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PERIPHERAL VEGETATION
of the Swan and Canning Estuaries 1981

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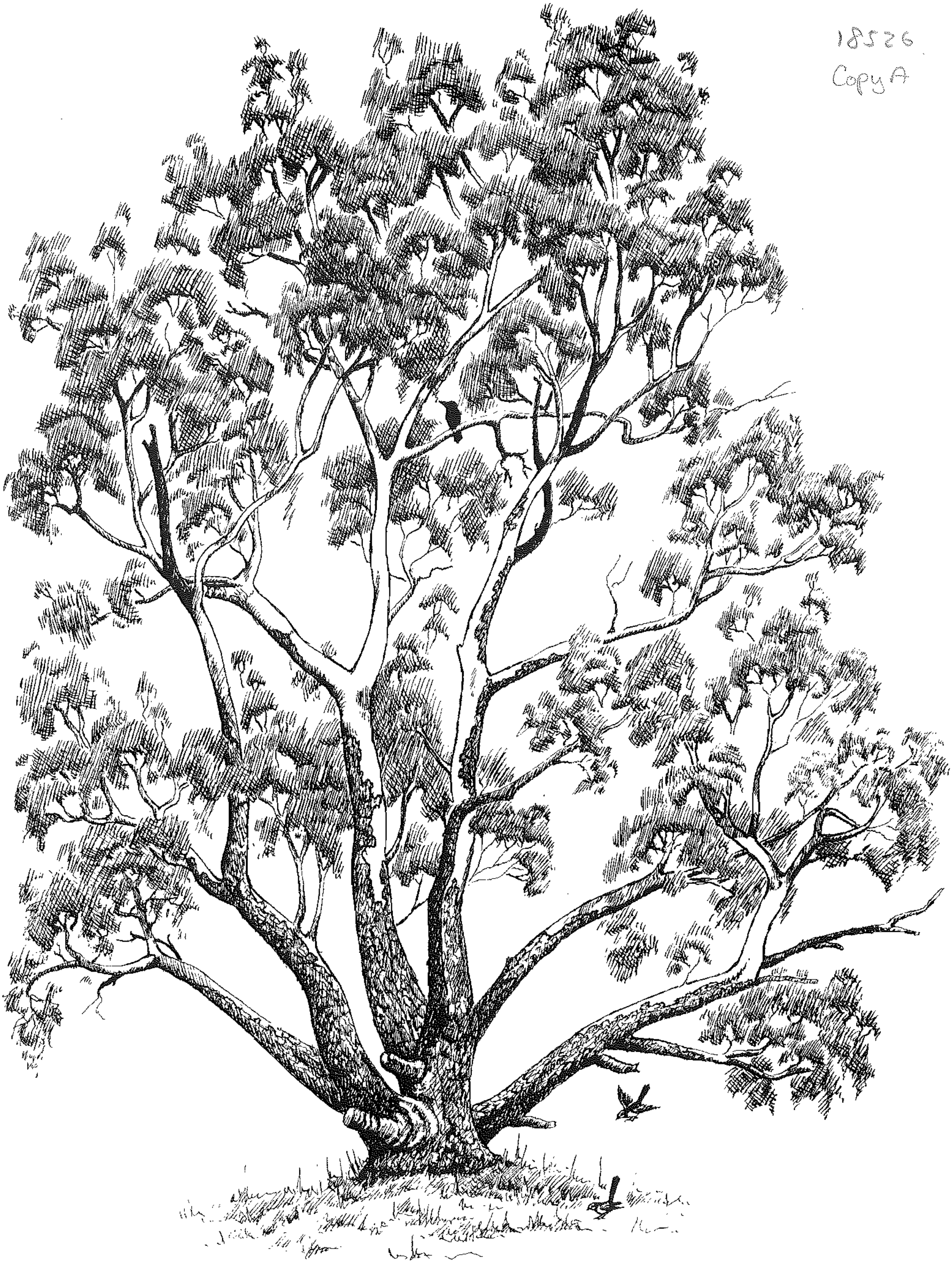

Elizabeth Rose 1983.

FLOODED GUM ON THE SWAN RIVER
AT SOUTH GUILDFORD.

Cover: Canning River, early morning —
Photography by S. Chape

PERIPHERAL VEGETATION

of the Swan and Canning Estuaries 1981

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Department of Conservation & Environment
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Acknowledgements

The study on which this publication is based was carried out under the supervision of Dr Peter Bridgewater in 1981 for the Degree of B.Sc.(Hons.), Murdoch University.

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Key to Abbreviations For Vegetation Units

SV	*Schoenoplectus validus* COMMUNITY
S	*Sarcocornia* COMPLEX
S1	*Sarcocornia* Typical Community
S2	*Sarcocornia-Bulboschoenus* Community
S3	*Bulboschoenus* Predominant Community
S4	*Sarcocornia-Triglochin-Isolepis marginata* Community
J	*Juncus* COMPLEX
J1	*Juncus* Typical Community
J1-A	*Juncus-Sarcocornia* Sub-community
J1-B	*Juncus-Samolus* Sub-community
J2	*Juncus-Melaleuca* Community
H	*Halosarcia* COMPLEX
H1	*Halosarcia* Typical Community
H2	*Halosarcia-Frankenia* Community
H3	*Halosarcia-Angianthus* Community
SB	*Sarcocornia blackiana* COMMUNITY
CM	*Casuarina-Melaleuca* COMPLEX
CM1	*Casuarina-Melaleuca* Typical Community
CM2	*Casuarina-Melaleuca-Baumea* Community
CM3	*Melaleuca-Typha* Community
CM4	*Casuarina-Bulboschoenus* Community
B	*Baumea juncea* COMMUNITY
MJ	*Melaleuca-Juncus* COMPLEX
	Melaleuca-Juncus Community
T	*Typha orientalis* COMMUNITY
EM	*Eucalyptus-Melaleuca* (River Bank) COMPLEX
EM1	*Eucalyptus-Melaleuca-Juncus pallidus* Community
EM2	*Eucalyptus-Melaleuca-Aster* Community
EM3	*Eucalyptus-Melaleuca* — Typical Community
EM3-A	*Eucalyptus-Melaleuca-Typha* Sub-community
EM3-B	*Eucalyptus-Melaleuca* — Typical Sub-community
MS	*Melaleuca* (Swamp) COMPLEX
MS1	*Melaleuca* Community
MS2	*Melaleuca-Agonis* Community
MS3	*Melaleuca-Melaleuca preissiana* Community
SF	*Schoenus subfasicularis* COMPLEX
	Schoenus subfasicularis Community

CONTENTS

INTRODUCTION

The peripheral vegetation of the Swan and Canning Estuaries is that which is characteristic of the estuarine and riverine landscape. It includes fringing forests and salt-marshes, but does not include the vegetation of the limestone cliffs. The fringing forests are characterised by Paper-barks (*Melaleuca* spp.), Saltwater She-oak (*Casuarina obesa*) and Flooded Gum (*Eucalyptus rudis*) and the salt-marshes by Shore Rush (*Juncus kraussii*) and Samphires (*Sarcocornia quinqueflora* and *Halosarcia* spp.).

Past studies of peripheral estuarine and riverine vegetation, of relevance to the Swan and Canning estuaries, have gone little beyond the above description. The work of N.H. Speck (1952) and R.L. Specht (1974) classified and described fringing forest plant communities, but not salt-marsh communities. T.D. Meagher and I. Le Provost (1975) classified, described and mapped a small section of the Canning estuary, but only as part of a mosquito study. So prior to 1981, no relatively large-scale study of the peripheral estuarine vegetation had been carried out.

The peripheral vegetation is a valuable resource. It contributes towards the aesthetics of the estuaries and their efficiency as waterways, as well as providing natural habitats. For this reason, adequate management is required to prevent any degradation of this resource. The recognition of this has led to a number of studies by P. Bridgewater and L. Pen of the School of Environmental and Life Sciences, Murdoch University, during the period 1980-81. In this time, the vegetation was studied to obtain a basic knowledge of the plant communities of the peripheral habitats, their distribution and environmental and dynamic relationships.

The aim of this report is to give an account of the peripheral estuarine vegetation. This includes describing the vegetation and its dynamics, in an estuarine environment much modified in the last 150 years. The report includes the findings of Pen, Bridgewater and those of the Swan River Management Authority in their foreshore rehabilitation work.

HISTORY: CLEARING, RECLAMATION AND WEIR CONSTRUCTION

Much of the peripheral vegetation along the estuaries has been destroyed by clearing for agricultural development. Clearing began as early as 1829 with the beginning of British colonisation, which in the early years was concentrated along the banks of the Swan and Canning Rivers. Approximately 100,000 acres (40,500 ha) of land along the rivers was granted before the end of the year (Battye (1978) 1924). River frontage was in demand because the soils seemed more promising and the rivers afforded an easy method of transit to and from the centre of the colony at Perth. In the book *Along the Canning* (Carden 1968), it is stated:

> 'By 1830, most, if not all, of the riparial land on both sides of the Canning River upstream as far as Gosnells was in private ownership. It was fairly good arable land, with an ample supply of fresh water, both from the river and shallow wells. It had only a slight tree and bush cover, which was easily cleared. No doubt, it was because of these factors that all of the land referred to was taken up so quickly.'

Equally as swift progress was made along the Swan. Since then, urban and city development have gradually replaced agricultural land, though pasture lands are still found on floodplains along the upper parts of the estuaries.

Certain areas were unsuitable for agricultural development either because the soils were water-logged and/or too saline for pasture development. The vegetation in these areas remained relatively intact until the 1880's when the demands of city and urban development necessitated the beginning of a programme of reclamation schemes. By 1942, some major reclamation projects had been completed, but only two significant areas of remaining peripheral vegetation were destroyed; that at Mill Point and that between Mounts Bay and Crawley. Map 1 shows the vegetation remaining in 1942 as seen from aerial photographs from that year. Since then, much has been destroyed by reclamation carried out to provide sanitary landfill sites, eradicate mosquito breeding areas, provide recreation areas and make lands available for city expansion, and some has been destroyed by further clearing. Between 1950 and 1971, 247.3 ha of foreshore tidal flat and flood plain land had been reclaimed along the rivers by using public refuse (Public Health Department 1974). The reclamation of Burswood Island began in the late 1930's, using slag, dredging material, fly-ash from the nearby power station and demolition refuse. Landfill continues to the present. As part of a river training programme, river bank walls were constructed along some parts causing the destruction of foreshore vegetation. At the Maylands peninsula, 14 hectares were removed from the north bank and used to elevate adjacent land, causing the destruction of a large area of salt-marsh.

In 1927, a weir was constructed at Kent Street on the Canning River to maintain freshwater conditions upstream. This has no doubt caused the transformation of the vegetation from that associated with an estuarine environment to that associated with a freshwater riverine environment. In effect, large stands of salt-marsh and estuarine fringing forest were slowly destroyed by this action. Today, the remnants of a past salt-marsh persist near Nicholson Road bridge.

Map 1 also shows that peripheral vegetation remaining in 1981. Although the vegetation has suffered severe reductions in the past, isolated areas, long strips and extensive tracts of estuarine vegetation, still remain. It is this vegetation which is described in this report.

VEGETATION CLASSIFICATION

For the description of any vegetation pattern, it is necessary to summarise or abstract. One way in which this can be done is to classify vegetation as plant communities. In this case, vegetation samples are grouped together as communities, on the basis of common species, into abstract units or classes of plant communities known as community-types. In Australia, vegetation has typically been classified according to height and foliage projective cover (structure) and dominant species. Any number of plant communities or stands sharing the same interval of structure of the dominant species and the dominant species themselves are said to belong to the same class. For example, Specht et al (1974) classifies vegetation dominated by *Casuarina obesa* (Swamp She-oak) having a height interval of 10-30 metres and a foliage projective cover of 30-10 per cent as *Casuarina obesa* woodland. However, classification can also be achieved by taking into account the total floristic composition of plant communities, and this is the approach used in this study.

One floristic approach is the Braun-Blanquet (1932) floristic association system, also referred to as the Zurich-Montpellier system of phytosociology, a name which pays greater credit to the school of thought which developed the system rather than to J. Braun-Blanquet, the school's most significant contributor. For a detailed layman's description of the system, see Bridgewater (1971), and for a simplified methodological description, see Mueller-Dombois and Ellenberg (1974).

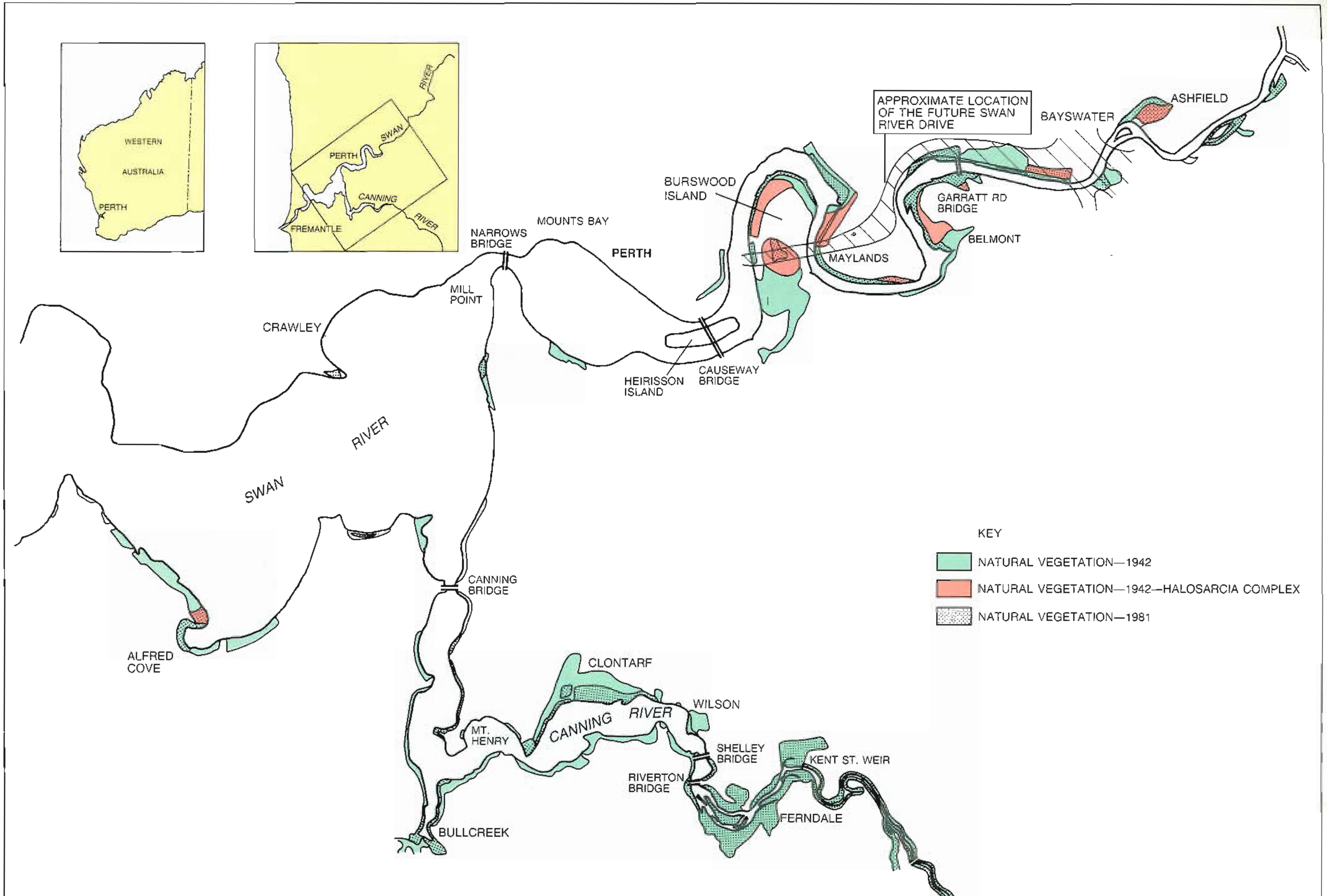
For this report, the method of vegetation classification used is basically as follows. The first stage is known as the **analysis** and involves sampling relatively homogeneous stands of vegetation. A 10 x 10 metre quadrat was found to give the minimum area in which the plant communities of the peripheral estuarine vegetation gave their full expression. That is, the quadrat was large enough to enable an accurate representative sample of any plant community to be obtained. Each sample consisted of a list of the species found within the quadrat and the quantity of each of those species found within the quadrat. To measure species quantities, the following cover-abundance scale by Braun-Blanquet (Bridgewater 1971) was used:

+ = occasional cover, less than 5%
1 = common, cover less than 5%
2 = very common, cover less than 5% or cover 5-20%, any number of individuals
3 = cover 20-50%, any number of individuals
4 = cover 50-75%, any number of individuals
5 = cover 75-100%, any number of individuals.

