexuosa)* and Tuart *(Eucalyptus gomphocephala)* woodlands of the dunes and plains.

In areas where there is seepage or goundwater flow near the surface of the sands, the typical understories of the Peppermint and Tuart are replaced by Bracken *(Pteridium aquilinum)* or Coast Sword Sedge *(Lepidosperma gladiatum)*. The *Pteridium* was only seen in this situation but the *Lepidosperma* is common across the Peninsula. *Acacia saligna* occurs sporadically along the boundary, usually as scattered trees, but in one location (about 1km north of 'Belvedere') it occurs as a small area of *Acacia saligna* Low Closed Forest.

The Peninsula has potential for several future land uses based on conservation of the Peninsula's natural values and the utilization of these values for nondestructive activities, which could enrich the lives of both local people and visitors.

It has potential as a resource for conservation of flora, vegetation, fauna, landscape, geological features, as a resource for education and scientific research and for recreation and tourism. These uses would benefit many members of our society and are largely compatible if carried out under good management, at appropriate scales of activity.

The conservation values of the Peninsula have been recognised by the author's of several reports including:

- Bunbury Region Plan (Taylor et.al. 1980).
- System Six Study Report to the Environmental Protection Authority (DCE, 1981).
- Leschenault Inlet Management Programme (Waterways Commission and Leschenault Inlet Management Authority, 1983).
- Shire of Harvey Town Planning Scheme No. 10 (Shire of Harvey, 1983).
- Conservation Reserves for Western Australia as recommended by the Environmental Protection Authority — 1983. The Darling System — System 6. Part II: Recommendations for Specific Localities (Department of Conservation) 1983).

The current use of the Peninsula for disposal of Laporte's effluent is incompatible with the realisation of these potentials.

Vegetation

The coastal dune vegetation types which form the bulk of the Peninsula are not well represented in secure conservation reserves. This factor means that the Peninsula has considerable potential to further the protection of representative areas of native vegetation. Some of the vegetation types on the Peninsula are represented in Yalgorup National Park, however, only a small proportion of this park abuts the coast so the near coastal sand dune systems without a consolidated limestone core are not well represented there.

There is a lack of coastal reserves elsewhere in the region. As well as the coastal dunes, the following vegetation types are of merit for conservation.

Mangrove Closed Scrub
The occurrences on the shores of Leschenault Inlet are the southernmost of this species in W.A. and the only Mangrove populations in The South West Botanical Province south of Shark Bay.

Coastal Salt Marshes
These are of limited occurrence in The South West Botanical District and all action possible should be taken to protect them because of this and their importance as feeding habitats for birds.

Tuart Forest
The long term conservation status of the Tuart, one of the major tree species of the Swan Coastal Plain, is far from secure. At present its representation in conservation reserves is inadequate. It should be realised that many areas of the remaining Tuart stands on the coastal plain have had their understoreys cleared and/or are being used for grazing and consequently the stands are not regenerating. In the absence of changes in their management, to permit the establishment of young trees, these stands will gradually disappear as existing trees decline with age. Protection of the Peninsula with its modest Tuart stands would be a step towards rectifying the Tuart conservation problem.

Flora

The flora of the Peninsula does not contain any gazetted rare species. This does not mean that it is not important to conserve populations of the species present. Rather it should be recognised that many of the populations of native plants on the Swan Coastal Plain are under threat and that the flora of the Coastal Plain as a whole is inadequately protected. Inevitably this means that as those areas on

the Coastal Plain, not in conservation reserves, are cleared or deteriorate as a result of grazing or lack or management, many more species will become rare of threatened. Thus, the Peninsula offers the opportunity to conserve populations of coastal and near coastal species, species whose habitat will undoubtedly be under ever increasing pressure due to urban and recreational developments and continued clearing for agriculture.

Of the one hundred and twenty-two species of native plants recorded from the Peninsula, forty-one have not been recorded from Yalgorup National Park. The Peninsula therefore offers the opportunity to protect these species of native plants. Five are found on the dunes closest to the beach, fourteen in the inlet edge sequence and the remainder in the Tuart and Peppermint woodlands.

Fauna

The Peninsula is known to support a variety of native fauna including grey kangaroos, bandicoots, possums, bats, water rats, a range of reptiles (lizards and snakes) and frogs. (Public Works Department, undated).

The statement that has been made (Public Works Department, undated) that "no rare species (of fauna) have been encountered" would appear to be essentially true; however, there has been no comprehensive survey of fauna to establish what species are actually present! Until this is done the true value of the Peninsula for fauna must be considered as unknown, with the exception of the well documented value of the salt marshes and fresh water seepages as feeding and breeding areas for water fowl.

Geological Features

McArthur and Bartle who mapped the soils of the Mandurah to Bunbury coastal area commented that this area "includes geological formations which are important in an understanding of the Quaternary history of the Swan Coastal Plain". They note that the four phases of the Quindalup Dunes "provide evidence of climate variations during the Holocene" and in regard to the Quindalup and Spearwood dune systems recommend that "In both instances representative examples should be set aside for study." (McArthur and Bartle, 1980).

The northern part of the Peninsula contains relatively undisturbed sequences of dunes which are of value in this context. There are also isolated examples of the oldest Quindalup Dunes (Q4) on the area of Yoongarillup Plain near 'Belvedere'.

Landscape

The maritime landscape of the Peninsula with its windblown dunes and vegetation presents a considerable contrast to the forest and farm landscapes of the nearby hinterland. As such it is a valuable resource for landscape as it provides an additional or alternative viewing choice. "The whole area (ie. the Peninsula and the Inlet) provides wide scenic vistas" (Department of Conservation and Environment 1983).

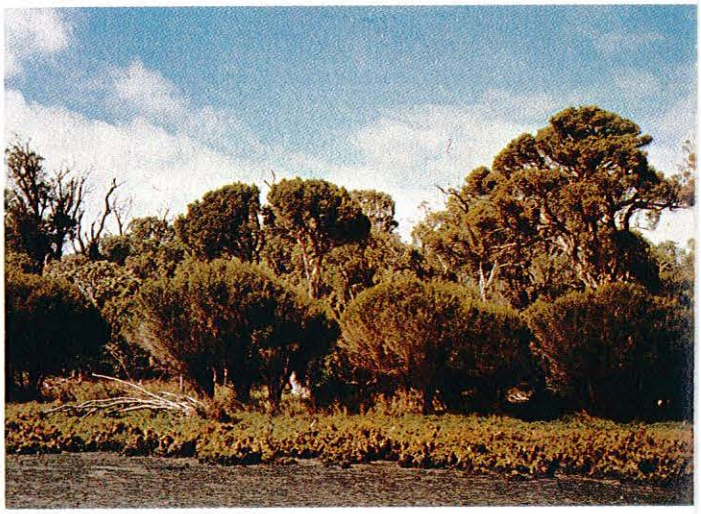
Education

The Peninsula has high value as an educational resource because the ecosystem of the mobile dunes is so obviously dynamic, that relationships between the environmental factors at work and the vegetation that results become readily appreciable.

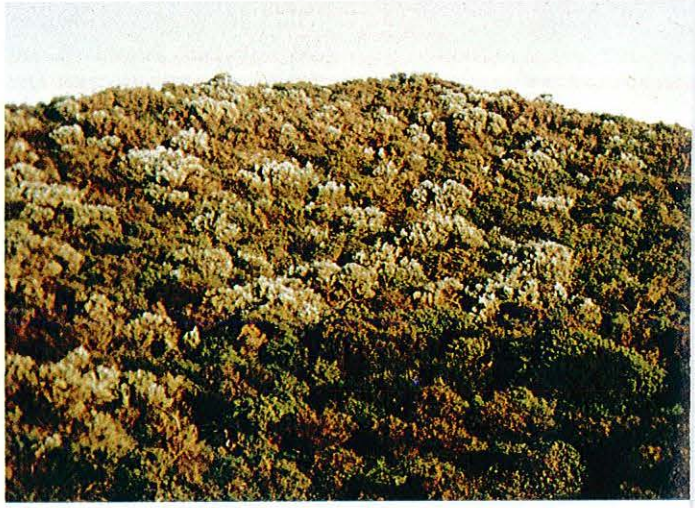
At the macro-scale there is the succession from the foredune plants to the coastal heath through to the Peppermint and Tuart forests. On the micro-scale, in the coastal marshes of the inlet there is the clear relationship between height above water level and the community of plants produced. As well, there are the east-west dunes which provide excellent examples of the effects of aspect on vegetation. On the north side of these dunes heaths predominate, on the south side woodland occurs, grading to forest near the base.