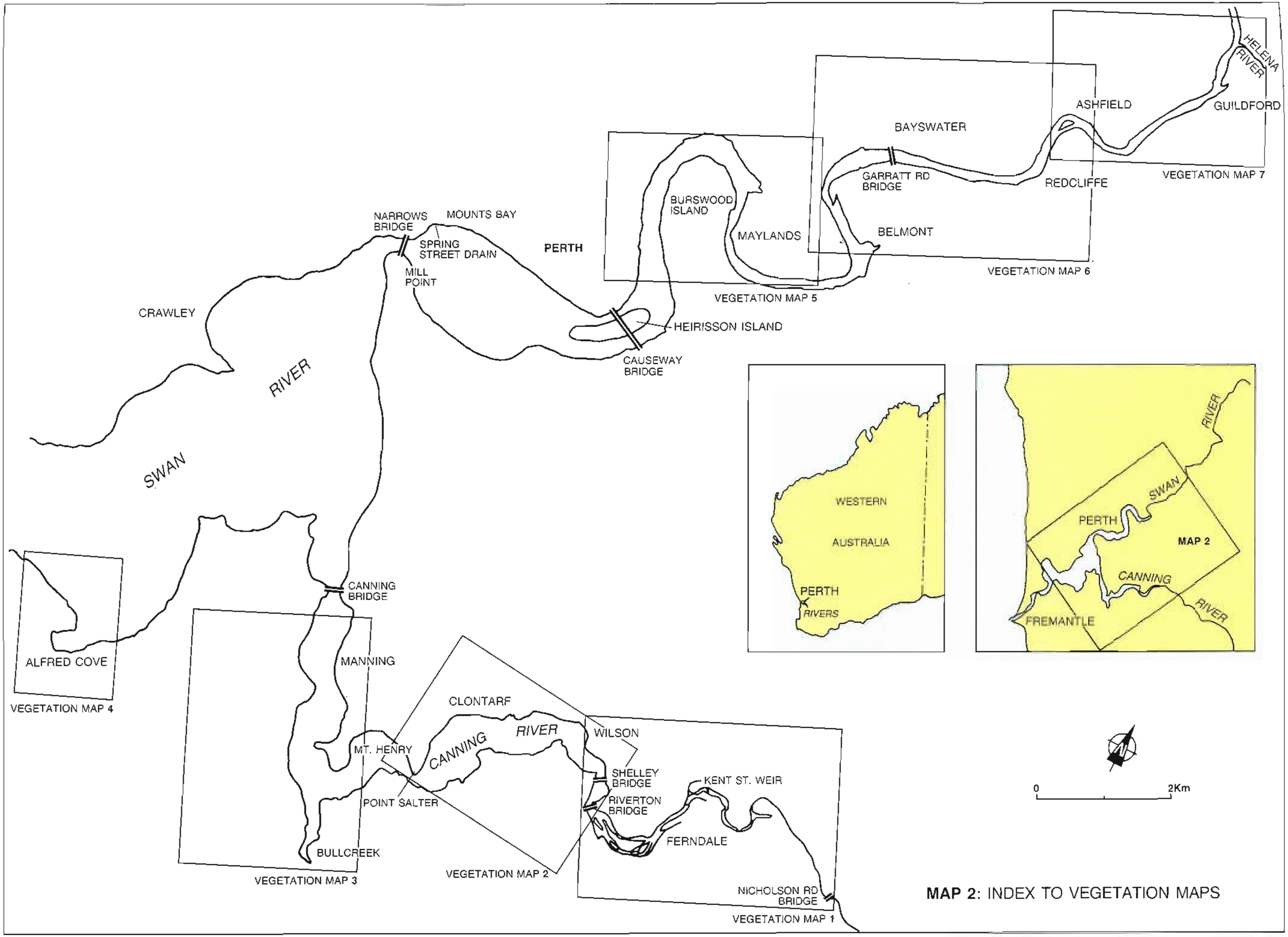
Because mapping the vegetation was one of the objectives of this study, virtually all the peripheral vegetation remaining along the rivers was sampled. All homogeneous stands were sampled, except those which showed an extremely high degree of disturbance, such as lawns, parklands and areas where no fragment of native vegetation remained. Where the vegetation formed a mosaic, the individual components were sampled separately.

The next stage is **synthesis** and involves grouping similar samples, using floristic similarity as a criterion. When there are a large number of samples, a great many distinct groups may be produced. It may be necessary to treat these as 'samples' and to continue to compare and group using those species which are of particular diagnostic value, until relatively distinct and homogeneous groups emerge (see Pen 1981 for a detailed description of the methods used). The result should be a hierachical classification. For example, Bridgewater using these methods, identified a comparable class to that of Specht's *Casuarina obesa* woodland described above. Known as the *Casuarinetum* Association (Bridgewater In press a) it is characterised by the species *Casuarina obesa* and *Juncus kraussii*, and it has two sub-groups known as sub-associations, one recognised especially by the species *Melaleuca rhaphiophylla* (Swamp Paper-bark) and the other especially by *Suaeda australis* (Seablite).

For the studies carried out in the period 1980-81, a great amount of detail was required. The objectives were to show clearly the plant community-types that exist, their relationships to one another (in time and space) and their expression of environmental conditions and variation along the rivers. For such detailed work, the floristic approach, or more accurately the Zurich-Montpellier system of phytosociology, has a number of advantages. Community-types are clearly defined by diagnostic species, they can be presented systematically, clearly showing the relationships of communities to one another and the continuous variation of species combinations and proportions.



MAP 1: EXTENT OF NATURAL PERIPHERAL VEGETATION OF THE SWAN AND CANNING RIVERS 1942 AND 1981



MAP 2: INDEX TO VEGETATION MAPS

VEGETATION UNITS

Nomenclature

The Zurich-Montpellier school has developed its own nomenclature for vegetation units. However, it is used only when the entire range of the particular vegetation pattern under study has been sampled. Because the 1980-81 studies only investigated the vegetation found along the Swan and Canning Rivers, a scheme was devised along the lines of the scheme proposed by J.J. de Smidt (Bridgewater 1975) for the heathlands of the Netherlands. This enables all the variation in vegetation from a limited area such as the rivers to be expressed within a classification scheme, without prejudice to the later inclusion of the material in a geographically wider survey.

This classification has, as the highest level, the **complex**, a group of communities linked by floristic and structural attributes. The **community** is the base level in the classification, although at the extremes of its range there may be sub-communities and variants distinguished by floristic attributes. For this report, a community which had no other comparable community, and therefore could not be grouped, was classified as a 'single community' complex. Any community which was regarded as the product of disturbance is left at the community level.

Vegetation Units

A list of the vegetation units is given in Table 1. Overall, there are eight complexes subdivided into 21 communities of which two are further subdivided into two sub-communities each. Two other vegetation forms are given also, but they are not part of the above classification, because they are the product of continuing severe disturbance. They are *Eucalyptus rudis* Woodland Community and the Weed Community. These are included because they are easily recognisable in the field and are significant both in a landscape sense and to environmental management. Those species especially characteristic of each unit are included.

The genus *Scirpus* has recently undergone a revision (Wilson 1981). The species formerly named *Scirpus caldwellii, S. marginatus, S. nodosus* and *S. validus*, all found commonly along the Swan and Canning Rivers, are now correctly identified as *Bulboschoenus caldwellii, Isolepis marginata, Isolepis nodosa* and *Schoenoplectus validus* respectively. All other species names are from Green (1981), and voucher specimens are held in the Murdoch University Herbarium.

The full floristic composition of each vegetation unit is given in Appendix 4.

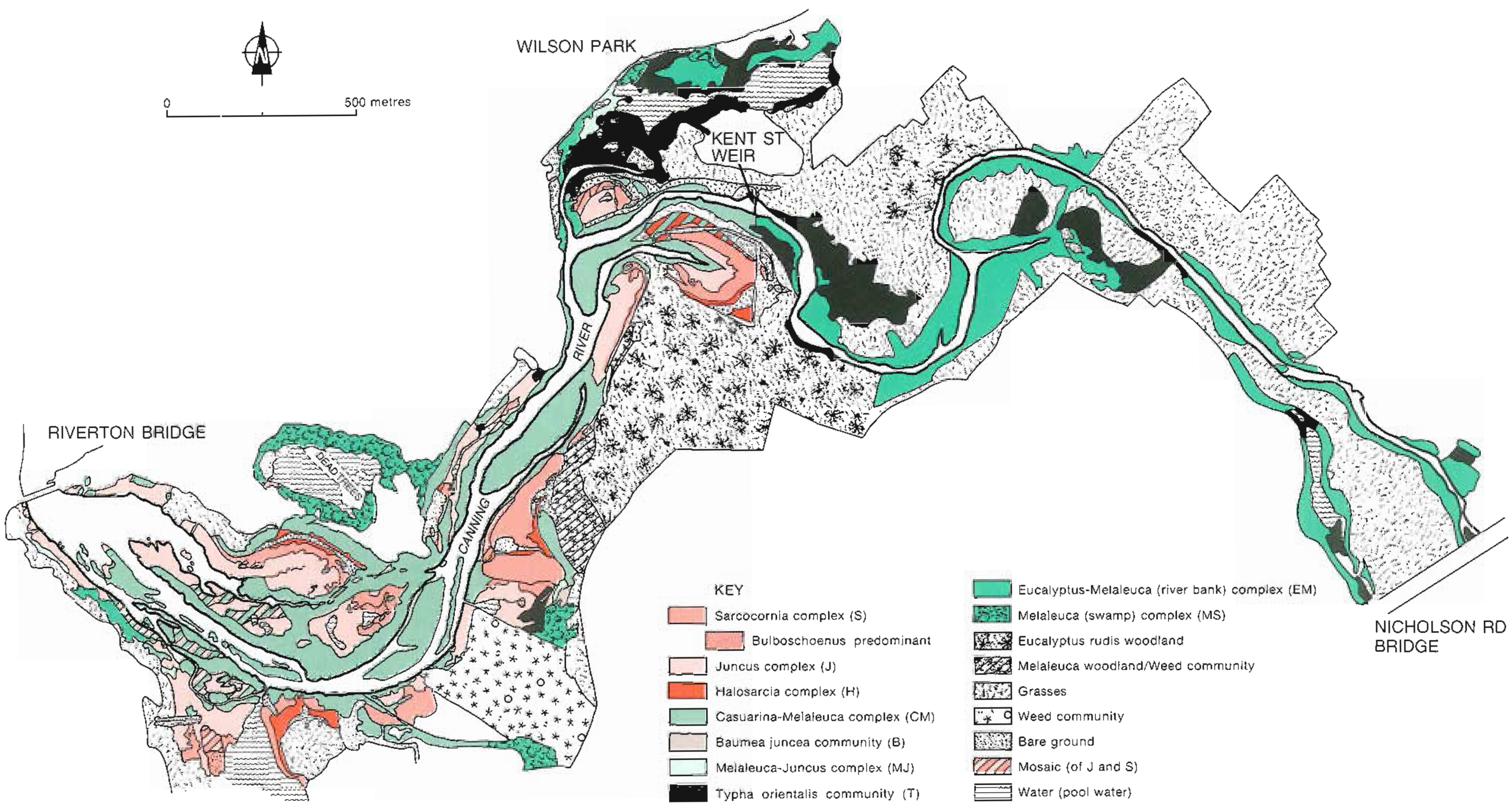
VEGETATION MAPPING AND MAPS

Virtually all the vegetation of the Swan and Canning estuaries was examined and mapped. Areas of remaining indigenous vegetation were identified using 1980 aerial photographs. Different community-types and their extent were sketch-mapped using a Zeiss Aero-Sketchmaster and then sampled and checked in the field. Colour aerial photographs from 1976 and 1980 were used, where available, to obtain further accuracy in relation to boundaries between community-types. Samples, where they were taken, were used to identify different community-types. Otherwise floristic characteristics were used and compared with the classification to enable identification. The vegetation maps show the distribution and extent of the complexes, those communities which are not classified at the complex level and *Eucalyptus rudis* Woodland and the Weed Community.

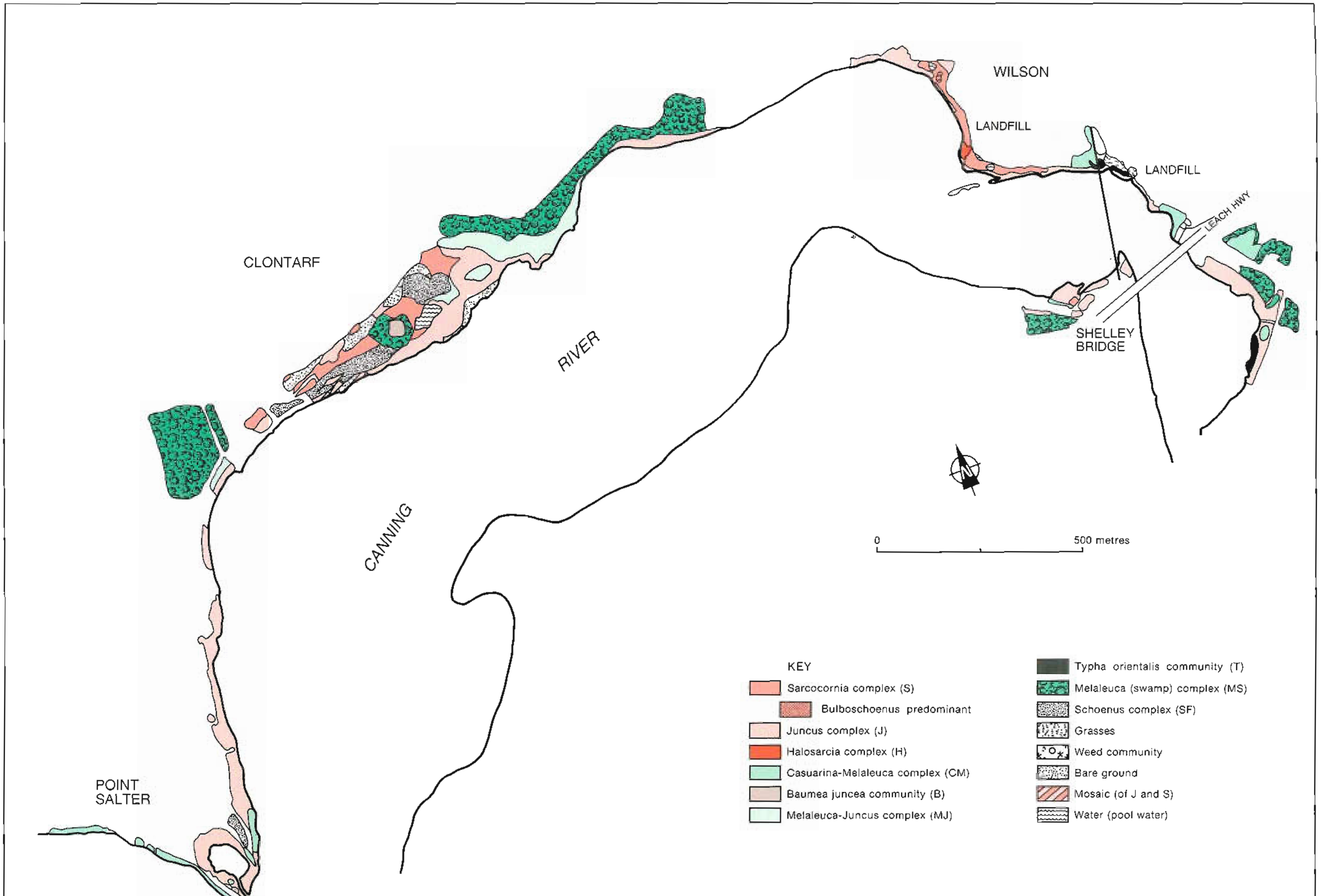
The colours used in the maps distinguish typical salt-marsh vegetation from fringing forest vegetation. Traditionally, red has been used to represent vegetation associated with dry climates and soils, but red was chosen for typical salt-marsh vegetation, because of the stressful environment of high salinities and tidal inundation associated with such vegetation. Fringing forest vegetation which is associated with much less stressful environments, such as those of river banks and swamps, is represented by the colour green. Different shades and symbols are used to represent and distinguish the different vegetation units.