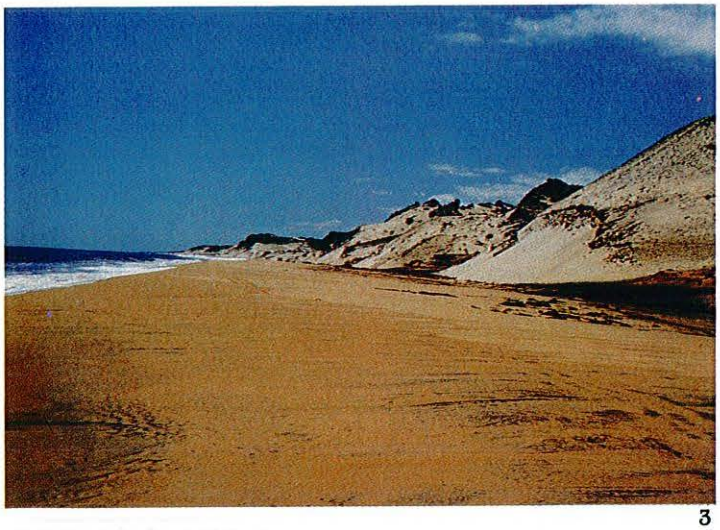
These features, along with others such as the wind pruning of Peppermint *(Agonis flexuosa)* and the presence of the mangroves offer an excellent opportunity to reserve a high quality, high value educational resource near to Western Australia's