ECOLOGY OF THE PERIPHERAL VEGETATION

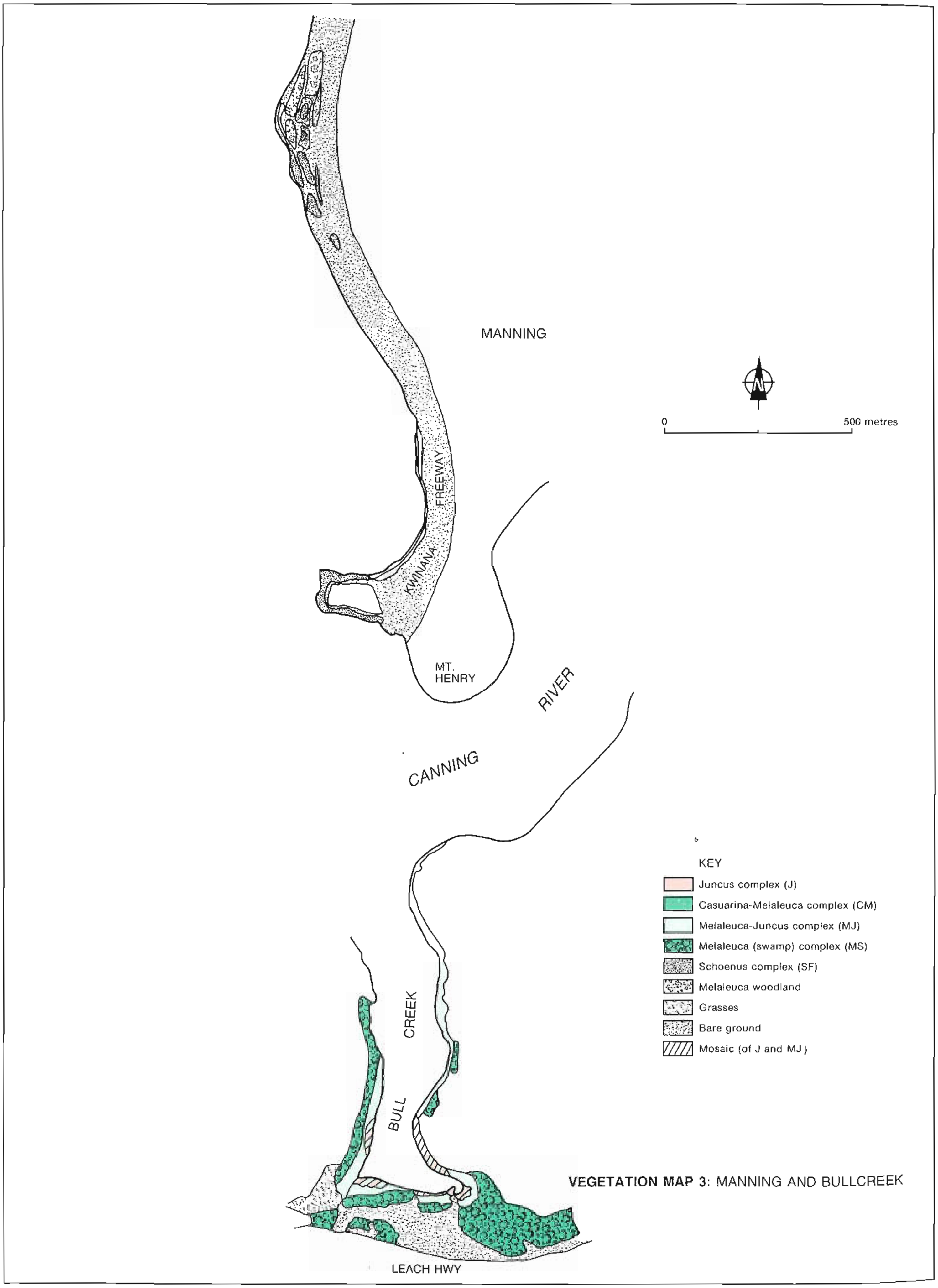
Ecological information was gained from a detailed study of a small area of salt-marsh and fringing forest vegetation at Ferndale on the Canning River, and from extensive observations of the vegetation pattern along both estuaries (see Pen 1981). The complexes and communities are discussed in the same order as they are in Table 1, and the communities, where mentioned, are sometimes referred to by their abbreviations (ie, S2 for the *Sarcocornia-Bulboschoenus* Community), as given in Table 1. For ease of reference, a list of abbreviations and their meanings are given at the beginning of this report and again in Table 2. (Examples of the plant communities are shown in Plates 1-10).



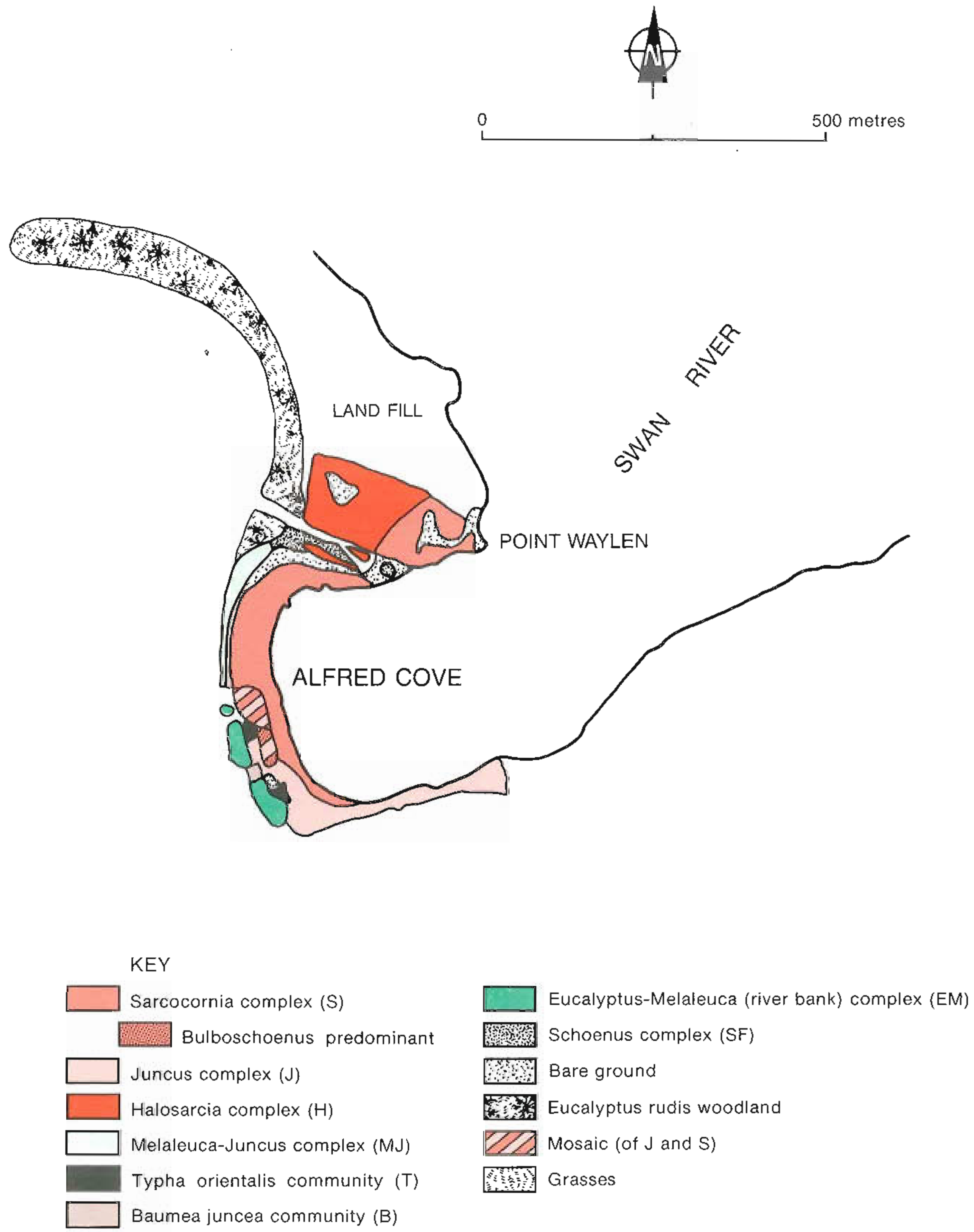
VEGETATION MAP 1: RIVERTON/NICHOLSON RD BRIDGE SECTION



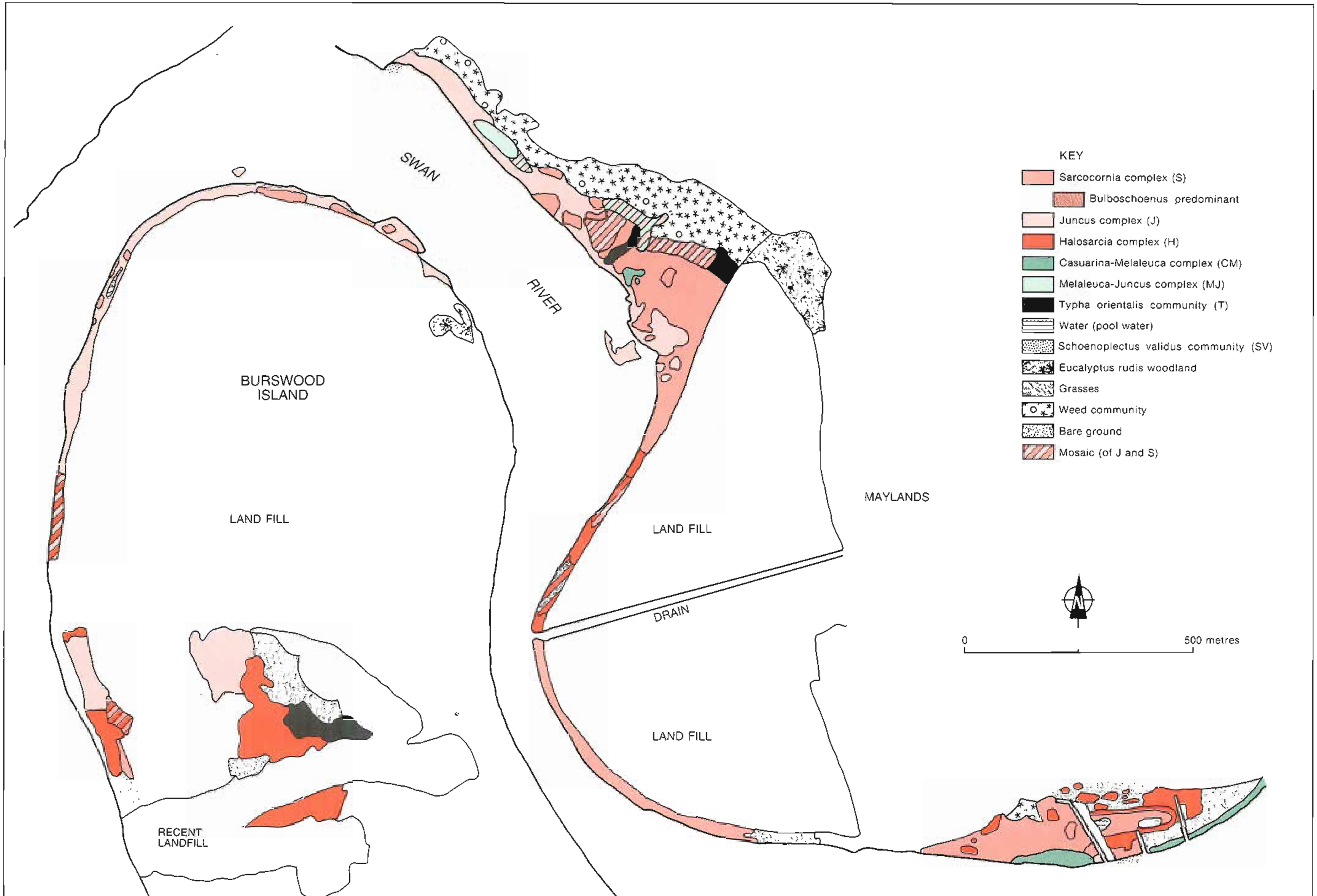
VEGETATION MAP 2: WILSON, CLONTARF AND POINT SALTER



VEGETATION MAP 3: MANNING AND BULLCREEK



VEGETATION MAP 4: ALFRED COVE



VEGETATION MAP 5: BURSWOOD ISLAND AND MAYLANDS

VEGETATION MAP 6: MAYLANDS, BELMONT, BAYSWATER AND REDCLIFFE.