1

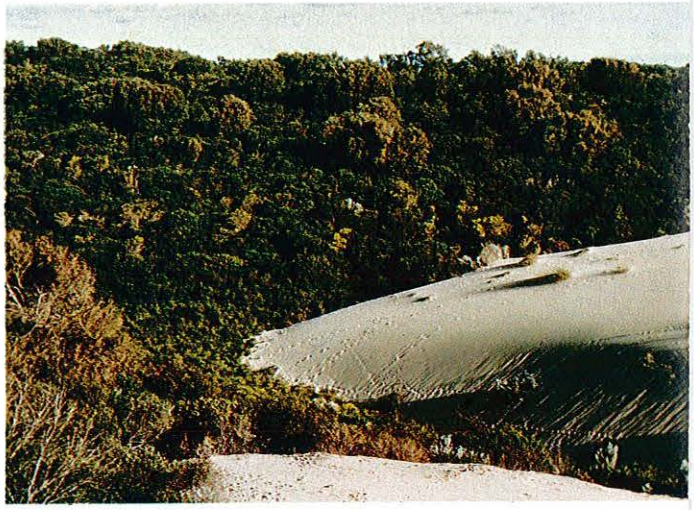


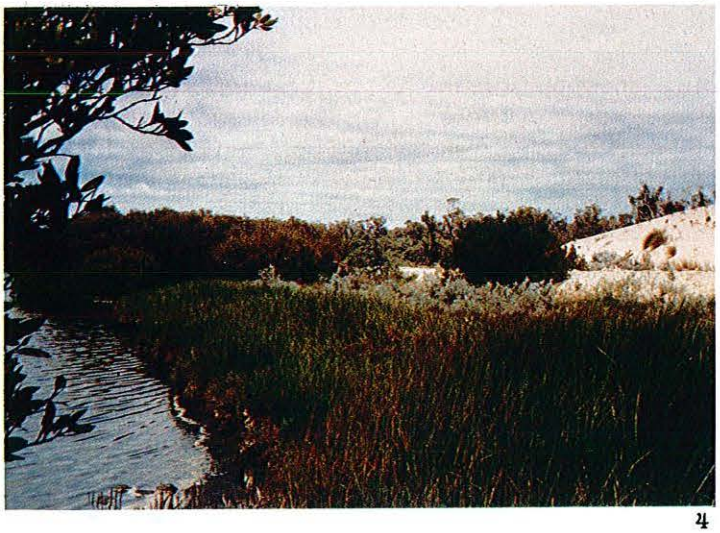
2



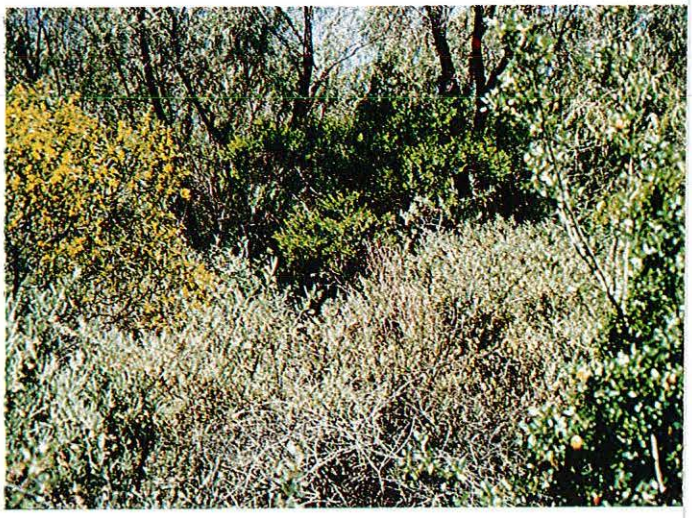


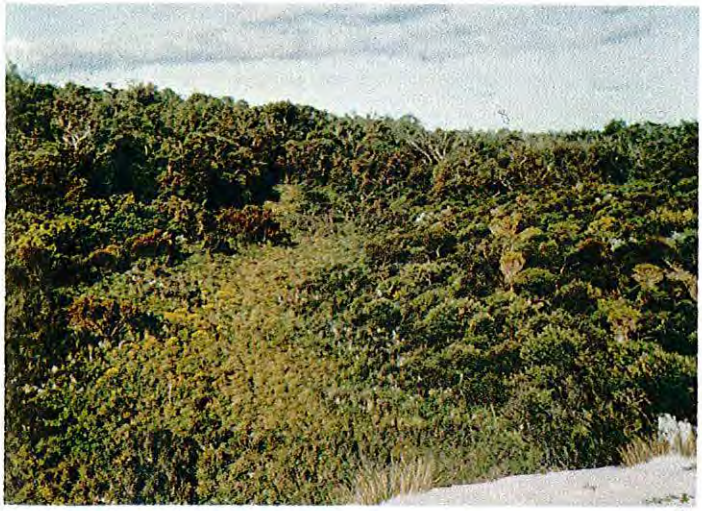
3





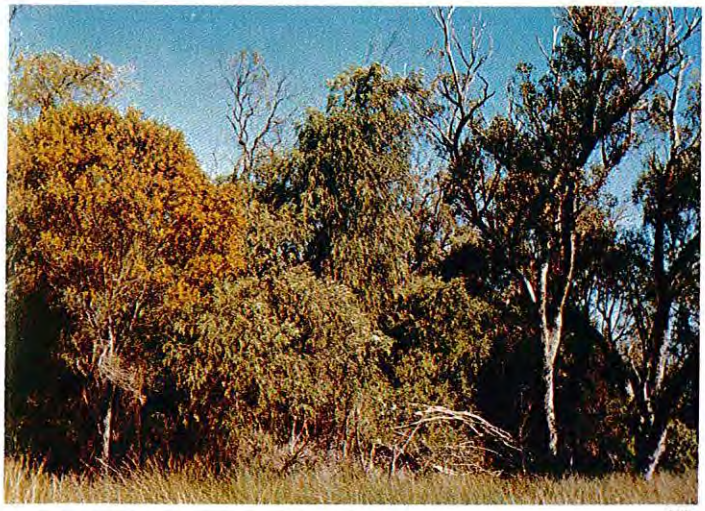
4



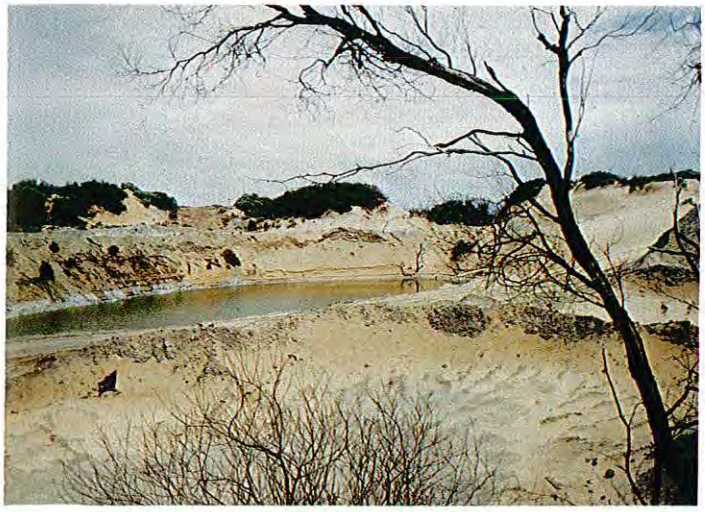


9

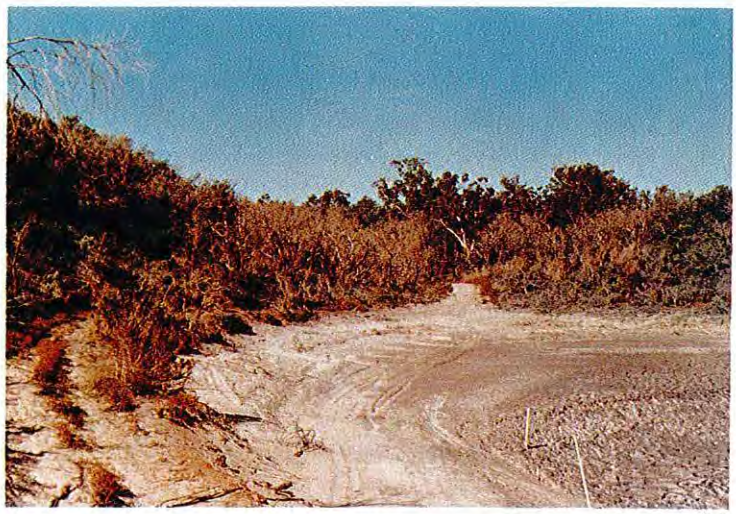
10



11



12



13

14

1. Northern section of the Peninsula showing the changes in vegetation across the Peninsula.
2. Southern section of the Peninsula showing effluent disposal ponds and staining of the beach.
3. Removal of foredune and undercutting of stabilised dune. The stabilised dune in the foreground has lost its vegetation (possibly due to its proximity to an old effluent pond) and erosion has now started.
4. First Inlet edge sequence. *Bulboschoenus caldwelli* Closed Sedgeland and *Avicennia marina* Closed Scrub.
5. *Melaleuca rhaphiophylla* Open Woodland over *M.* aff.*hamulosa*, *Sarcocornia* and *Juncus*, with some *Halosarcia* in the foreground.
6. *Olearia*, *Jacksonia*, *Acacia*, *Diplolaena templetonia* Closed Heath on second stabilised dune. *Acacia rostellifera* Low Shrubland in the foreground.
7. Mobile dune invading *Acacia rostellifera* Low Shrubland with *Diplolaena templetonia*, *Spyridium*, *A. rostellifera* Closed Heath on slope of dune and *Agonis* High Open Shrubland near the crest.
8. *Agonis* High Open Shrubland with *Guichenotia* (left and centre), *A. rostellifera* (yellow flowers), *Diplolaena* (right), *Templetonia* (centre, dark green) and *Agonis* (background).
9. Depression between W-E trending Q3 dunes with *A. rostellifera* Low Shrubland. *Hakea prostrata* High Open Shrubland along left side of depression. *Agonis* Woodland in background and *Diplolaena*, *Templetonia*, *Spyridium*, *A. rostellifera* Closed Heath on the dune slope to the right.
10. *Agonis* and *Eucalyptus gomphocephala* (Tuart) Woodland.
11. Yoongarillup Plain, Inlet edge boundary with Tuart, *Agonis* and *Acacia saligna* next to *Juncus krausii* Closed Sedgeland.
12. Disposal pond showing physical disturbance.
13, 14. Death of vegetation associated with disposal ponds.

second largest city. Properly used, this resource would be of great value for instructing young Western Australians in the workings of a dynamic and diverse ecosystem and thereby give them a better understanding of the natural processes of the world we live in.

Scientific Research

The need to set aside areas of coastal dunes for geological research has been referred to above.

The vegetation of the Peninsula also has value for scientific research. Of obvious interest from the scientific viewpoint are the mangroves, less obvious but of equal interest is the potential for studies of the relationship of the plants to the environment and the response of the vegetation to fire. The latter is of particular interest at this locality because some parts of the Peninsula do not appear to have been burnt for a considerable period of time.

Recreation and Tourism

The value of the Peninsula for landscape was commented on above. This contributes significantly to its potential value as a recreational and tourist destination and ofcourse the favoured nature of coastal areas for recreation is well known.

The potential of the area is significant because it has a special relaxed atmosphere from having water on both sides of it.

This recreational and tourist potential is limited however by the contraints of a fragile ecology. Thus, the potential as a tourist resource needs to be viewed in terms of what limits the environment can be stretched to. If the full potential of the area for these purposes is to be realised and maintained, careful management is vital. Continuation or extension of the practice of disposal of acid-iron wastes on the Peninsula will also impose additional constraints on recreational and tourist use of the Peninsula.

"Recreation activities include the use of the sheltered waters of the estuary . . . use of the ocean for beach activities and the shores of the Inlet for picknicking, camping and sightseeing." (Department of Conservation and Environment, 1983).

Regional Conservation Significance

The conservation significance of the Leschenault Peninsula relates not only to its value for the conservation of nature but also to its location. Its proximity to Bunbury greatly enhances its value as it makes it readily accessible to this cities rapidly increasing population.

If the Peninsula was properly developed its relationship to Bunbury would be unique. Though not directly comparable to the relationship of Rottnest or King's Park to Perth the situation would be of comparable value. It would give Bunbury a recreational venue of high value near its doorstep; yet almost surrounded by water and thereby having almost an island like character.

"The recommended area (ie. the Peninsula, the inlet and eastern shore) constitutes open space of regional significance because of its high conservation and recreation values and its proximity to the Perth and Bunbury regions and neighbouring rural districts." (Department of Conservation and Environment, 1983). "The area is of high recreation value and includes a wide range of terrestrial, estuarine and ocean recreation resources." (Department of Conservation and Environment, 1983).

CURRENT LAND USE

Types of Land Use on the Peninsula

There are two 'active' land uses being carried out on the Peninsula; effluent disposal by The Public Works Department for the Laporte titanium dioxide factory and agriculture on the small property 'Belvedere'. The remainder of the Peninsula is largely undeveloped freehold land with a small reserve for recreation on the areas adjacent to 'the cut'.

These two land uses are being carried out in quite different soil types and landscape areas and are associated with markedly different disturbances of the original ecosystems.

Agriculture

The small property 'Belvedere' is situated on part of the largest area of the Yoongarillup Plain unit on the Peninsula. The soil types of this land unit are suitable for agriculture (McArthur & Bartle, 1980) and there is no erosion associated with the property. Over a relatively small area the vegetation (Tuart woodland) has been cleared and replaced with pasture of exotic species.

The northern part of the Peninsula is zoned 'rural' in the Harvey Shire Town Planning Scheme, in which it has also been classified as having Heritage Importance. The development of this land for agriculture purposes is not regarded as a suitable land use, because of its conservation value and the fact that in this area the soils are mostly Quindalup dunes and not suitable for agriculture.

Effluent Disposal

Effluent containing sulphuric acid and iron sulphate, as well as other contaminants, is disposed of in ponds constructed in the Quindalup dune system. The sulphuric acid is neutralised by calcium carbonate rich dune sands and the iron is largely removed from solution. This disposal practice involves the clearing of vegetation for effluent ponds, access tracks and pipeworks and the resultant death of vegetation adjacent to the ponds.

As the ponds have largely been built in areas where the dunes have been mobilised it is difficult to assess the contribution of effluent disposal to the present disturbance. It seems likely however, that it would have impeded natural regeneration and that if the practise was carried out in undisturbed areas it would contribute to erosion as well as the destruction of vegetation.

McArthur and Bartle who mapped the soils of the Mandurah-Bunbury area and developed land use recommendations based on the characteristics of the soils made the following recommendation: "All areas of Q4 dunes (the most westerly) should be excluded from developments or disturbance. Areas of Q3 dunes which occur near to the coastline should also be protected. In both cases the sand is potentially unstable." "The zone along the coast between Leschenault Inlet and the ocean . . . has severe sand instability problems. Any development in . . . these areas is likely to cause further environmental damage and consequently impose financial burdens on those charged with continued management" (McArthur and Bartle, 1980).

The current method of effluent disposal conflicts heavily with these guidelines for sound land use and is considered to be a most unsuitable land use for the Quindalup Dune ecosystem.

It also conflicts heavily with the criteria determined by the Environmental Protection Authority (Department of Conservation and Environment, 1983 pii) in its evaluation of the disposal of effluent from Laporte onto land. Of particular concern from the viewpoint of this study are the following:—

- Area to be of low conservation value
  The areas involved and planned to be used in the future are of high conservation value.
- No significant impact on terrestrial biota and any adjoining marine estuarine biota
  The impact on the terrestrial biota is high, including clearing of vegetation for construction of ponds, service roads and the laying of pipelines. In addition there would be subsequent destruction of the biota by the effluent.

- Not to preclude more appropriate land uses.
  The effluent disposal precludes a range of more appropriate land uses including:
  Conservation of vegetation, flora, fauna, landscape and geological features;
  Educational use;
  Scientific research;
  Recreational and tourist use.

It should be realised that even extensive (and expensive) rehabilitation would not replace all these values and that a very substantial time (at least 100 years) would be needed to replace many of the woodland stands at their present state of development.