VEGETATION MAP 7: ASHFIELD FLATS AND GUILDFORD

Table 1 Vegetation Units of the Peripheral Vegetation of the Swan and Canning Rivers

Schoenoplectus validus Community (SV)
  Schoenoplectus validus

Sarcocornia Complex (S) (plate 1)
  Sarcocornia quinqueflora,
  Suaeda australis,
  Samolus repens

  Sarcocornia Typical Community (S1)
    As above
  Sarcocornia-Bulboschoenus Community (S2)
    As above and
    Bulboschoenus caldwellii
  Bulboschoenus Predominant (S3) (plate 2)
    Bulboschoenus caldwellii
  Sarcocornia-Triglochin-Isolepis marginata Community (S4)
    As above and
    Triglochin mucronata,
    Isolepis marginata

Juncus Complex (J) (plates 1, 5)
  Juncus kraussii

  Juncus Typical Community (J1)
    As above
    Juncus-Sarcocornia Sub-community (J1-A)
      Juncus kraussii,
      S. quinqueflora
      S. australis
    Juncus-Samolus Sub-community (J1-B)
      Juncus kraussii,
      Samolus repens
  Juncus-Melaleuca Community (J2)
    Juncus kraussii and
    Melaleuca cuticularis,
    M. hamulosa or
    M. rhaphiophylla

Halosarcia Complex (H) (plate 3)
  Halosarcia indica subsp. *bidens* and/or
  Halosarcia halocnemoides

  Halosarcia Typical Community (H1)
    As above
  Halosarcia-Frankenia Community (H2)
    As above and
    Frankenia pauciflora
  Halosarcia-Angianthus Community (H3)
    As above and
    Angianthus preissianus,
    Angianthus micropodioides

Sarcocornia blackiana Community (SB)
  Sarcocornia blackiana,
  Polypogon monspeliensis

Casuarina-Melaleuca Complex (CM) (plate 4)
  Casuarina obesa and/or
  Melaleuca rhaphiophylla
  J. kraussii

Casuarina-Melaleuca Typical Community (CM1)
  As above and
  Bulboschoenus caldwellii,
  S. repens,
  Myoporum caprarioides
Casuarina-Melaleuca-Baumea Community (CM2)
  As above and
  Baumea juncea
Melaleuca-Typha Community (CM3)
  Melaleuca rhaphiophylla,
  J. kraussii,
  Typha orientalis
Casuarina-Bulboschoenus Community (CM4)
  C. obesa,
  B. caldwellii,
  J. kraussii

Baumea juncea Community (B)
  Baumea juncea

Melaleuca-Juncus Complex (MJ) (plates 1, 5)
  M. rhaphiophylla
  J. kraussii

  Melaleuca-Juncus Community (MJ)
    As above

Typha orientalis Community (T) (plate 6)
  Typha orientalis

Eucalyptus-Melaleuca (River Bank) Complex (EM)
  Eucalyptus rudis (plate 7)
  Melaleuca rhaphiophylla,
  Rumex crispus,
  Paspalum dilatatum
Eucalyptus-Melaleuca-Juncus pallidus Community (EM1)
  As above and
  Juncus pallidus,
  Centella cordifolia,
  Paspalum distichum
  P. dilatatum,
  Typha orientalis
Eucalyptus-Melaleuca-Aster Community (EM2)
  As above and
  Aster subulatus
Eucalyptus-Melaleuca Typical Community (EM3)
  As above
  Eucalyptus-Melaleuca-Typha Sub-community (EM3-A) (plate 10)
    Typha orientalis
  Eucalyptus-Melaleuca — Typical Sub-community (EM3-B)

Salt-marsh

Fringing Forest

Table 1 continued

Melaleuca (Swamp) Complex (MS)
M. rhaphiophylla,
E. rudis,
P. dilatatum,
Agonis linearifolia,
Lepidosperma longitudinale

Melaleuca Community (MS1)
As above and
Cynodon dactylon,
Baumea juncea and/or
J. kraussii
Melaleuca-Agonis Community (MS2)
As above and
Agonis linearifolia
Melaleuca-Melaleuca preissiana Community (MS3)
As above and
Melaleuca preissiana,
Eucalyptus calophylla,
Oxylobium linearifolium

Schoenus Complex (SF) (plate 8)
Schoenus subfasicularis

Schoenus Community (SF)
As above

Eucalyptus rudis Woodland (plates 9, 21)
Dominant species —
E. rudis
Other (understorey) species:
* *Stenotaphrum secundatum,*
* *Rumex crispus*
* *Pennistum clandestinum*
Cynodon dactylon
* *Conyza bonoriensis*
* *Sonchus asper*
Paspalum dilatatum
* *Watsonia bulbilifera*
Acacia saligna
* *Lolium multiflorum*
* *Lolium rigidum*
Iridaceae sp.
* *Avena barbata*
* *Stachys avensis*
* *Erharta erecta*
Briza maxima
* *Lotus uliginosus*
* *Raphanus raphanistrum*
* *Oxalis pes-caprae*
* *Fumaria officinale*
* *Homeria collina*
* *Hyperchoeris radiata*
* *Erodium cicutarium*
* *Arctotheca calendula*
* *Sonchus oleraceus*
Salvia sp.

Weed Community
Common Species:
Paspalum dilatatum
* *Conyza bonariensis*
Acacia saligna
* *Cortaderia selloana*
* *Stenotaphrum secundatum*
* *Rumex crispus*
* *Ricinus communis*
Pteridium aquilinum
* *Rubus selmerii*
* *Arundo donax*
* *Pennistum clandestinum*
* *Zantedeschia aethiopica*
Cynodon dactylon

Ecological Notes

The *Schoenoplectus validus* Community is found along the Swan upstream from Maylands. *Schoenoplectus* is completely emergent as a separate strip, one to three metres wide, parallel to and about one to two metres from, the river bank. It is often associated with fresh water drains, particularly those entering more saline waters such as encountered at Maylands. Sometimes, *Bulboschoenus caldwellii* is found fringing with it, but mostly it is a totally separate monospecific stand of *Schoenoplectus validus*.

The *Sarcocornia* Complex (S) occurs along tidal flats somewhat sheltered from the river by vegetation characterised by *Casuarina obesa* and/or *Juncus kraussii* on low river bank levees. The complex rarely abuts onto the rivers. Of great significance in this complex is *Bulboschoenus caldwellii*. It is totally absent in the *Sarcocornia* Typical Community (S1) possibly due to the high soil salinities associated with this community, but is quite abundant in the *Sarcocornia-Bulboschoenus* Community (S2) where this complex is at its minimum associated salinity level. Bridgewater (1982) recognised a very similar plant community and stated that it 'appears controlled by a dynamic system where the saline waters of the estuary are balanced by surface groundwater flows of freshwater'. S2 is often found in salt-marshes dissected by drains or which are close to drainage outlets, an observation which strongly supports this explanation. *Bulboschoenus* Predominant Community (S3) is dominated completely by *B. caldwellii* and represents the extreme success of this species in the *Sarcocornia* Complex, often displacing those species characteristic of the complex. It is mostly found landward of the *Juncus* Complex and around tidal pools. *Sarcocornia-Triglochin-Isolepis marginata* Community (S4) which is differentiated by the presence of *Triglochin mucronata* and *Isolepis marginata* is found at the highest land surface elevation associated with this complex.

Bridgewater (1982) also recognised the *Suaeda australis* Community, consisting of mainly *S. australis*.

This was observed in only a few locations along the rivers, and too few samples were taken to enable it to be classified as a plant community. However, it was noted to be strongly associated with organic debris, derived from algae and *Casuarina obesa* litter.

The *Juncus* Complex (J) is found fringing the rivers and tidal creeks, and replaces the *Sarcocornia* Complex where salinities decrease. It is mainly seen as a stand of *J. kraussii*, *Juncus* Typical (J1), but close investigation has shown that two sub-communities exist within this community. J1-B, the *Juncus-Samolus* Sub-community, is distinguished by the presence of *Samolus repens*, and is classified as an association by Bridgewater (1982), and J1-A, the *Juncus-Sarcocornia* Sub-community, is distinguished by the presence of *Sacorcornia quinqueflòra*. However, the latter sub-community is only a stage of temporal succession, where the *Juncus* Complex is succeeding the *Sarcocornia* Complex, a process which is evident from photographic analysis, and is not a persisting type of plant community. The second community, the *Juncus-Melaleuca* Community (J2) is distinguished by the presence of low *Melaleucas*.

Table 2 Key to Abbreviations For Vegetation Units

SV		*Schoenoplectus validus* COMMUNITY
S		*Sarcocornia* COMPLEX
	S1	*Sarcocornia* Typical Community
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	H3	*Halosarcia-Angianthus* Community
SB		*Sarcocornia blackiana* COMMUNITY
CM		*Casuarina-Melaleuca* COMPLEX
	CM1	*Casuarina-Melaleuca* Typical Community
	CM2	*Casuarina-Melaleuca-Baumea* Community
	CM3	*Melaleuca-Typha* Community
	CM4	*Casuarina-Bulboschoenus* Community
B		*Baumea juncea* COMMUNITY
MJ		*Melaleuca-Juncus* COMPLEX
		Melaleuca-Juncus Community
T		*Typha orientalis* COMMUNITY
EM		*Eucalyptus-Melaleuca* (River Bank) COMPLEX
	EM1	*Eucalyptus-Melaleuca-Juncus pallidus* Community
	EM2	*Eucalyptus-Melaleuca-Aster* Community
	EM3	*Eucalyptus-Melaleuca* — Typical Community
	EM3-A	*Eucalyptus-Melaleuca-Typha* Sub-community
	EM3-B	*Eucalyptus-Melaleuca* — Typical Sub-community
MS		*Melaleuca* (Swamp) COMPLEX
	MS1	*Melaleuca* Community
	MS2	*Melaleuca-Agonis* Community
	MS3	*Melaleuca-Melaleuca preissiana* Community
SF		*Schoenus subfascicularis* COMPLEX
		Schoenus subfascicularis Community

Plate 1
The *Sarcocornia* Complex (foreground), *Juncus* Complex (midground) and *Melaleuca-Juncus* Complex (background), on the Canning River, Karawara, near Clontarf Boys town.

Plate 2
The *Bulboschoenus* Predominant Community, on the Canning River at Ferndale.

Plate 3
The *Halosarcia* Complex, at Alfred Cove.

Plate 4
The *Casuarina-Melaleuca* Complex, on the Canning River, just upstream of Riverton Bridge, Riverton.

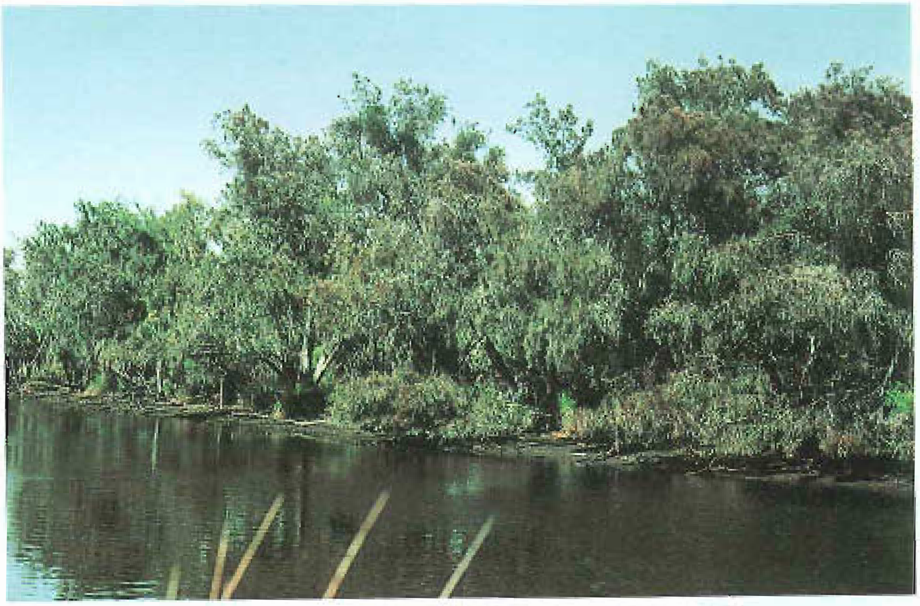

Plate 5
The *Melaleuca-Juncus* Complex (background), on the Canning River at Karawara. *Juncus* Complex in foreground.

Plate 6
The *Typha orientalis* Community, fringing tidal pools on the Canning River at Wilson.

Plate 7
The *Eucalytus-Melaleuca* (River Bank) Complex, on the Canning River upstream of the Kent Street Weir. *Typha orientalis* is in the foreground.

Plate 8
The *Schoenus* Complex (midground), fringing with *Sarcocornia* Complex (foreground). The shrubs are *Melaleuca cuticularis*.

Plate 9
The *Eucalyptus rudis* Woodland,
on the Canning River at Ferndale.

Plate 10
The *Eucalyptus-Melaleuca-Typha* Sub-community (EM3-A); where *Typha orientalis* has invaded the understorey of the *Eucalyptus-Melaleuca* Complex. This stand is on the Canning River upstream of Kent Street Weir.

The *Halosarcia* Complex (H) occurs in the supra-littoral zone often adjacent to the *Sarcocornia* Complex. Evidence from the detailed study suggests that this complex tolerates periodically extremely high salinities (up to twice that of seawater for the soil water) during summer, with low salinities (near that of freshwater) during winter. The *Halosarcia* Typical Community (H1) is strongly associated with severe mechanical disturbance and as such there is often marked difference in floristic composition between different stands. The *Halosarcia-Angianthus* Community (H3), which is distinguished by *Angianthus* spp, suffers some disturbance, but there is a relatively strong uniformity of floristic composition among different stands. Bridgewater (1982) noted that a similar plant community often backed onto vegetation dominated by *Melaleuca cuticularis, M. rhaphiophylla* and/or *C. obesa*, a situation which was observed at Ferndale on the Canning River. Finally, the *Halosarcia-Frankenia* Community (H2), which is distinguished by the shrub *Frankenia pauciflora*, is found in only one location close to tidal pools. A possible explanation for the rare occurrence of this community on the Swan-Canning estuaries is given on page 25.

The *Sarcocornia blackiana* Community (SB) has a highly restricted distribution and has been greatly disturbed. It was recognised only by its unusual abundance of *Sarcocornia blackiana*. It occurs with H1, indicating an environment similar to that associated with the *Halosarcia* Complex, although it is possibly found on slightly higher ground.

The *Casuarina-Melaleuca* Complex (CM) fringes the rivers on land having a slightly higher elevation and lower salinities than the *Sarcocornia* Complex and the *Juncus* Complex. Often, salt-marshes are found to the landward indicating that the presence of this complex and the *Sarcocornia* Complex go hand in hand with the development of a levee. The most widely distributed community is the *Casuarina-Melaleuca* Typical (CM1) distinguished particularly by *Myoporum caprarioides*. Where freshwater intrudes, as a result of drains, the *Melaleuca-Typha* Community (CM3) is found, characterised by the absence of *C. obesa* and the abundance of *Typha orientalis* (Bulrush). The *Casuarina-Bulboschoenus* Community is marked by the abundance of *B. caldwellii* under *C. obesa*. Backshall (1977) believed this community-type to be a consequence of the destruction of *J. kraussii* at the shoreline, enabling *B. caldwellii* to colonise and form 'an unnatural' (and temporary) association with *C. obesa*.

The *Baumea juncea* community (B) is associated more with stationary (lentic) waters than flowing (lotic) waters, and so is an oddity along the rivers (Bridgewater pers comm). It is found only in a few locations near relatively stationary bodies of water, such as Alfred Cove and Salter Point.

The *Melaleuca-Juncus* Complex (MJ) is typically found fringing the river, with a band of *Juncus* Complex separating it from the water's edge. The complex is commonly found at elevations equal to that of the *Juncus* Complex, but where the soil water salinity is considerably less due to freshwater flushing.

The *Typha orientalis* Community (T) is found in areas subject to strong freshwater flushing, being virtually always associated with the existence of a nearby drain, although it can tolerate relatively high summer salinities. It develops in areas where there has been a swift change in environmental conditions brought about by drains, and much prefers stationary waters. Its introduction and distribution is therefore linked with man's alterations to the natural drainage system.

The *Eucalyptus-Melaleuca* (River Bank) Complex (EM) occurs along the upper parts of the estuaries where freshwater conditions are experienced. The *Eucalyptus-Melaleuca-Juncus pallidus* Community (EM1) occurs between Kent St Weir and Nicholson Rd Bridge on the Canning and is probably associated with the non-tidal lentic conditions which prevail during summer as a result of the weir. The *Eucalyptus-Melaleuca-Aster* Community (EM2) is found along the upper Canning River. The *Eucalyptus-Melaleuca* — Typical Community (EM3) is characterised by a relatively low number of species either as a result of *T. orientalis* displacing many of the understorey species where an apparent '*Typha* invasion' has occurred, giving rise to the *Eucalyptus-Melaleuca-Typha* Sub-community (EM3-A), or as a result of considerable mechanical disturbance along the river bank, giving rise to the *Eucalyptus-Melaleuca* — Typical Sub-community (EM3-B).

The *Melaleuca* (Swamp) Complex (MS) is found, as the name implies, in swampy areas. It is the most extreme freshwater-associated complex found along the rivers. The *Melaleuca* Community (MS1) is very similar in form to the *Melaleuca-Juncus* Complex, often found fringing landward of it. The *Melaleuca-Agonis* Community (MS2) is associated with large-scale flushing during winter as a result of drains, natural creeks and freshwater ground flow. While a definite composition has been given (see Appendix 4) the community varies from place to place, because it is often highly disturbed, and species composition is determined by what species had access to an area in the past. This composition was chosen because it has a greater proportion of indigenous and native species and probably represents the closest approximation to the natural state of that community. The *Melaleuca-Melaleuca preissiana* Community (MS3) is found in one location only (Clontarf) fringing between MS1 and pasture on higher ground.

The *Schoenus* Complex (SF) occurs on dry sandy beach ridges and is associated with the highest land surface elevation on which peripheral estuarine vegetation can be found. It is sometimes found in close proximity to the *Halosarcia* Complex, but there is little floristic similarity. Indeed, the complex is not a strongly associated member of the overall vegetation variation and further investigation is warranted.

The two other vegetation types, *Eucalyptus rudis* woodland and weed community are worthy of discussion. Along both rivers are extensive flood plains which may have once supported a distinct plant community, but now are parklands and pasture lands dominated by large *Eucalyptus rudis* trees. These woodlands, though floristically poor in indigenous species, are important since they contribute towards the aesthetic appeal of the rivers. In certain areas, cleared land has been abandoned and no regeneration of the natural vegetation has occurred. Instead, exotic species, grasses and weeds have colonised these areas to form 'weed communities'. Remnant vegetation found on the fringes of these weed communities indicate that the original assemblage was of the *Melaleuca* (Swamp) Complex.

Spatial Zonation

Figure 1 illustrates the directions of spatial zonation recognised. Rarely are any of these sequences fully observable in the field, though number three exists at Alfred Cove. Usually, the vegetation pattern is a combination of these sequences, as a result of the environmental gradients interacting. For example, the *Juncus* Complex (J) may replace the *Sarcocornia* Complex, and then the *Casuarina-Melaleuca* Complex (CM) replace J as a purely decreasing salinity gradient gives way to a sudden increase in elevation. Sequence two is peculiar in that the *Halosarcia* Complex zone may not occur. Possibly, it exists only where high summer salinities are experienced, otherwise CM follows immediately.

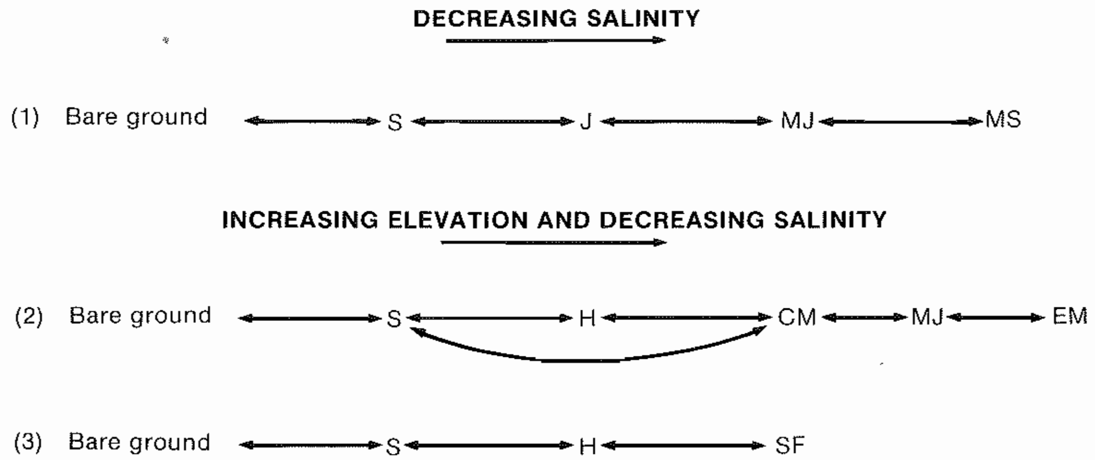

FIGURE 1 DIRECTIONS OF SPATIAL ZONATION FOR PERIPHERAL ESTUARINE AND RIVERINE VEGETATION

Distribution

Peripheral estuarine vegetation is a mosaic of the *Sarcocornia, Halosarcia, Casuarina-Melaleuca* and *Melaleuca-Juncus* Complexes. This mosaic is found along the Swan River between Alfred Cove and Bayswater. But further upstream, a transition from estuarine to the freshwater riverine vegetation of the *Eucalyptus-Melaleuca* (River Bank) Complex begins. This transition ends about Guildford, and from thereon up the river, the riverine vegetation (EM) is continuous. Along the Canning River, there is no transition as the Kent Street weir forms a definite upper limit to the estuary and therefore to estuarine vegetation. However, from field observations of remnant salt-marsh vegetation, it is likely that the transition from estuarine to riverine vegetation once existed between the present sites of the Kent St Weir and Nicholson Rd Bridge.

While most communities have a wide distribution, some are restricted or are only found along one or the other rivers. The *Schoenoplectus validus* Community is only found along the Swan, as is the *Sarcocornia blackiana* Community which only occurs at Ashfield Flats. Other communities occur only along the Canning, probably because more vegetation has survived along that river. *Melaleuca cuticularis* does not exist naturally along the Swan upstream of Burswood Island, and this accounts for why the *Juncus-Melaleuca* Community (J2) is not found along that river. The *Melaleuca* (Swamp) Complex communities are mainly found along the Canning, but a small community remains at Ashfield Flats, indicating that it probably had a much wider distribution along the Swan in the past. The *Eucalyptus-Melaleuca-Juncus pallidus* Community is probably associated with the weir and is therefore only found on the Canning.

VEGETATION DYNAMICS

This chapter deals with vegetation changes over time. Such changes include the development, succession and the regeneration (after disturbance) of plant communities and the introduction of exotic species. They were observed by comparing the present situation, derived from 1980 aerial photographs, with past aerial photographs. Aerial photographs of the estuaries were obtained for 1942-45, 1953, 1958-59, 1963, 1970, 1976 and 1980. From the study two types of vegetation changes were observed. Those which are natural responses to environmental change and those which are essentially unnatural responses and which bring about the degradation of plant communities. This degradation involves the introduction and establishment of exotic species and the subsequent displacement of indigenous species.

Possible System of Dynamic Relationships

By combining all the types of succession which were recognised in the photographic investigation, two schema illustrating the possible dynamic relationships have been produced. That shown in Figure 2 is for estuarine vegetation and that in Figure 3 is for up-river fresh water vegetation. Reasons for change were inferred from natural processes and man's activities evident in the photographs, using information gained in the detailed environmental study.

A general dynamic trend of estuarine vegetation is towards fringing forests. Where decreasing salinity is the primary cause of change, forests of the *Melaleuca-Juncus* Complex (MJ) and the *Melaleuca* (Swamp) Complex (MS) develop. Where an increase in elevation is more significant forests of the *Casuarina-Melaleuca* Complex (CM) develop. In the latter case the various pathways are largely determined by the rate at which elevation of the land surface increases. For example, where deposition of sediment produces a sufficiently high piece of land CM may develop directly, but if the increase in elevation is a slow process the *Juncus* Complex (J) will precede it. These processes have occurred on small islands on the Swan and Canning Rivers. By 1958 a small island of silt had formed at Belmont. Immediately, fringing forest vegetation of the CM complex began to develop. In 1970 mature stands were present after only 10-15 years and today the entire island has been colonised by the CM complex. On the Canning a small island of silt had formed by 1953 and by 1963 had been completely colonised by J which was succeeded by CM by 1980.

The development of vegetation associated with an increase in the elevation of the land surface is a one-way process. No substantial evidence could be found to show that CM or the *Halosarcia* Complex (H) were ever succeeded by a prior complex unlike J and MJ. Ranwell (1972) stated that, of the processes of deposition erosion, one is usually in ascendency. For the Swan and Canning rivers deposition seems to remain in ascendancy long enough for succession to reach the J or CM stage and then erosion may occur, undermining these complexes. Therefore the system is balanced by the destruction of J and CM by erosion, at one end, and the creation of new areas from the deposition of silt, siltation, at the other end. However, in the past 30 to 40 years siltation has been by far the predominant process along the Swan and Canning Rivers giving rise to an ultimate increase in the distribution of CM.

Many of the vegetation changes are natural responses to environmental changes induced by man. For example a common change in salt-marshes is the succession of the *Sarcocornia* Complex (S) by J along drains, where the drains have caused a localised decrease in salinity. This is evident at Clontarf. Another example is seen in areas which are well flushed by fresh water and are characterised by the existence of fringing forest of the MJ and MS complexes behind a belt of J. Any increases in flushing as a result of inland clearing, which increases runoff, and man-made drainage, causes the fringing forest complexes to take a step toward the river's edge in which case J is succeeded, sometimes completely. This has occurred at Clontarf and Bullcreek. Of more significance is the succession of fringing forest by salt-marsh. This requires a considerable environmental change, and in one area this has occurred as a result of digging drains straight through the fringing forest vegetation, causing a cessation of flushing. Where once fresh water flushed the area, maintaining relatively low salinities, it is now directed straight out to the river. The effect is that the saline river water has intruded into these areas, considerably increasing the salinity and thereby causing a successional trend towards that of the J and S salt-marsh complexes. This has occurred in the area of vegetation on the western bank of the Maylands peninsula, and has brought about the destruction of probably the largest stand of MJ found along the estuaries.

The *Halosarcia* and *Sarcocornia* Complexes are dynamic in themselves in that they are capable of maintaining themselves despite severe disturbance. The success of these complexes is due to the species *Halosarcia indica* subsp. *bidens, H. halocnemoides, Sarcocornia quinqueflora* and *S. blackiana* which are all able to regenerate well within ten years of being cleared, eventually giving rise to the total regeneration of the plant communities. *H. halocnemoides* can regenerate very successfully despite on-going disturbance. It is the high salinities associated with these complexes, precluding the establishment of weeds and exotic species which could possibly prevent regeneration, that causes the cleared areas to remain free for regeneration. Although some exotic species have successfully established, they are winter ephemerals which have complemented these complexes rather than 'degraded' them. (Examples of salt-marsh regeneration are shown in Plates 11 and 12).

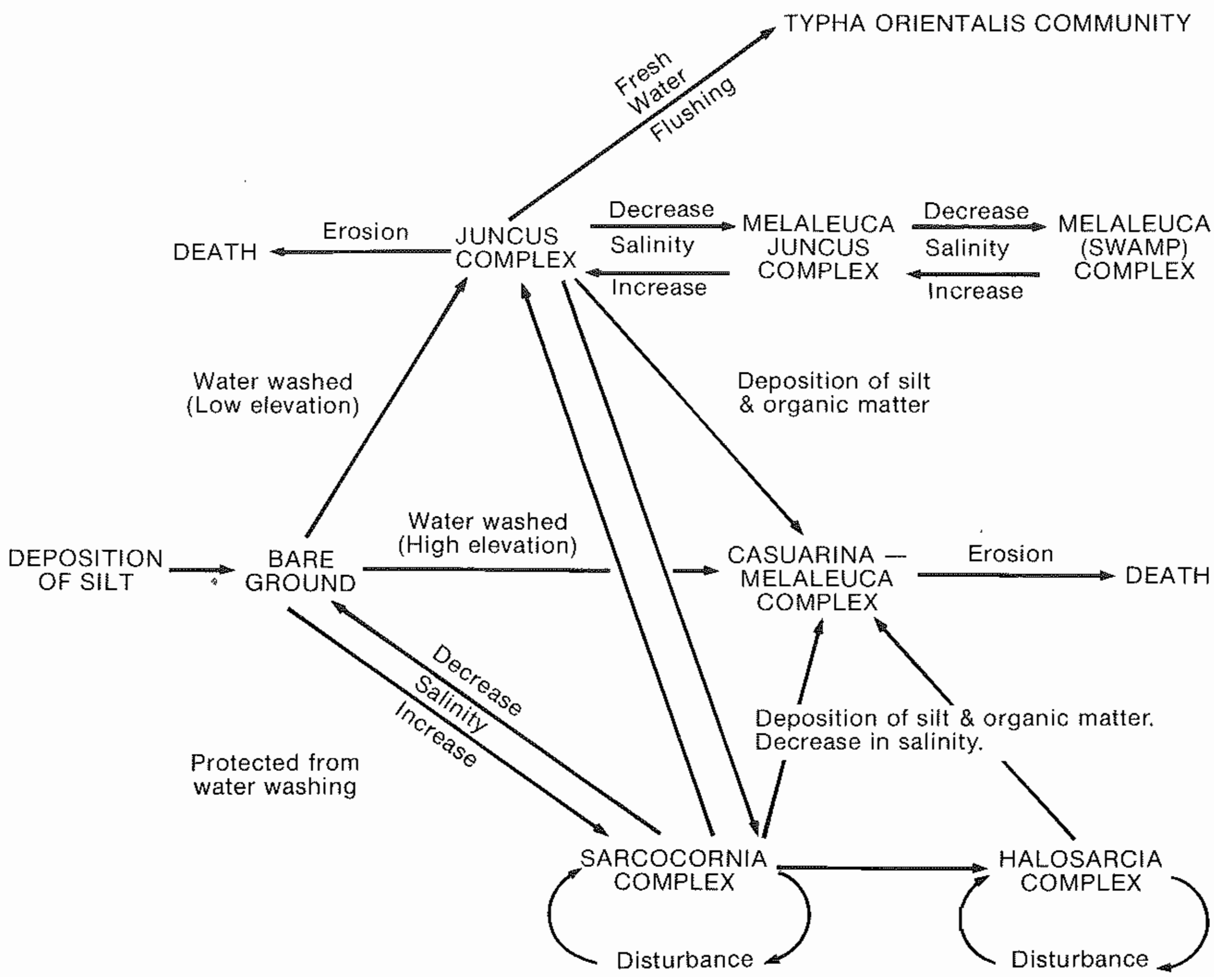

FIGURE 2 POSSIBLE DYNAMIC RELATIONSHIPS — ESTUARINE VEGETATION

Pioneer Species

Areas newly colonised by the *Juncus* Complex were examined in 1981. The study revealed *Juncus kraussii* over *Sarcocornia quinqueflora, Suaeda australis* and *Atriplex hypoleuca* in one area, and in another area *J. kraussii* along with *Atriplex hastata, Sporobolus virginicus* and *Carpobrotus edulis*. Some of these species were observed growing on a strip of beach downstream from Mount Henry. It is probable that all of these species form the initial pioneer community on bare silt. For the highly saline soils of tidal flats *S. quinqueflora* and *S. australis* only would be the pioneers.