Tuart *(Eucalyptus gomphocephala)* Woodland with an understorey including shrubs of *Spyridium, Templetonia, Olearia* and *Acacia* and with Peppermint *(Agonis flexuosa)* in the background.

View along part of the Inlet shore of the Peninsula with blowouts encroaching on the Inlet edge sequence.

Diplolaena dampieri is a common shrub species of the heathlands of the Peninsula, but is also found in the woodlands of Peppermint and Tuart.

Vehicle tracks through the *Sacrocornia quinqueflora* Closed Herbland (foreground) and the *Juncus krausii* Closed Sedgeland of the Inlet edge sequence showing the sensitivity of this area to physical disturbance.

The Peninsula currently has two major economic roles.

- It creates and protects the Leschenault Inlet which is of economic value as a nursery area for commercially important species of fish, and also as an important area for recreation and tourism.
- It is used for waste disposal for the Laporte titanium dioxide manufacturing plant.

It also has the potential to have a significant economic role as a recreation and tourism destination in its own right.

It is beyond the scope of this report to put an economic (dollar) value on the conservation, recreation and tourism potential of the Peninsula. However, the statement can justifiably be made that if such a value were to be computed then it would be a considerable figure.

Therefore, it is obvious that any assessment of the economics of different waste disposal strategies for Laporte, should include not only an appropriate and realistic, allowance for the alternative economic values of the Peninsula, but also an allowance for the substantial amount of rehabilitation work needed on the Peninsula.

Conostylis aculeata subspecies *aculeata* one of the common herbaceous species of the Peninsula.

Peppermint *(Agonis flexuosa)* Woodland with a Bracken *(Pteridium aquilinum)* understorey. This variant of Peppermint Woodland is only found near the Inlet edge.

Four wheel vehicle tracks along the beach and at the base of a dune undercut by wave action. Vehicle use is adding to, but is not the major cause of, dune mobilisation.

View along part of the heathlands of the Western side of the Peninsula.

REFERENCES

APLIN T.E.H., (1979). "The Flora" in Environment and Science, edited by B.J. O'Brien, Perth, W.A. University of Western Australia Press.

BLACKWELL, M. (Undated). Ecological and Taxonomic Survey of the Leschenault Peninsula. Blackwell and Cala, Landscape Consultants, Ord Street, Perth. (Unpublished Report).

DEPARTMENT OF CONSERVATION AND ENVIRONMENT (1981). The Darling System Western Australia — Proposals for Parks and Reserves. The System 6 Study Report to the Environmental Protection Authority. Report No 8. W.A. Department of Conservation and Environment.

DEPARTMENT OF CONSERVATION AND ENVIRONMENT (1983). Evaluation of Disposal Options for Effluent from Laporte Titanium Dioxide Manufacturing Plant. Report and Recommendations by the Environmental Protection Authority, Bulletin 137. W.A. Department of Conservation and Environment.

FOX, J.E.D., DOWNES,S., MASLIN, B.R. (1980). The Vascular Plants of Yalgorup National Park. Western Australian Herbarium Research Notes, No.3.

GREEN, J.W. (1981). Census of the Vascular Plants of West Australian Herbarium. (Perth)

MCARTHUR W.M. and BARTLE, G.A. (1980). Soils and Land Use Planning in the Mandurah-Bunbury Coastal Zone, Western Australia. CSIRO Land Resources Management Series No. 6.

PUBLIC WORKS DEPARTMENT, (undated). Summary Report on Laporte Factory Effluent Disposal, W.A. Public Works Department.

SEMENIUK, V. and MEAGHER, T.D. (1981). The Geomorphology and Surface Processes of the Australind-Leschenault Inlet Coastal Area. Journal of the Royal Society of Western Australia, Vol. 64, Part 2.

SHIRE OF HARVEY (1983). Town Planning Scheme No. 10. W.A. Government Gazette, No. 41, 17 June, 1983.

TAYLOR, R. and BURRELL, W. (1980). Bunbury Region Plan, June 1980. A report on Regional Planning for Bunbury and Parts of Harvey, Dardanup and Capel.

THE BUNBURY REGION PLAN. Summary. (1981). Based upon a report prepared by Taylor and Burrell, Town Planning Consultants, for the Bunbury and Districts Regional Planning Committee.

WATERWAYS COMMISSION AND LESCHENAULT INLET MANAGEMENT AUTHORITY, 1983. Leschenault Inlet Management Programme.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made of the help given in this study by the following people.

The curator of the Western Australian Herbarium for permission to consult the collection.

Natham Sammy for identification of lichens and mosses, Roger Hilton for identification of fungi and Paul Wilson for identification of Chenopodiaceae.

P. Watson for word-processing, L. Capill for assistance with drafting of the vegetation map and E.M. Mattiske for reading the section on vegetation.

Photographs are by the author except for the front cover, 1, 2 & 12, which were supplied by S. Chape of the Department of Conservation and Environment.

Brian Stewart, Patsy Moran, of the Department of Conservation and Environment and Tony Berman (Tony Berman Drafting Services) for the design, layout and artwork of the published Report.

APPENDICES

APPENDIX ONE

Flora of the Leschenault Peninsula

(i) Vascular Flora

* indicates a naturalised (adventive) species
\+ indicates a species recorded by Blackwell but not by the present survey
\# indicates species not recorded by Fox et.al. (1980) for Yalgorup National Park
RS indicates rarely seen
O indicates occasional
C indicates common
VC very common
EC extremely common

Authorities for names of the vascular plants follow Green 1981 and can be obtained from that reference. The family order follows the same authority.

PTERIDOPHYTA (ferns)
DENNSTAEDIACEAE

#	Pteridium aquilinum	C

ANGIOSPERMAE (flowering plants)
MONOCOTYLEDONS
RUPPIACEAE

#	Ruppia megacarpa	O-C

JUNCAGINACEAE

#	Triglochin calcitrapa	VC	#	Triglochin mucronata	RS-O
#	Triglochin striata	O-C	#	Triglochin trichophora	VC

POACEAE

*	Aira caryophyllea	O	*	Ammophila arenaria	O-C
#*	Arundo donax	RS	#*	Avena barbata	O
*	Briza maxima	O	*	Briza minor	O
*	Cynodon dactlyon	O-C	#*	Ehrharta longiflora	O
#*	Poa annua	O		Poa drummondiana	O
	Spinifex hirsutus	O	#	Spinifex longifolius	O
	Stipa ? variabilis	O-C	*	Vulpia myuros	O-C

CYPERACEAE

#	Baumea juncea	O	#	Carex preissii	C
#	Bulboschoenus caldwelli	RS			
	Cyperus tenellus	RS	#	Cyperus tenuiflorus	RS
	Gahnia trifida	RS	#	Isolepis sp.	O
	Lepidosperma angustatum	C-VC		Lepidosperma gladiatum	C-VC
#	Lepidosperma longitudinale	RS	#		
	Scirpus nodosus	C			

ARACEAE

#*	Zantedeschia aethiopica	C

RESTIONACEAE

#	Loxocarya pubescens	RS

CENTROLEPIDACEAE

	Centrolepis drummondii	C

JUNCACEAE

#*	Juncus bufonius	RS		Juncus kraussii ssp. australis	C

LILIACEAE (Sensu latu)

	Acanthocarpus preissi	EC	*	Asphodelus fistulosus	EC
#	Bulbine semibarbata	RS	#	Lomandra sp.	O
#	Thysanotus arenarius	RS		Thysanotus patersonii	C
	Tricoryne elatior	RS	#	Wurmbea monantha	RS

Appendix One Continued

HAEMODORACEAE					
	Conostylis aculeata ssp. aculeata	C			
ORCHIDACEAE					
	Caladenia latifolia	VC-EC		Caladenia menziesii	RS
#	Eriochilus dilatatus	RS			
DICOTYLEDONS					
URTICACEAE					
#	Parietaria debilis	EC			
PROTEACEAE					
	Dryandra sessilis	RS		Hakea prostrata	C
SANTALACEAE					
	Exocarpos sparteus	C		Santalum acuminatum	O-C
POLYGONACEAE					
*	Emex australis	RS			
CHENOPODIACEAE					
#	Atriplex hypoleuca	O	#	Halosarcia halocnemoides ssp. halocnemoides	C-VC
#	Halosarcia indica ssp. bidens	RS		Rhagodia baccata	VC-EC
	Sarcocornia quinqueflora	VC		Suaeda australis	O-C
	Threlkeldia diffusa	O-C			
AIZOACEAE					
	Carpobrotus virescens	O		Tetragonia decumbens	O
PORTULACEAE					
	Calandrinia brevipedata	VC	#	Calandrinia calyptrata	VC
CARYOPHYLLACEAE					
#*	Cerastium ? diffusum	C	*	Petrorhagia velutina	RS
*	Polycarpon tetraphyllum	C			
RANUNCULACEAE					
	Clematis microphylla	VC			
	Ranunculus colonorum	RS	#*	Ranunculus muricatus	RS
LAURACEAE					
	Cassytha racemosa	VC			
FUMARIACEAE					
#*	Fumaria capreolata	O			
BRASSICACEAE					
*	Brassica tournefortii	RS	*	Cakile maritima	O-C
#	Stenopetalum lineare	O-C			
CRASSULACEAE					
	Crassula colorata	C	#	Crassula natans	RS
#	Crassula pedicellosa	C			
PITTOSPORACEAE					
#	Pittosporum phylliraeoides var. phylliraeoides	C			