Degradation of the Plant Communities

Much of the change which has occurred along the Swan and Canning estuaries has brought about the floristic degradation of the plant communities. The succession of MJ by MS is a natural response to an increase in flushing, but today it is far from being a natural response. Many species recognised as aquatic weeds are abundant in the MS communities. They include *Rumex crispus, Paspalum dilatatum, Baumea articulata* and *Nasturtium officinale* (Mitchell 1978). One exotic species, *Zantesdeschia aethiopica* (Arum Lily) is also widely abundant. The abundance of the species indicates that such was the rapidity of change in environmental conditions, that species of a 'weedy nature' colonised new areas before the indigenous successional species. Some examples of the MS complex have no indigenous species at all present in the understorey.

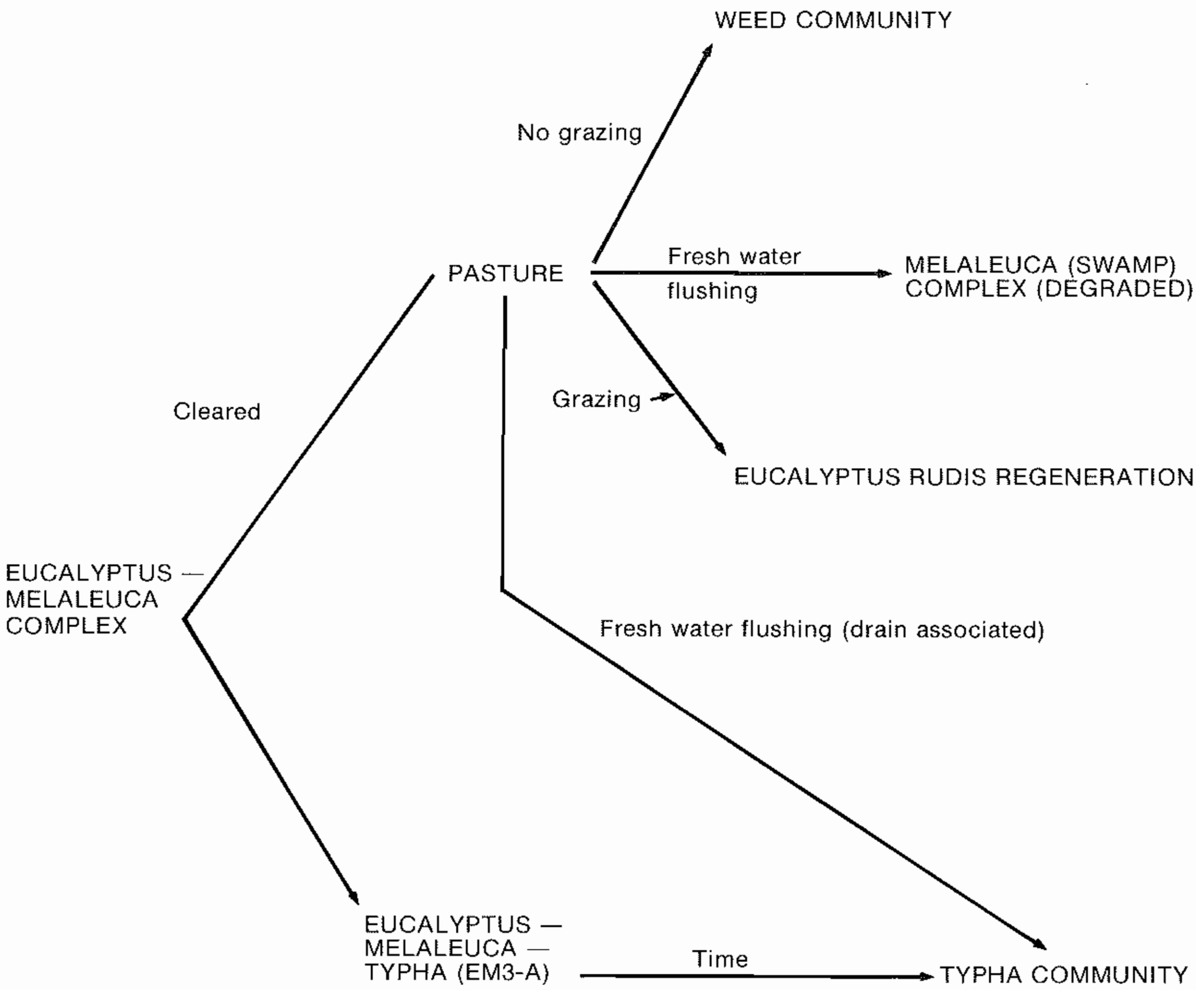

FIGURE 3 POSSIBLE DYNAMIC RELATIONSHIPS — FRESH WATER RIVER VEGETATION

One particular change which is foreign to the natural system of dynamic relationships is the establishment of the *Typha orientalis* Community (T). This community is characterised by the abundant growth or invasion of *T. orientalis* (Bulrush), a species which rapidly establishes in areas where man-made drainage has caused a swift change in environmental conditions. Most of the occurrence of T can be correlated with the existence of drains, and it tends to have its greatest success near and in stationary waters. Salt-marshes are particularly prone to *Typha* invasion and many have suffered the loss of large sections now completely dominated by *Typha orientalis*. The introduction of T along the estuaries is the most significant change to have occurred.

Apart from the development of T the *Typha orientalis* invasion has also caused the displacement of many understorey species normally associated with the fringing forest complexes. In MJ and CM this is as a result of localised flushing and is not a serious problem, but in the *Eucalyptus-Melaleuca* Complex (EM) the degradation caused by *T. orientalis* has been more widespread and complete. This complex is found upstream along the river banks where fresh water conditions prevail. Where relatively stationary waters are found such as upstream of the weir on the Canning River and in pools, *T. orientalis* has rapidly invaded the understorey and has caused the development of the sub-community EM3-A, which is a degraded form of EM1 and EM2. Where this has occurred there has been no continued development of the upper storey components, mainly *Eucalyptus rudis* and *Melaleuca rhaphiophylla* and so it is probable that in the long run this degraded plant community will be succeeded by T.

Bulboschoenus caldwellii is another species the distribution of which can be correlated with fresh water flushing originating from drains. This species, as with *Typha orientalis*, enjoys much success in salt-marshes though it is relatively confined to the *Sarcocornia* Complex, indicating that it can tolerate much higher salinities than *Typha*. While *Typha* displaces the indigenous species of those communities associated with the lower range of summer salinities for salt-marshes, there is evidence to indicate that *B. caldwellii* is doing the same for those communities associated with all but the very extreme of the higher range of summer salinities for salt-marshes. The *Bulboschoenus* Predominant Community (S3) is therefore probably equivalent to the *Typha* Community, while the *Sarcocornia-Bulboschoenus* Community (S2) representing a degraded form of the *Sarcocornia* typical Community (S1).

Mosquitoes have long been a problem associated with salt-marshes. In the past all measures to eradicate mosquito breeding have been directed at the mosquitoes (spraying with pesticide) or at the salt-marshes (reclamation). But recently, drainage channels have been dug at Ferndale to enable the rapid and complete drainage of tidal flats and thereby prevent mosquito breeding. These channels, apart from causing the destruction of salt-marsh vegetation and the erosion and subsequent undermining of peripheral areas, also impart an environmental disturbance. This takes the form of a decrease in the salinity of the salt-marsh especially near the drain. Studies by Bridgewater and Potter (1982) show that an increase in the number of exotic species, both in population size and range, is the resultant form of degradation. *Bulboschoenus caldwellii, Lolium multiflorum* and *Polypogon monspeliensis* benefit especially from the drains.

Although the *Halosarcia* Complex (H) is not threatened by mechanical disturbance, there is some evidence to indicate that degradation has occurred. At the southern tip of the Maylands peninsula the *Halosarcia-Frankenia* Community (H2) is found. As mentioned it is distinguished by the unique abundance of *Frankenia pauciflora*, and the area in which it occurs has not suffered any past disturbance. However, an adjacent area, which has species of the *Halosarcia* Complex but no *F. pauciflora*, has a history of continued disturbance. Two possible conclusions can be made regarding this situation. Either *F. pauciflora* does not exist in areas of disturbance, or it cannot regenerate under conditions of severe disturbance. Since *F. pauciflora* has a very restricted distribution on the Swan and Canning estuaries and most stands have been disturbed, the latter conclusion is probably correct. If so, *F. pauciflora* can be considered a diminishing species along the rivers, and H a degraded complex.

The greatest form of degradation is caused by the clearing of fresh water-associated complexes, MS and EM. Clearing for the most part has been carried out for pasture and parkland development. Along the upper sections of the estuaries the trees have been left intact. On the flood plains this has given rise to the *Eucalyptus rudis* woodlands. Also, strips of vegetation have been left to support the river bank, but in the case of EM3 the vegetation is often depauperate in species due to considerable mechanical disturbance spilling over from surrounding parklands or pasture lands. This has given rise to the sub-community EM3-B, again a degraded form of the EM1 and EM2 communities. While pasture lands are grazed at low to moderate levels, continued regeneration of trees is possible. When grazing pressure is completely removed, weeds and other species of a weedy nature rapidly establish themselves, preventing any regeneration of the natural vegetation. Eventually, weed communities develop which are totally composed of exotic species.

Ageing Eucalypts

The *Eucalyptus rudis* woodlands consist of many large trees of a variety of shapes, creating a tranquil and grand landscape which contributes much to the aesthetic value of the upper sections of the estuaries. For this reason a study was carried out to see how well the *E. rudis* populations were maintaining themselves. Figure 4 shows the extent of tree canopy for woodland areas of Bayswater, Ashfield and Redcliffe for the years 1953, 1963, 1970 and 1980. Large shapes show large mature trees, and the smaller circles and spots, small young trees. In all areas it can be seen that small trees are disappearing, though there has been some recent growth at Redcliffe. At Ashfield and Bayswater the woodlands are also parklands and it is likely that small trees are prevented from replacing the mature trees probably because of general parkland-associated disturbance; well-kept lawns preclude germination, and other activities kill seedlings and saplings. The Redcliffe area is not a maintained parkland and hence there is less activity to prevent regeneration. However, as more of these woodlands come under parkland-type management and regeneration is prevented, the populations will become increasingly aged. Therefore the future maintenance of the *E. rudis* woodland component of the estuarine and riverine landscape is in doubt. (A typical *E. rudis* woodland scene is shown in Plate 21).

Vegetation Stability and Resilience

This section is concerned with the maintenance of the plant communities after suffering disturbances which are temporary or slight and which are not associated with environmental changes of a large enough scale to bring about the replacement of whole plant communities by others. Stability refers to the capacity of the natural vegetation to remain in its natural state and not to be altered by the introduction of exotic species where there has been some slight environmental change allowing exotic species to react and establish before indigenous species. Resiliency refers to the capacity for recovery after severe mechanical disturbance.

The *Eucalyptus-Melaleuca* (River Bank) Complex and the *Melaleuca* (Swamp) Complex have generally poor stability and resiliency. Environmental change and mechanical disturbance have in all cases caused the swift and virtually complete displacement of indigenous understorey species by exotic species. In the upper storey the indigenous tree species *E. rudis* and *M. rhaphiophylla* still predominate as does *Agonis linearifolia* and *Astartea fascicularis* in some locations, but some exotic species such as *Ricinus communis* (Castor Oil Bush), *Erythrina caffra* (Coral Tree), *Shinus terebinthifolius* (Japanese Pepper), a *Ficus* species (Fig) and the giant reed *Arundo donax* have even displaced these in some instances. There is even a stand of Giant Bamboo (*Bambusa arundinaceae*) at Gosnells. Although not an introduced species, *Acacia saligna* (Port Jackson Wattle) was observed to prefer disturbed ground, and for this reason it enjoys an unnatural abundance along the rivers at the expense of the typical peripheral estuarine and riverine trees and shrubs.

The *Melaleuca-Juncus* Complex and *Casuarina-Melaleuca* Complex (CM) are relatively resilient and stable. The introduction of exotic species causes only some reduction in the abundance of the indigenous species. However CM does suffer the total displacement of understorey species brought about by the establishment of *Bulboschoenus caldwellii* (see page 20).

The salt-marsh complexes *Sarcocornia (S)* and *Halosarcia (H)* are highly resilient and stable. Small clearings and vehicle tracks in the vegetation can disappear through regeneration in less than a year, but large-scale clearing requires from 10 to 20 years before regeneration is complete. Regeneration even proceeds despite continued and prolonged mechanical disturbance. Some exotic species such as the ephemerals *Atriplex hastata, Lolium* species and *Polypogon monspeliensis* do benefit from disturbance and establish in these complexes but, given time and stable environmental conditions (the absence of disturbance), their success diminishes (Bridgewater and Potter 1982) (see Plates 13a and 13b). The high salinities associated with these complexes preclude the permanent establishment of perennial weeds.

The *Juncus* Complex is particularly prone to disturbance. Often small areas are flattened or cleared for activities such as fishing or passive recreation and tracks are formed to enable easy access to the foreshore. Such areas are invaded by *Aster subulatus* and *Atriplex hastata*. On foreshores *J. kraussii* maintains itself well where disturbance is not too severe, and probably would regenerate entirely if disturbance ceased. Elsewhere, the complex was observed to have only fair resiliency. All stands of the *Juncus* Complex have been invaded by *A. subulatus* and *A. hastata* and, for the most part, these exotic species simply complement the existing community.

VEGETATION REHABILITATION

The peripheral vegetation of the estuaries is not determined solely by its capacity to maintain and regenerate itself in man's environment, but also by the foreshore vegetation rehabilitation programme carried out by the Swan River Management Authority (SRMA). The objective of the programme is mainly to protect foreshore from erosion, and thereby stabilise the river banks and prevent the loss of property and maintain the rivers as efficient waterways. However, it is also recognised that rehabilitating the vegetation will produce a more aesthetically pleasing estuarine environment, contribute towards the conservation of indigenous species and the maintenance of habitats and support the estuarine ecosystem.

(The following information was obtained in a field-based interview with Mr Vic Fitzsimmons, Inspector with the SRMA).

Methods

The main exercise carried out is the transplantation of *J. kraussii* along foreshores. Clumps are dug out from particularly healthy stands or stands which are about to be destroyed by reclamation, and are planted from the lower foreshore to the upper foreshore level where necessary. Then most of the leaves are cut off at about 10 centimetres above the base so that the plants do not have to sustain too much plant material after transplantation and to stimulate new growth. The best time to transplant *J. kraussii* is during its dormant period, just before its maximum growth period from July to October.

Often *J. kraussii* is simply transplanted on the beach. But sometimes it is necessary to modify the foreshore to prevent the clumps from being washed away and eroded. One strategy is to place concrete slabs and rocks at the lower foreshore level to cut down wave action and below the ridge to help prevent erosion. Sometimes *Carpobrotus edulis* (Pigface) is planted below the beach ridge to aid in stabilisation; grasses subsequently move in to help in this. This technique is illustrated in cross-section in Figure 5, and can be seen just downstream from the Causeway on the western bank of the Swan River. Another strategy uses an eight inch (20 cm) board to help stabilise the foreshore in areas suffering from heavy erosion. The board helps to trap sediment and prevent erosion and maintain stable conditions for *J. kraussii*. Often *Schoenoplectus validus* is transplanted in front of the board. This method is illustrated in Figure 6 and can be seen at Guildford just up from the mouth of the Helena River on the eastern bank. Where erosion is particularly severe at the beach ridge, trees and grasses planted in conjunction with the use of sandbags are needed to stabilise the foreshore completely. This set-up is illustrated in Figure 7 and can be seen just down from the mouth of the Helena River on the eastern bank. At the mouth of the Helena River a deflector has been constructed as

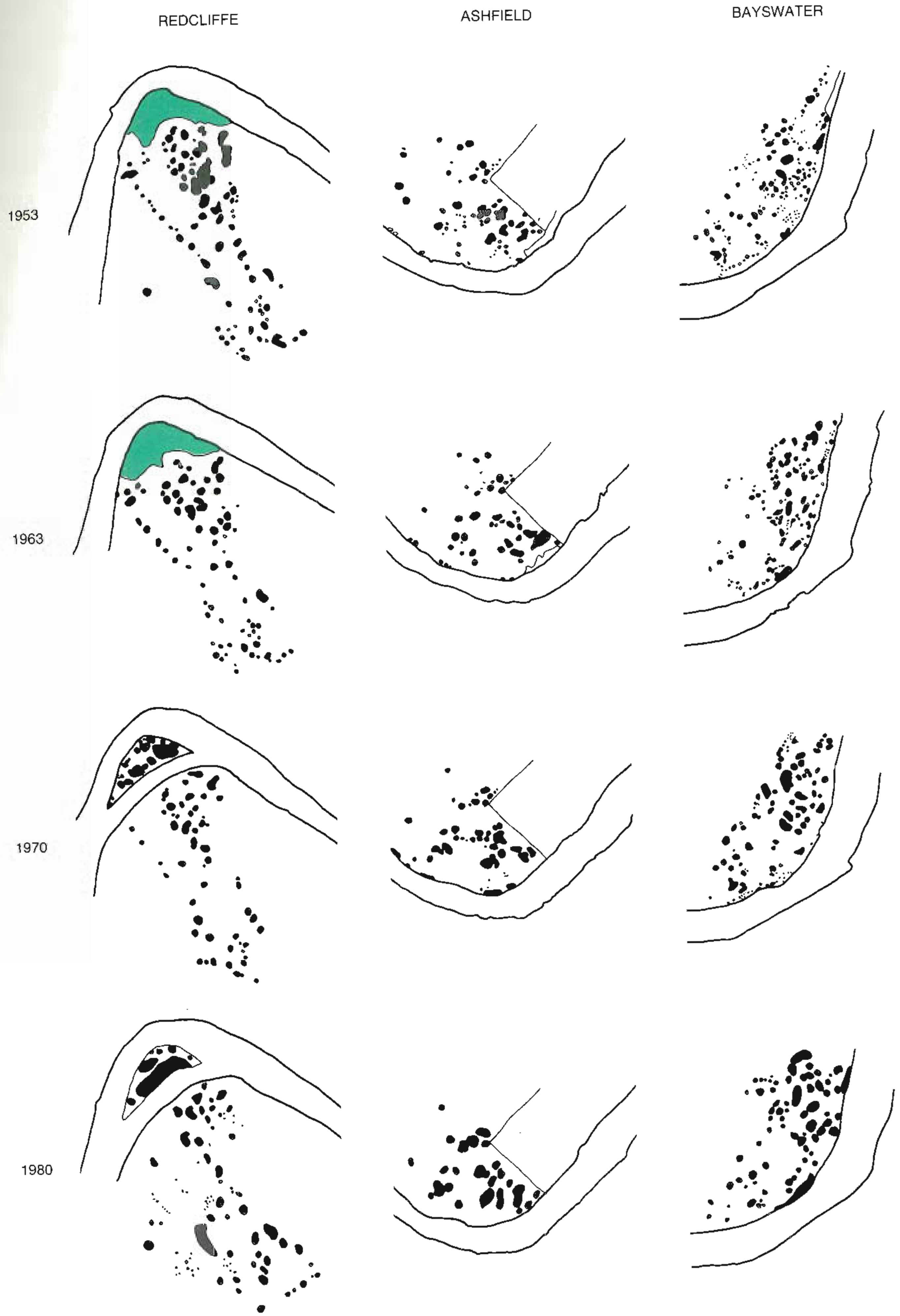

FIGURE 4: *EUCALYPTUS RUDIS.* WOODLANDS REGENERATION

shown in Figure 8, and is used to prevent erosion. In the eroded area a beach has been created and the vegetation rehabilitated as shown in Figure 7.

Other methods of foreshore rehabilitation are used less often. The simple transplantation of *Schoenoplectus validus* has been carried out but the plant grows only slowly and regeneration is sluggish though often successful. There is a very healthy stand of *Schoenoplectus validus* at the mouth of the Helena River, which was initiated from transplanting plants from nearby existing stands. On Ron Courtney Island *Paspalum distichum* (Water Couch) has been planted along with *J. kraussii* on the foreshore. Runners of *Paspalum* were obtained from the Northam district and were transplanted as an experimental exercise. This experiment has proved successful (see Plate 20). Another method using nylon stockings to contain and support soil and seed, when using only seed, has proved successful in some areas.

Recently the SRMA completed a walling construction along the Swan River near the Spring Street drain outlet at the Narrows Interchange. Limestone contained in wire mattresses (Gabions or Reno Mattresses) were used to form a horizontal band of rocks and a wall as shown in Figure 9. It is hoped that sand will collect in the rock band and permit rehabilitation measures to be taken. At present some sand has already collected, but when a stable sandy foreshore has formed it is intended to seed the area with *J. kraussii* seeds and use the 'Nylon Stockings' method described above.

Finally the SRMA also plants trees and shrubs along the river banks to help prevent erosion and subsidence. *Melaleuca cuticularis* and *Casuarina obesa* are planted on foreshores and beach ridges and *Melaleuca preissiana, Eucalyptus rudis* and *E. camaldulensis* on adjacent land. A few other species are also planted (See Appendix 1). Seedlings are planted where there is an obvious absence of trees or where the trees have become aged or are threatened by erosion. It is estimated that 5 to 6 out of every 10 trees planted are destroyed by vandalism.

Success and Failure

Foreshore rehabilitation is generally successful. Though mostly the programme is centred around one species, *Juncus kraussii,* the transplanted clumps usually also contain *Suaeda australis, Aster subulatus, Sarcocornia quinqueflora, Atriplex hastata* and *Atriplex hypoleuca* and certainly carry seeds, and so in effect the *Juncus* Typical Community is being successfully transplanted. One area, between the Causeway Bridge and Burswood Island, was planted in 1979 and all the above species plus *Stenotaphrum secundatum* (Buffalo Grass), *Sporobolus virginicus* (Saltwater Couch) and *Halosarcia indica* subsp. *bidens* (which prefers the zone just below the beach ridge) are present today in abundance. Other successes have ocurred at Guildford on the eastern bank about 2-300 metres down stream from the Helena River and at Burswood Island where *J. kraussii* has formed seed heads reflecting considerable vigour, after only ten months of being transplanted. (Examples of rehabilitation are shown in Plates 14-19).

Significant failures in rehabilitation have been recorded. In 1976, at the request of SRMA, the foreshore between Spring Street Drain and the Narrows Bridge was planted with *J. kraussii* by the Public Works Department, Harbours and Rivers Branch, but severe erosion has left only some healthy clumps near the bridge. A similar failure occurred at Heirrisson Island. At Maylands and down from the Causeway on the western bank, *J. kraussii* was transplanted in 1981 and has failed to take a hold. Many clumps have been washed out or have died. Some new growth has occurred in those clumps planted at the mid-foreshore level, and as these plants, after only five months of being planted, have yet to experience their optimum period for growth, it is too early to make a complete judgement. At one site at Maylands there has been very successful regeneration and this is thought to be due to a nearby drain which flushes the beach with fresh water and nutrients from adjacent parkland. At Guildford up stream from the Helena River, there has been some isolated success using the 'board method', but failure elsewhere.

Some Useful Observations and Findings for Rehabilitation

Casuarina obesa was noted by Pen (1981) to be a tree worthy of special attention for rehabilitation of estuarine foreshore. It was observed to have an extraordinary capacity for regeneration, quickly establishing on bare silt and initiating the development of the *Casuarina-Melaleuca* Complex. At Redcliffe abandoned pits have been colonised by *C. obesa* and *J. kraussii*. Today the flooded pits are connected to the river by a small channel, enabling tidal conditions to prevail, maintaining an artificially induced and aesthetic stand of estuarine fringing forest of the *Casuarina-Melaleuca* Complex (CM). It is possible, therefore, for rehabilitation to include the development of CM for the creation of new habitats.

Halosarcia indica subsp. *bidens* was often observed to be present just below the beach ridge section of foreshores. It is likely therefore that this species could be used to help to consolidate a zone presently left to be colonised by grasses.

In upper estuarine sections of the rivers *Eucalyptus rudis* regeneration is often either negligible or 'explosive'.

In areas where grasses are allowed to grow unchecked there is little regeneration. No young tree or seedlings are seen at all. But in paddocks where herbivores such as cattle or horses keep the grasses down *E. rudis* trees are often found to form low very dense stands of juvenile trees in wet patches. So densely packed are they, that they retard each others growth, eventually forming a low twisted tangled and even aged stand of trees. To produce a more typical age distribution and therefore a more typical spatial distribution attention should be given to thinning these stands whilst at the juvenile stage.

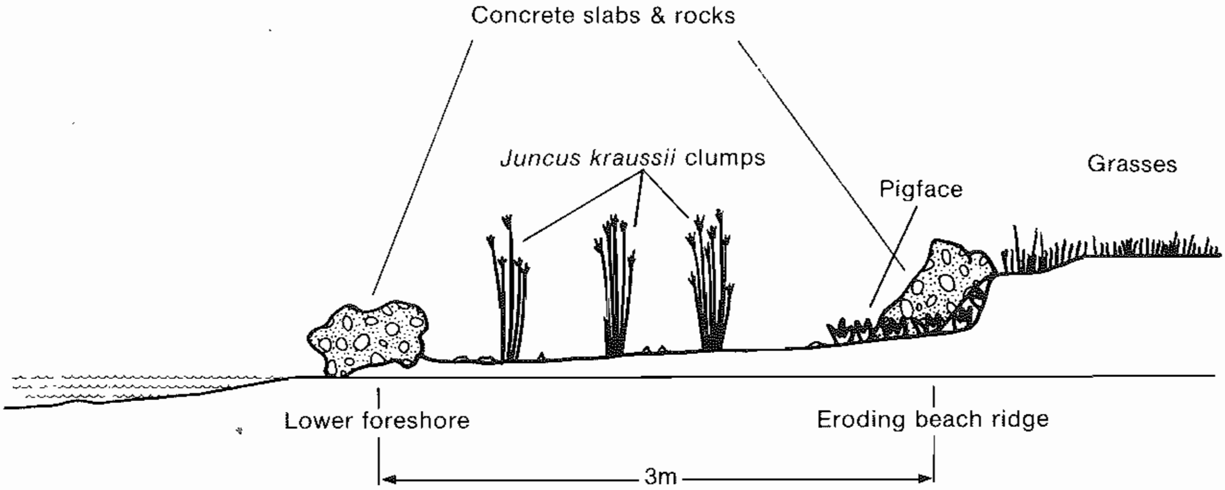

FIGURE 5: FORESHORE REHABILITATION USING CONCRETE SLABS AND ROCKS.
Concrete slabs and rocks break down wave action to protect *Juncus kraussii* clumps or support the beach ridge. *Carpobrotus edulis* (Pigface) is planted to help stabilise the beach ridge.

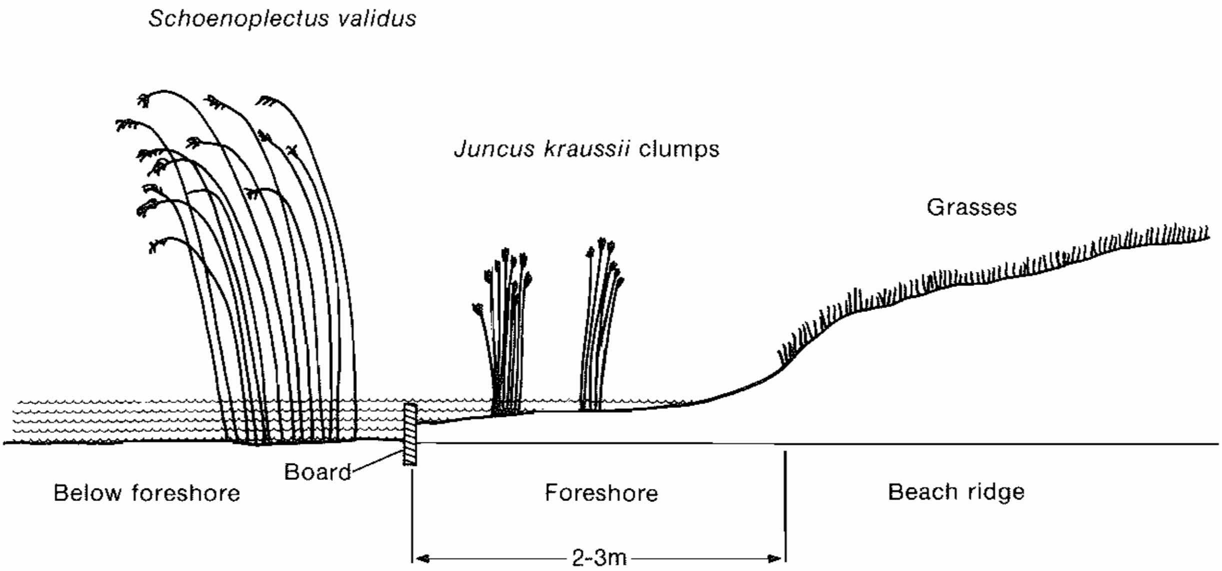

FIGURE 6: FORESHORE REHABILITATION USING AN 8 INCH BOARD.
The board is used to stabilise the foreshore by helping to trap sediment and prevent erosion and thus maintain stable conditions for *Juncus kraussii* regeneration. Sometimes *Schoenoplectus validus* is planted in front of the board.

Plate 11
Salt-marsh regeneration. The samphire species *Sarcocornia quinqueflora* and *Halosarcia halocnemoides* regenerate from seed on ground cleared only a year before. This example is found on the Canning River south of the Kent Street Weir.

Plate 12
Colonisation of an area of sandy tailings by salt-marsh species at Ferndale. Stabilised salt-marsh in the background.

Plate 13(a)
Wheel ruts through a healthy stand of *Sarcocornia* Complex at Ferndale. The aquatic weed *Polypogon monspeliensis* can be seen germinating on the edges of the ruts (August 1982).

Plate 13(b)
Four months later (December 1982) the aquatic weed *Polypogon monspeliensis* seeds abundantly along the wheel ruts.

Plate 14
Successful rehabilitation of *Juncus kraussii* (Shore Rush) along the south-western foreshore of Burswood Island. This area was planted in mid 1981 and 10 months later the *Juncus* has produced seed heads, reflecting a healthy and vigorous state.

Plate 15
Western bank of Burswood Island just south of the Bunbury Railway Bridge. Here disturbance and harsh environmental conditions have prevented vigorous growth. Many of the *Juncus kraussii* clumps are dead or washed out.

Plate 16
Western bank of Burswood Island just south of the Bunbury Railway Bridge. Severe mechanical disturbance has prevented the rushes and samphires from colonising much of the tidal flat.

Plate 17
South-western foreshore of Burswood Island. *Juncus kraussii* enduring at the foreshore after 10 months of being transplanted. Note grasses behind the *Juncus;* this indicates the possibility of fresh water flushing in this area, which would encourage *Juncus* regeneration.