Appendix One Continued

MIMOSACEAE

	Acacia cochlearis	C		Acacia cyclops	O-C
	Acacia lasiocarpa var. lasiocarpa	RS-O		Acacia rostellifera	EC
	Acacia saligna	O-C			

PAPILIONACEAE

	Hardenbergia comptoniana	VC		Jacksonia furcellata	C
	Kennedia coccinea	RS	*	Medicago ? lupulina	O-C
	Templetonia retusa	EC			

GERANIACEAE

*	Erodium cicutarium	EC	*	Geranium molle	EC
*	Pelargonium capitatum	C			

OXALIDACEAE

	Oxalis corniculata	VC	*	Oxalis pes-caprae	O

ZYGOPHYLLACEAE

#	Zygophyllum fruticulosum	O

RUTACEAE

	Diplolaena dampieri	EC

EUPHORBIACEAE

	Adriana quadripartita	O		Phyllanthus calycinus	EC
	Poranthera microphylla	RS-O	#*	Euphorbia peplus	VC

RHAMNACEAE

	Spyridium globulosum	EC

STERCULIACEAE

#	Guichenotia ledifolia	O-C		Thomasia cognata	RS

DILLENIACEAE

	Hibbertia cuneiformis	V

MYRTACEAE

	Agonis flexuosa	EC		Eucalyptus gomphocephala	C
	Melaleuca cuticularis	RS	#	Melaleuca aff. hamulosa	O
	Melaleuca rhaphiophylla	O-C			

APIACEAE

#	Apium annuum	RS		Centella asiatica	O-C
	Daucus glochidiatus	C-VC		Hydrocotyle diantha	C-VC
#	Hydrocotyle ? hispidula	VC		Hydrocotyle tetragonocarpa	VC
	Trachymene caerulea	O		Trachymene pilosa	VC

EPACRIDACEAE

	Leucopogon parviflorus	EC

PRIMULACEAE

*	Anagallis arvensis	C	#	Samolus repens	C

LOGANIACEAE

	Logania vaginalis

APOCYNACEAE

	Alyxia buxifolia	VC

Appendix One Continued

CONVOLVULACEAE					
#*	Convolvulus arvensis	O	#	Dichondra repens	O
AVICENNIACEAE					
#	Avicennia marina	RS			
LAMIACEAE					
	Hemiandra pungens	O			
SOLANACEAE					
	Anthocercis littorea	C	*	Solanum nigrum	RS-O
	Solanum simile	O			
SCROPHULARIACEAE					
*	Bellardia trixago	O	*	Dischisma arenarium	VC
OROBANCHACEAE					
	Orobanche australiana	RS			
MYOPORACEAE					
	Eremophila glabra	O		Myoporum insulare	RS
	Myoporum tetrandrum	RS			
PLANTAGINACEAE					
*	Plantago lanceolata	RS			
RUBIACEAE					
*	Galium murale	C	#	Galium sp.	C
	Opercularia vaginata	O	#*	Sherardia arvensis	RS
LOBELIACEAE					
#	Grammatotheca bergiana	RS		Lobelia alata	RS
	Lobelia ? heterophylla	O-C			
GOODENIACEAE					
	Scaevola crassifolia	C			
ASTERACEAE					
*	Arctotheca calendula	O		Arctotheca populifolia	O
#	Calocephalus brownii	O	#*	Carduus pycnocephalus	RS-O
#	Cotula australis	O-C		Cotula coronopifolia	RS
#	Cotula cotuloides	RS	*	Dittrichia graveolens	RS-O
	Helichrysum cordatum	O-C		Lagenifera huegelii	RS
#	Millotia tenuifolia	C		Olearia axillaris	VC
	Senecio lautus	C-VC	*	Sonchus oleraceus	O
	Waitzia citrina	C			

(ii) Non-Vascular Flora

CHAROPHYTA (Stoneworts)

CHARACEAE

Chara sp.

BRYOPHYTA, Musci (Mosses)

BRYACEAE

? Bryum capillare

DICRANACEAE

Dicroanoloma diaphanoneurum

Appendix One Continued

POTTIACEAE
Tortella cirrhata

RHACOPILACEAE
Rhacopilum convolutaceum

SEMATOPHYLLACEAE
Sematophyllum homamallum

PHYCOPHYTA, (Fungi and Lichens)

(a) Fungi

BOLBITIACEAE
Bolbitius vitellinus

LYCOPERDACEAE
Lycoperdon asperum

NIDULARIACEAE
Cyathus aff. stercoreus

POLYPORACEAE
Pycnoporus coccineus
Trametes blacino-gilva

TRICHOLOMATACEAE
Panus fasciatus

(b) Lichens

CLADONIACEAE
Thysanothecium hyalinum

PARMELIACEAE
Parmelia ferax
Parmelia perlata
Parmelia rutidota
Usnea angulosa

PHYSCIACEAE
Physcia stellaris

RAMELINACEAE
Ramelina celastri

TELOSCHISTACEAE
Teloschistes chrysopthalmus
Xanthoria parietina

APPENDIX TWO

Detailed Description of the Vegetation

Introduction

This appendix follows the same order as the section on the vegetation but gives more detail of the diversity and species composition of the plant communities found on the Peninsula and also gives details of height and percentage projective foliar cover.

* Indicates a naturalised (adventive) species.

Vegetation Descriptions

Vegetation of the Yoongarillup Plain

The Yoongarillup Plain consists of the moist inlet edge and dry, low lying, areas on the eastern side of the Peninsula.

Communities of the Inlet Edge

(I) First Inlet Edge Sequence (Fig. 1A)

***Avicennia marina* Closed Scrub**

e.g.	Avicennia marina	5-6m	95%
	Lobelia alata	20cm	< 1%
	Sarcocornia quinqueflora	30cm	< 1%

***Bulboschoenus caldwellii* Closed Sedgeland**

e.g.	Bulboschoenus caldwellii	0-100cm	40%
	Cynodon dactylon (couch)	50cm	80%
	Suaeda maritima	50cm	5%

(II) Second Inlet Edge Sequence (Fig. 1B)

***Juncus kraussii* Closed Sedgeland**

e.g.	Juncus kraussii	1.5m	75%
	Sarcocornia quinqueflora	30cm	25%
	Suaeda maritima	60cm	< 5%

***Sarcocornia quinqueflora* Closed Herbland**

e.g.	Sarcocronia quinqueflora	30cm	98%

This community has been treated as a herbland because the form of the plants is not shrubby (though related plants such as *Halosarcia* spp. are shrubs). Rather it has semiprostrate stems with weak (herbaceous ?) erect stems from them. Certainly it seems closer in appearance (as a community) to the *Triglochin* community rather than the *Halosarcia* community.

***Triglochin striata* Closed Herbland**

e.g.	Triglochin striata	30cm	85%

This community is most frequent near the edge of the Inlet but also occurs near drainage channels through the Inlet edge communities and in the drainage from soaks near the upper edge of the Inlet edge sequence. (It may indicate less saline water in the soil.)

The community intergrades with the one above to give *Sarcocornia quinqueflora*, *Triglochin striata* closed herblands. One example had the following composition:—

	Sarcocornia quinqueflora	30cm	60%
	Triglochin striata	30cm	40%

***Samolus repens* Closed Herbland**

e.g.	Samolus repens	35cm	99%

Occurs as monospecific stands or with the *Triglochin* or *Sarcocornia*.

e.g.	Samolus repens	35cm	85%
	Sarcocornia quinqueflora	30cm	15%

***Ruppia megacarpa* Closed Herbland**

	Ruppia megacarpa	60-100%

This species can cover the bottom of the water body, or occur in patches.

Appendix Two Continued

***Halosarcia halocnemoides* Low Open Heath**

e.g.	Halosarcia halocnemoides	30-60cm	50%
	Sarcocornia quinqueflora	15-25cm	40%
	Samolus repens	20cm	1%
	Suaeda maritima		1%

or as monospecific stands of the dominant.

***Sarcocornia quinqueflora* Low Closed Heath**

(See above)

***Juncus kraussii* Closed Sedgeland**

e.g.	Juncus kraussii	1.5m	95%
	Sarcocornia quinqueflora	35cm	20%
	Suaeda maritima	50cm	<1%

***Melaleuca cuticularis* Low Open Forest**

e.g.	Melaleuca cuticularis	4.0m	40%
	Sarcocornia quinqueflora	30cm	70%

This community was only observed at one locality in the study area (the upper north eastern corner) and may have been disturbed at this locality by roadworks.

***Melaleuca rhaphiophylla* Low Open Forest to Closed Forest**

This is a variable community (or several communities) with different understoreys.

e.g.	Melaleuca rhaphiophylla	5.0m	30%
	Sarcocornia quinqueflora	30cm	70%

This atypical example was immediately adjacent to the *Melaleuca cuticularis* community described above. This understorey situation was only seen at this location. More typical examples are:

Melaleuca rhaphiophylla	10m	60%
Juncus kraussii	1.2m	50%
Gahnia trifida	1.6m	10%

or

Melaleuca rhaphiophylla	7.0m	30%
Melaleuca aff. hamulosa	5.0m	15%
Halosarcia indica	80cm	10%
Gahnia trifida	1.4m	10%

This community appears to be somewhat disturbed, (by road building changing underground water flow.)

***Chara sp.* Aquatic Closed Herbland**

The Chara grows as a very dense cover on the bottom of soaks.

Mixed Herbland

e.g.	*Cynodon dactylon	5cm	40%
	*Dittrichia graveolens	5-35cm	15%
	*Emex australis	15cm	<1%
	Grammathotheca bergiana	5cm	1%
	*Polycarpon tetraphyllum	5cm	<1%
	*Crassula natans	5cm	<1%
	Cotula australis	5cm	<1%
	*Cyperus tenellus	5cm	<1%
	Isolepis sp.	5cm	<1%
	*Juncus bufonius	5cm	<1%
	*Vulpia myuros	5cm	<1%

The native species occurring in this community are not well developed (in terms of percentage foliar cover) and it might be interpreted as a degraded occurrence of another community occurring on the Peninsula. However, this is not thought to be the case as it abuts quite healthy *Agonis flexuosa* forest on one side and *Melaleuca rhaphiophylla* woodland on the other.

Appendix Two Continued

Vegetation of the drier parts of the Yoongarillup Plain.

***Eucalyptus gomphocephala* Woodland to Open Forest**

e.g.	Eucalyptus gomphocephala	25m	15-20%
	Agonis flexuosa	5-6m	20-25%
	Templetonia retusa	2m	10-15%
	Spyridium globulosum	.8m	<5%
	Phyllanthus calycinus	30cm	<5%
	Clematis microphylla	3m	<5%
	Hardenbergia comptoniana	3m	<5%
	Olearia axillaris	2m	<5%
	Carex preissii	30cm	<5%
	Caladenia latifolia	25cm	<1%
	Lepidosperma angustatum	1m	<1%
	Rhagodia baccata	2m	<5%
	Acacia rostellifera	2.2m	<1%
	Triglochin calcitrapa	30cm	<1%
	Pelargonium	35cm	1%
	*Asphodelus fistulosus	40cm	<5%
	*Zantedeschia aethiopica	1m	<1%
	Oxalis corniculata		
	*Galium murale		
	Galium sp.		
	*Polycarpon tetraphyllum		
e.g.	Eucalyptus gomphocephala	24m	35%
	Pittosporum phylliraeoides	3.5m	<5%
	Templetonia retusa	2.5m	<10%
	Spyridium globulosum	2.5m	<5%
	Anthocercis littorea	3m	<5%
	Diplolaena dampieri	2m	<5%
	Acacia rostellifera	1.5m	<5%
	Rhagodia baccata	80cm	20%
	Phyllanthus calycinus	50cm	<1%
	Clematis microphylla		<5%
	Hardenbergia comptoniana		<5%
	Lepidosperma gladiatum	1m	<1%
	*Aspholdelus fistulosa		
	*Zantedeschia aethiopica		
	Senecio lautus		
	Caladrinia calyptrata		
	Isolepis sp.		
	Centrolepis drummondii		
	Millotia tenuifolia		
	Bulbine semibarbata		
	Parietaria debilis		
	Trachymene pilosa		
	Oxalis corniculata		
	*Erharta longiflora		
	*Euphorbia peplus		
e.g.	Eucalyptus gomphocephala	25m	30%
	Agonis flexuosa	15m	30%
	Spyridium globulosum	4m	15%
	Templetonia retusa	2m	25%
	Acacia cochlearis	2.5m	<5%
	Olearia axillaris	1m	<1%
	Rhagodia baccata	1m	20%
	Phyllanthus calycinus	80cm	<5%
	Adriana quadripartita	1.5m	<5%
	Exocarpos sparteus	1.5m	<1%
	Hardenbergia comptoniana		<5%

Appendix Two Continued

	Clematis microphylla		<5%
	Pittosporum phylliraeoides	4m	<1%
e.g.	Eucalyptus gomphocephala	20m	<10%
	Agonis flexuosa	5-10m	15-20%
	Templetonia retusa	2-3m	30%
	Spyridium globulosum	2m	15%
	Olearia axillaris	1m	<1%
	Phyllanthus calycinus	50cm	1%
	Acacia cochlearis	1-1.5cm	1%
	Acanthocarpus preissii	40cm	1%
e.g.	Eucalyptus gomphocephala	25-28m	40%
	Agonis flexuosa	8-10m	25%
	Acacia cochlearis	(1)2-2.5m (plus 30% dead)	5%
	Templetonia retusa	2m	10%
	Olearia axillaris	1.5m	15%
	Diplolaena dampieri	1.5m	5%
	Rhagodia baccata	1m	25%
	Hibbertia cuneiformis	80cm	<1%
	Acanthocarpus preissii	50cm	10%
	Spyridium globulosum	2m	1%
	Exocarpos sparteus	1.8m	<1%
	Phyllanthus calycinus	40cm	<1%
	Senecio lautus		
	Lobelia ? heterophylla		
	Trachymene pilosa		
	Parietaria debilis		
	* Asphodelus fistulosus		
e.g.	Eucalyptus gomphocephala	25m	15%
	Agonis flexuosa	8-10m	60%
	Acacia cochlearis	2-3m	20%
	Templetonia retusa	2m	5%
	Hibbertia cuneiformis	1.4m	<1%
	Rhagodia baccata	80cm	10%
	Phyllanthus calycinus	40cm	1%
	Acanthocarpus preissii	40cm	20%
	Olearia axillaris	60cm	<1%
e.g.	Eucalyptus gomphocephala	25m	<10%
	Agonis flexuosa	6-10cm	50%
	Dryandra sessilis		25%
	Rhagodia baccata	1m	20%
	Exocarpos sparteus	1.8m	<1%
	Hibbertia cuneiformis	1.6m	1%
	Olearia axillaris	1m	<1%
e.g.	Eucalyptus gomphocephala	20m	15%
	Agonis flexuosa	8m	60%
	Acacia rostellifera	5m	10%
	Spyridium globulosum	2-3m	10%
	Acacia cyclops	4m	5%
	Lepidosperma gladiatum	1.6-2m	60%
	Rhagodia baccata	2m	30%
	Parietaria debilis		
	Trachymene pilosa		
	Oxalis corniculata		
	*Euphorbia peplus		
	Galium sp.		

On Inlet edge; changes abruptly to *Juncus kraussii* Closed Sedgeland.

Appendix Two Continued

***Acacia cochlearis, Acacia rostellifera* Closed Scrub**

e.g.	Acacia cochlearis	3m	80%
	Acacia rostellifera	3m	15%
	Anthocercis littorea	1.8m	<1%
	Olearia axillaris	2m	<5%
	Agonis flexuosa	5-6m	<10%
	(Scattered emergents)		

Flat area on plain; only one example of this vegetation community was seen.

Vegetation of the Quindalup Sand Dunes and Plains (Fig. 2)

(i) Sand Dunes Closest to Beach (Q4) (first stabilised dunes)

Seaward face of Dune

***Spinifex hirsutus, Spinifex longifolius* Open Grassland**

e.g.	Spinifex hirsutus	50cm	<5%
	Spinifex longifolius	50cm	<5%
	*Ammophila arenaria	40cm	15%
	Scirpus nodosus	40cm	<1%
	Tetragonia decumbens	30cm	<1%
	Carpobrotus virescens	15cm	<5%
	Poaceae sp.	5cm	<1%

Crest of Dune

***Olearia axillaris* Low Scrubland**

e.g.	Olearia axillaris	1.2m	10-15%
	Alyxia buxifolia	80-100cm	15-20%
	Scaevola crassifolia	50cm	5%
	Acanthocarpus preissii	40cm	<5%
	Acacia rostellifera	60-80cm	5%
	Poaceae sp.	5cm	<1%
	Tetragonia decumbens	30cm	<1%
	Hardenbergia comptoniana	30cm	<1%
	Daucus glochidiatus	8cm	<1%
	Crassula colorata	4cm	<1%
	Triglochin trichophora	4cm	<1%

e.g.	Olearia axillaris	1.1m	1-10% (patchy)
	Scaevola crassifolia	1.1m	30%
	Alyxia buxifolia	1m	1-10% (patchy)
	Acacia rostellifera	80cm	1%
	Acanthocarpus preissii	50cm	<5%
	Spinifex longifolius	60cm	15%
	(badly dissected by erosion)		

Variant with wind pruned *Agonis flexuosa* in patches

e.g.	Olearia axillaris	1m	5%
	Scaevola crassifolia	1m	10-15%
	Agonis flexuosa	1.5-2m	60%
	Acacia cochlearis	1m	<5%
	Alyxia buxifolia	1-1.5m	5%
	Acacia rostellifera	1m	<5%
	Hibbertia cuneiformis	60cm	<5%
	Acanthocarpus preissii	50cm	5%
	Lepidosperma gladiatum	80cm	5%
	Myoporum insulare	50cm	<1%
	Pittosporum phylliraeoides	1m	<1%

Landward Face of Dune

Appendix Two Continued

***Olearia axillaris, Rhagodia baccata* Low Open Shrubland**

e.g.	Olearia axillaris	1.2m	15%
	Rhagodia baccata	60cm	25%
	Acanthocarpus preissii	40cm	10%
	*Asphodelus fistulosus	30cm	5%
e.g.	Acacia rostellifera	50cm	10%
	Lepidosperma gladiatum	80cm	20%
	*Asphodelus fistulosus	30cm	30%

Deflation Basin (Interdune)

***Acacia rostellifera* Low Shrubland**

e.g.	Acacia rostellifera	1m	30%
	Rhagodia baccata	60cm	40%
	Zygophyllum fruticulosum	60cm	<10%
	*Asphodelus fistulosus	30cm	10%

This composition occurs right in the bottom of the deflation basin and grades into

	Acacia rostellifera	1m	50%
	Spyridium globulosum	1.4m	<5%
	Alyxia buxifolia	1.4m	10%
	Scaevola crassifolia	1-1.4m	25%
	Acacia cochlearis	1m	<5%
	Rhagodia baccata	80cm	10%
	Zygophyllum fruticulosum	60cm	<5%
	Acanthocarpus preissii	50cm	5%
	Hardenbergia comptoniana	1m	<1%
e.g.	Acacia rostellifera	1m	30%
	Rhagodia baccata	60cm	<5%
	Suaeda maritima	1m	<5%
	Clematis microphylla	1m	<1%
	Zygophyllum fruticulosum	50cm	<1%
	Tetragonia decumbens	50cm	<1%
	Senecio lautus	30cm	<1%
	Parietaria debilis	25cm	10%
	*Asphodelus fistulosus	30cm	15%
e.g.	Acacia rostellifera	50cm	10%
	Lepidosperma gladiatum	50cm	15%
	Rhagodia baccata	60cm	10%
	*Asphodelus fistulosus	30cm	25%

(ii) Second Stabilised Dune — where this is also Q4 in age

Seaward Face

***Olearia axillaris, Jacksonia furcellata, Acacia cochlearis, Acacia rostellifera, Diplolaena dampieri, Templetonia retusa* Closed Heath**

e.g.	Olearia axillaris	1.2-1.8m	15-20%
	Jacksonia furcellata	1-1.8m	5-10%
	Templetonia retusa	1m	<5%
	Acacia rostellifera	1m	5-10%
	Scaevola crassifolia	80cm	<5%
	Diplolaena dampieri	1m	5%
	Acacia cochlearis	1m	10%
	Zygophyllum fruticulosum	60cm	<1%
	Acanthocarpus preissii	50cm	5%
	Rhagodia baccata	50cm	<10%
e.g.	Jacksonia furcellata	4-5m	<5%
	Acacia cochlearis	1.5-2m	5-10%
	Acacia rostellifera	1.5-2m	5%
	Acacia lasiocarpa	1m	1%

Appendix Two Continued

	Diplolaena dampieri	1.8m	<5%
	Templetonia retusa	1.8m	<5%
	Santalum acuminatum	1.5-2m	<5%
	Rhagodia baccata	80cm	<5%
	Acanthocarpus preissii	50cm	5%
	Exocarpos sparteus	1.4m	<1%
	Conostylis aculeata	20cm	<1%
	Clematis microphylla	1.5m	<1%
	Lepidosperma angustatum	40cm	1%

This community is on the seaward end of a dune which may be Q3 in age, however, the vegetation developed is closest to the Q4 second stabilised dunes, detailed research would be necessary to enable further division of the heaths with *Jacksonia furcellata* in them. It may be that the end of this Q3 dune has had Q4 age sand deposited on it. Overlaying of dunes by sand of later age seems to be not infrequent and has led to intergrading of vegetation communities, particularly in the heath areas.

e.g.	Olearia axillaris	1.4m	<5%
	Jacksonia furcellata	1-2.5m	<5%
	Templetonia retusa	2m	<5%
	Acacia rostellifera	1.8m	5-10%
	Acacia cochlearis	2m	<5%
	Spyridium globulosum	1.4m	5%
	Leucopogon parviflorus	1.6m	1%
	Alyxia buxifolia	80cm	<1%
	Acanthocarpus preissii	60cm	5%
	Phyllanthus calycinus	60cm	<1%
	Caladenia latifolia	30cm	<1%
	Acacia lasiocarpa	80cm	<1%
	Exocarpos sparteus	1.2m	<1%

e.g.	Olearia axillaris	1.5m	20-30%
	Diplolaena dampieri	1.4m	10%
	Acacia rostellifera	1.5m	<10%
	Alyxia buxifolia	1-2m	20%
	Templetonia retusa	1m	15%
	Phyllanthus calycinus	60cm	<10%
	Acanthocarpus preissii	50cm	15%
	Rhagodia baccata	50cm	<10%
	Spyridium globulosum	1.4m	<1%

e.g.	Olearia axillaris	1.5m	10%
	Acacia rostellifera	1.6m	40%
	Spyridium globulosum	1.4m	20%
	Jacksonia furcellata	2m	1%
	Rhagodia baccata	80cm	5%
	Santalum acuminatum	1.5m	1%
	Diplolaena dampieri	1.5m	5%
	Acacia cochlearis	1.4m	5%
	Cassytha racemosa	1.4m	10%
	Zygophyllum fruticulosum	80cm	1%

Landward Face of Second Dune

***Agonis flexuosa* Low Open Forest**

e.g.	Agonis flexuosa	10m	60%
	Spyridium globulosum	1.5-2m	5-10%
	Acacia rostellifera	2-3m	5%
	Rhagodia baccata	1m	20%
	Hibbertia cuneiformis	1.5m	<1%

(iii) Parabolic Dune typically at right angles to the coast

North Facing Side

Appendix Two Continued

***Diplolaena dampieri, Templetonia retusa, Spyridium globulosum, Acacia rostellifera* Closed Heath**

e.g.	Diplolaena dampieri	2-2.5m	10-20%
	Templetonia retusa	2-5m	<10%
	Spyridium globulosum	2m	5%
	Acacia rostellifera	2m	1%
	Rhagodia baccata	1m	<5%
	Acanthocarpus preissii	50cm	5%
	Phyllanthus calycinus	80cm	<1%
	Agonis flexuosa	4.5m	<5% (in patches)

Variant with Guichenotia ledifolia

e.g.	Guichenotia ledifolia	1m	25%
	Diplolaena dampieri	1m	25%
	Acacia rostellifera	1.5m	<5%
	Templetonia retusa	1.8m	<5%
	Acacia cochlearis	1m	<5%
	Leucopogon parviflorus	80cm	<5%
	Olearia axillaris	1.2m	<1%
	Agonis flexuosa	5m	5% (in patches)

Towards the Crest

***Agonis flexuosa* High Open Shrubland to High Shrubland**

This is essentially similar to the heath examples above with a higher percentage of *Agonis flexuosa*.

South Facing Side

***Agonis flexuosa* Low Open Forest to Low Closed Forest**

e.g.	Agonis flexuosa	6-8m	30-40%
	Spyridium globulosum	2m	<5%
	Templetonia retusa	2m	<5%
	Rhagodia baccata	1.5m	<5%
	Phyllanthus calycinus	40cm	<5%
	Clematis microphylla		1%
	Hardenbergia comptoniana		1%
	Olearia axillaris	1.5m	<1%
e.g.	Agonis flexuosa	6-10m	30%
	Spyridium globulosum	2m	<5%
	Rhagodia baccata	1.2m	5-10%
	Lepidosperma gladiatum	1m	20%
	Templetonia retusa	1m	<5%
	Olearia axillaris	1.5m	<1%

Deflation Hollows Left by Advancing Parabolic Dune Lobes

***Acacia rostellifera* Low Shrubland**

e.g.	Acacia rostellifera (+ dead individuals to 1m)	50cm	15-20%
	*Asphodelus fistulosus	35cm	50%
	Poaceae sp.	8cm	<5%
	Oxalis corniculata	10cm	<1%
	*Geranium molle		<1%
	Hydrocotyle ? hispidula		
	Hydrocotyle tetragonocarpa		
	Adriana quadripartita	50cm	<1%
	Clematis microphylla	50cm	<1%

***Hakea prostrata* High Open Shrubland to Shrubland**

e.g.	Hakea prostrata	3-4m	15%
	Acacia rostellifera	60cm	35%

Appendix Two Continued

	(also dead to 1.4m, water stress?)		
	Rhagodia baccata	50cm	5%
	Clematis microphylla	2m	5%
	(rich lichen flora on trunks of Hakea prostrata)		
e.g.	Hakea prostrata	3.5-4cm	15-20%
	Rhagodia baccata	1m	5-10%
	Spyridium globulosum	2-2.5cm	10-15%
	Cassytha racemosa	2m	<5%
	Clematis microphylla	2-3m	<5%
	Acacia rostellifera	1m	5%
	(young regeneration)		
	Templetonia retusa	2m	<5%
	Senecio lautus	35cm	<5%
e.g.	Hakea prostrata	3m	5%
	Acacia rostellifera	3m	5-10%
	Exocarpos sparteus	1.2-2m	<5%
	Spyridium globulosum	3m	<5%
	Templetonia retusa	2m	<5%
	Rhagodia baccata	2m	<5%
	Clematis microphylla		<5%
	Cassytha racemosa		<5%
	Caladenia latifolia	30cm	<1%
	*Asphodelus fistulosus	35cm	<5%

Some *Acacia rostellifera* to 4m tall; phase regeneration at this and many other sites, while the other species are longer lived.

***Acacia rostellifera* Low Open Woodland to Low Woodland**

e.g.	Acacia rostellifera	3-4m	15% (small trees)
	Spyridium globulosum	1.5-2m	15-20%
	Santalum acuminatum	3m	<1%
	Hakea prostrata	2m	<1%
	Rhagodia baccata	1m	<5%
	Alyxia buxifolia	1m	<1%
	Olearia axillaris	1m	<1%
e.g.	Acacia rostellifera	2-3m	5-10%
	Spyridium globulosum	2m	15%
	Templetonia retusa	2.5-3m	15%
	Guichenotia ledifolia	1m	15%
	Acacia cochlearis	2.5m	<5%
	Zygophyllum fruticulosum	1m	1%
	Acanthocarpus preissii	1m	<5%
	Calandrinia calyptrata	5cm	<5%
	Hydrocotyle spp.	5cm	<5%
e.g.	Acacia rostellifera	4m	25%
	Acacia rostellifera	2m	15%
	(two generations)		
	Exocarpos sparteus	2m	<1%
	Spyridium globulosum	2.2m	60%
	Leucopogon parviflorus	1m	5%
	Rhagodia baccata	1m	10%
	Phyllanthus calycinus	50cm	<5%
	Acacia cochlearis	1.2m	<1%
	Templetonia retusa	1m	<1%
	Clematis microphylla		<5%
	Acanthocarpus preissii	80cm	15%
	Olearia axillaris	2m	1%
	Zygophyllum fruticulosum	60cm	<1%

Appendix Two Continued

Q2 and Q1 Dunes and Interdunes *Agonis flexuosa* Woodland to Forest

e.g.	Agonis flexuosa	10m	25-35%
	Rhagodia baccata	60cm	<5%
	Spyridium globulosum	2.5-3m	<1%
	Pittosporum phylliraeoides	2.5m	1% (young)
	Hibbertia cuneiformis	2m	<1%
	Hardenbergia comptoniana	?8m	<5%
	Clematis microphylla		1%
	Cassytha racemosa		1%
	Lepidosperma gladiatum	1m	<1%
	Acacia rostellifera : small patches in open areas		
	Hakea prostrata : small patches in open areas		
e.g.	Agonis flexuosa	10-12m	50-60%
	Templetonia retusa	1.8m	20%
	Spyridium globulosum	2.25m	10%
	Rhagodia baccata	80cm	5%
	Acanthocarpus preissii	50cm	5%
	Clematis microphylla		1%
	Cassytha racemosa		1%
	Acacia cochlearis	1-2m	1%
	Exocarpos sparteus	1.5m	<1%
	Leucopogon parviflorus	60cm	1%
	Olearia axillaris	1m	<1%
e.g.	Agonis flexuosa	14cm	45-55%
	Templetonia retusa	2m	<5%
	Spyridium globulosum	2m	<5%
	Diplolaena dampieri	2-2.5cm	<5%
	Rhagodia baccata	80cm-1m	<10%
	Anthocercis littorea	1.5m	<1%
	Phyllanthus calycinus	50cm	<1%
	Hibbertia cuneiformis	2.5m	<1%
	Clematis microphylla		<5%
	Hardenbergia comptoniana		<5%
	Acanthocarpus preissii	60cm	10%

***Agonis flexuosa* Closed Scrub**

e.g.	Agonis flexuosa	3.5-4cm	85%
	Leucopogon parviflorus	80cm	30%
	Acacia rostellifera	3m	<5%
	Spyridium globulosum	3-3.5m	<5%
	Rhagodia baccata	1.5m	5%
e.g.	Agonis flexuosa	4-5m	95%
	Acacia rostellifera	4-5m	5%
	Spyridium globulosum	2-3.5m	5%
	Olearia axillaris	4m	5%
	Rhagodia baccata	2m	5%
	Exocarpos sparteus	1.5m	<1%
	Hardenbergia comptoniana		1%
	Leucopogon parviflorus	1m	<5%
	Trachymene pilosa		
	*Galium murale		
	Galium sp.		
	Parietaria debilis		
	Senecio lautus		
	Anagallis arvensis		

Boundary of Inlet Edge Sequence with Quindalup Sand Dunes or drier parts of the Yoongarillup Plain

Appendix Two Continued

***Acacia saligna* Low Closed Forest**

e.g.	Acacia saligna	8m	95%
	Agonis flexuosa	1.5m	<5%
	(? invading this community)		
	Hibbertia cuneiformis	20cm	<1%
	Rhagodia baccata	40cm	1%
	Spyridium globulosum	2m	1%
	Lepidosperma longitudinale	1m	25%
	Carex preissii	60cm	1%
	Baumea juncea	80cm	5%
	Parietaria debilis	30cm	20%
	*Galium murale	20cm	10%
	Daucus glochidiatus	20cm	1%
	Ranunculus colonorum	35cm	<5%

This community is rare (one locality) on The Peninsula and would be threatened if the main track down The Peninsula was widened or re-aligned.

***Agonis flexuosa* Open Forest**

— example with Bracken (Pteridium esculentum) understorey

Agonis flexuosa	12-14m	60%
Pteridium esculentum	1.6-1.8m	85%
Hardenbergia comptoniana		<1%
Clematis microphylla		<1%
Hibbertia cuneiformis	50cm	<1%
Rhagodia baccata	50cm	1%
Parietaria debilis		
Briza maxima		
Ehrharta longiflora		
Dichondra repens		

APPENDIX THREE

Methods of Vegetation and Flora Surveys

Vegetation Survey

The vegetation survey was based on the use of coloured aerial photographs at a scale of 1:7400. These were examined under a stereo viewer and areas interpreted as different vegetation units marked directly onto them using a chromograph pencil. These were then examined in the field to check the correlation of photograph texture with actual observation, and notes taken on the vegetation.

The Peninsula was visited three times:

15. 9.83 to 18. 9.83
28. 9.83 to 29. 9.83
10.10.83 to 18.10.83

Species composition, height and percentage foliage cover were recorded at 107 sites, with areas about 20 metres in diameter being examined. Perennial species were concentrated on, but where time permitted the presence of annual species was recorded to provide information on their distribution.

Transects were made by vehicle and on foot, with most being made on foot due to the tracks being largely suitable only for four wheel drive vehicles, but also many areas can not be reached except on foot.

Due to time limitations not all areas could be visited; these were assigned to vegetation units on the map by comparing the photographic textures to those of areas visited.

Due to the complexity of variation in the heath and shrubland communities it proved impossible, in the time available, to divide them for mapping purposes.

Flora Survey

The flora survey was undertaken concurrently with the vegetation survey, and was based on the collection of plant specimens and on the observation of occurrences of populations of plant species. Most specimens were collected at vegetation data recording sites, but a number were collected en-route between these.

Specimens were identified by keying out and comparison with herbarium specimens.

Allocation of species as either extremely common through to rarely seen was largely subjective, but does correlate with frequency recorded in the vegetation data.

Department of Conservation and Environment
Perth, Western Australia.
Bulletin 157 December 1983.