Plate 18
Severe erosion at Redcliffe, opposite Ron Courtney Island. It is the aim of the Swan River Management Authority to prevent such erosion by rehabilitating foreshore vegetation. It should be noted that erosion is a natural process of rivers.

Plate 19
Between the Causeway and Burswood Island. This area was planted with *Juncus kraussii* in 1979 and rehabilitation has been particularly successful.

Plate 20
Ron Courtney Island. The grass growing on the foreshore is *Paspalum distichum* (Water Couch), another species used to rehabilitate river foreshore.

Plate 21
The predominant feature of riverine and estuarine landscape along the Swan and Canning Rivers — *Eucalyptus rudis* (Flooded Gum). This stand exists at Ferndale along the Canning River.

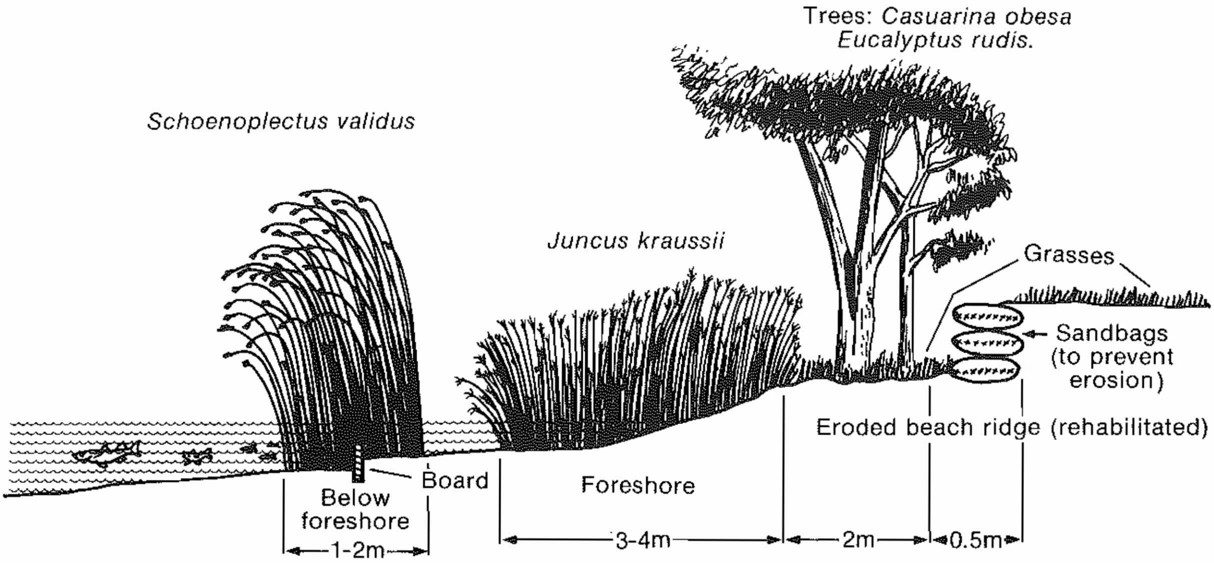

FIGURE 7: FORESHORE AND BEACH RIDGE REHABILITATION USING AN 8 INCH BOARD AND SANDBAGS.
Here an 8 inch board and sandbags are used to help stabilise the entire area from the foreshore to the beach ridge. At the base of the beach ridge trees *(Casuarina obesa* and *Eucalyptus rudis)* are planted.

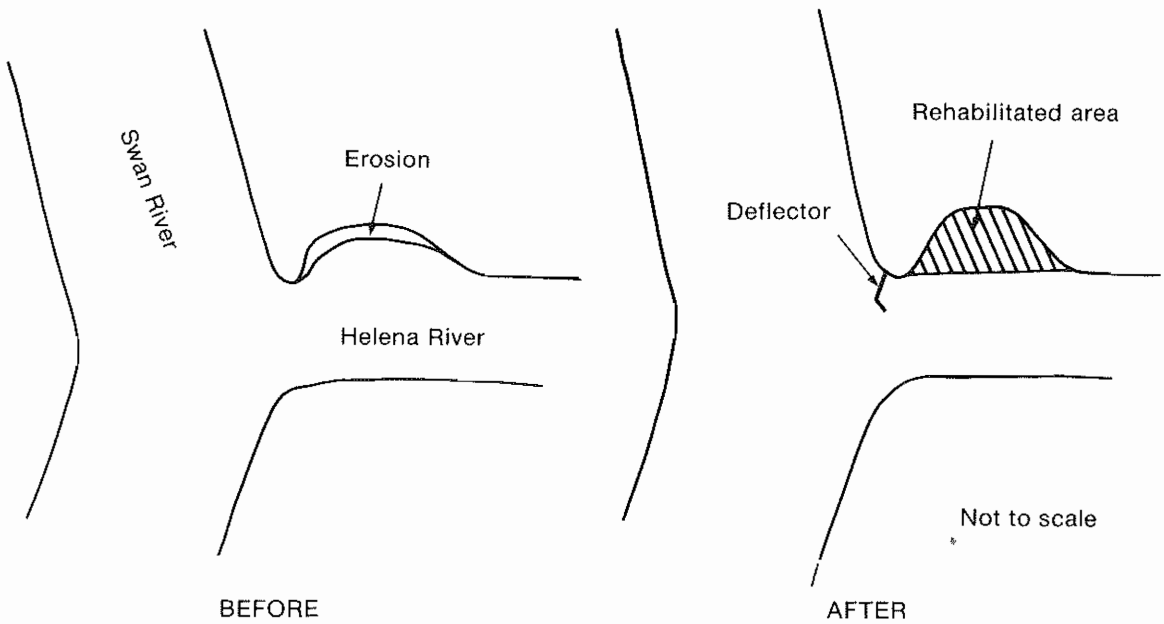

FIGURE 8: PLACEMENT OF A DEFLECTOR AT THE MOUTH OF THE HELENA RIVER TO PREVENT EROSION.

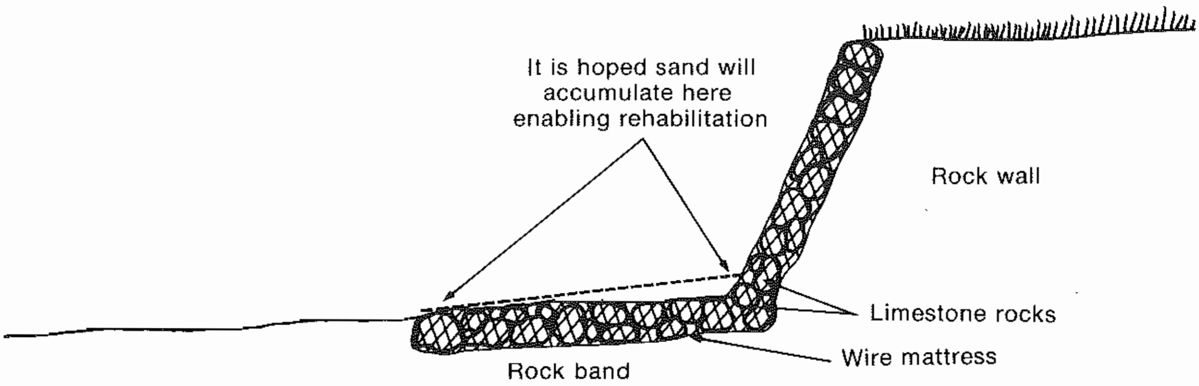

FIGURE 9: ROCK BAND AND WALL CONSTRUCTION USING LIMESTONE ROCKS AND WIRE MATTRESSES

FUTURE STATE OF THE VEGETATION

Further Reduction of Vegetation and Conservation

The clearing and reclamation of peripheral vegetation has not yet come to a halt. Presently the vegetation in the centre of Burswood Island is being destroyed through land reclamation, and the construction of the planned Swan River Drive Highway will cause the destruction of some vegetation at Maylands and most of the vegetation at Bayswater, and Redcliffe. The area to be affected by this road development is shown on Map 1.

Of all communities and complexes along the rivers, all but the *Halosarcia* Complex is adequately reserved on land zoned as Parks and Recreation by the Metropolitan and Regional Planning Authority (MRPA). In the past this complex had a wide distribution with the three largest stands of *Halosarcia* being found at Burswood Island, Maylands and Belmont. These have now all been completely destroyed, and another large stand at Alfred Cove significantly reduced. In 1981 significant stands remained at Alfred Cove, Burswood Island, Maylands, Bayswater and Ashfield Flats. However the Burswood and Bayswater stands are to be destroyed by future development (as discussed above), the Maylands stand which is the rare *Halosarcia-Frankenia* Community (See page 25), is not reserved under Parks and Recreation and is therefore threatened by future development and the Ashfield Flats stand is severely disturbed. Only at Alfred Cove and along the Canning River upstream of Riverton Bridge is this complex reserved.

The large-scale decrease in the distribution of the *Halosarcia* Complex (H) may have serious consequences. H is one of the stages of succession, and if so significant stands exist to provide a source of seed, one of the links in the successional chain will be weakened or even broken. The efficiency of the vegetation system will be decreased and the subsequent communities will be of a degraded form.

Continuing Vegetation Degradation

As more and more drains are dug and new areas of vegetation are disturbed, the displacement of indigenous species by exotic species will continue. The *Typha orientalis* and *Bulboschoenus caldwellii* invasions show no evidence of ceasing within the next few decades. The rate at which *T. orientalis* is invading new areas along the Canning indicates that there will be a progressive degradation of the *Eucalyptus-Melaleuca* Complex communities along bodies of periodically standing water. Recent observations at Ferndale have revealed a major increase in the distribution of *B. caldwellii* in stands of the *Sarcocornia* Complex. This is probably the case for all salt-marshes along the rivers containing this complex. Also, the increased use of areas of peripheral vegetation for recreation will cause the repeated introduction of exotic species.

Ashfield Flats is one area undergoing particularly severe degradation at the moment. Here the *Melaleuca-Juncus* Complex is on the verge of extinction, due to environmental change, and is being replaced by *T. orientalis*. The *Eucalyptus-Melaleuca* Complex present here will probably suffer the same fate.

As for the upstream sections of the estuaries, although there has been near complete understorey degradation, the upper storey of *M. rhaphiophylla* and *E. rudis* is maintaining itself in a healthy state. However, the *E. rudis* woodlands are becoming an increasingly aged population and their continued survival is in doubt.

Degradation of the Vegetation System

Three factors presently degrade the system of dynamic relations as outlined on page 23. Those already described include a reduction in the distribution of certain components such as the *Halosarcia* Complex and the floristic degradation of the natural plant communities. These retard the efficiency of the system to respond to environmental change. However two processes which have not been discussed are the deposition of silt or siltation to form new areas of bare ground, and erosion. These processes are essential to balance the vegetation system and to enable it to endure. But at the present time they are not permitted to occur freely because siltation is hazardous to boating, and erosion destroys property. Therefore accretion will only occur in areas of existing vegetation and, as a result, the peripheral vegetation will progress towards fringing forest. No new areas will form on which salt-marsh communities can establish, and no areas of fringing forest will be eroded. The distribution of salt-marsh communities will decrease and the system will become 'top heavy' with stabilized fringing forest vegetation. All of these factors threaten to retard the vegetation dynamics and bring about the formation of degraded plant communities. As a result, the peripheral vegetation of the Swan and Canning Estuaries is progressing towards a floristically degraded and much less dynamic and variable pattern.

MANAGEMENT RECOMMENDATIONS

Some of the findings of this study could be useful for the management of the peripheral vegetation of the rivers. They are stated below:

For Foreshore Rehabilitation

1. More attention should be paid to those species listed below and regarded as pioneers. Apart from just being successful in beach sand, they probably play an active part in the establishment of vegetation on bare silt. These species include:

   * *Atriplex hastata*
   Atriplex hypoleuca
   * *Carpobrotus edulis*
   Suaeda australis
   Sarcocornia quinqueflora

2. *Casuarina obesa* is excellent for wide scale regeneration along the estuary. (See page 28).

For Salt-marsh and Fringing Forest Conservation

3. For the regeneration of natural vegetation by man, attention should be paid to the zonation of the existing vegetation. This will provide information on where and where not to plant a particular species, and what species to choose for a particular site. For example bare ground adjacent to *Sarcocornia* marsh but slightly higher would best be seeded with *H. halocnemoides* and *H. indicia* subsp. *bidens*. Ground of equal height would be seeded with *S. quinqueflora* if the salinity was very high, or planted with *J. kraussii* if not very high. The understanding of spatial relationships will enable more productive regeneration.
4. Malcolm and Cooper (1974) give methods for seed collection and sowing of *Halosarcia* species for the successful establishment of these species on saline waterlogged soils in the wheatbelt. These methods could be adapted to the rivers, to make use of the extraordinary capacity which *S. quinqueflora, H. halocnemoides* and *H. indica* subsp. *bidens* have for recolonising disturbed areas. This capacity could be used to encourage and rehabilitate existing *Halosarcia* Complex stands, and possibly create artificial stands. The objective would be to ensure the continued existence of regenerating communities so that the associated species are present to fulfil their successional role.
5. To maintain salt-marshes, drains should be cut right across them. In the case of *Melaleuca-Juncus* Complex and *Melaleuca* (Swamp) Complex, the drains should empty into the vegetation, if the drain flow replaces the natural drainage flow. This will maintain fresh water flushing and preserve both complexes in a more natural state. Though degradation will occur, it is to be preferred to destruction.
6. Drains should not empty into stationary bodies of water since they support the most vigorous growth of *T. orientalis*. This may help to contain the *Typha* invasion.
7. To prevent erosion along the periphery of drainage channels constructed to combat the mosquito problem, *J. kraussii* should be transplanted to help support the soil. The drainage channels will create environmental conditions on the adjacent land similar to that found at the river bank. These conditions are suitable for sustaining *J. kraussii* and the plant should not interfere with drainage. If *J. kraussii* becomes too dense and does impede drainage it can be thinned from time to time and the thinnings used to rehabilitate other areas.
8. Public and stock access to areas of natural vegetation should be discouraged, so as to prevent the further spread and hence increased abundance of exotic species and weeds at the expense of indigenous species.
9. Erosion and new deposition are necessary to maintain the dynamic relationships of the river vegetation system. Any prevention of these processes would conserve the *Casuarina-Melaleuca* Complex at the expense of those complexes which precede it in the successional sequence.
10. The following native species were found to be particularly successful in areas having undergone a major environmental change. They may be useful in replanting and upgrading existing swampy areas. They include:

    Inundated areas: *Baumea articulata*
    Schoenoplectus validus

    Seasonally Inundated Areas: *Melaleuca rhaphiophylla*
    Alternanthera nodiflora
    Hemarthria uncinata
    Agonis linearifolia
    Eucalyptus rudis

Other

11. It is a policy of the MRPA to lease riverside public land to neighbouring land owners for grazing where appropriate (D. Everall, pers. comm.). Generally only cattle are permitted because they do little damage to the land. This practice should be continued and extended where possible to enable *E. rudis*

regeneration. The dense stands which form should be thinned to enable them to develop from tangled, stunted thickets to mature large trees. This should be done at a stage where the remaining isolated trees are large enough to survive trampling by the cattle. This would help to fulfil the management objective of maintaining the land in order to preserve the options for its use. The presence of trees will help prevent erosion and subsidence. In permitting the access of cattle to riverside land, however, provision should be made to exclude them from the water's edge where they could damage the peripheral vegetation and hence possibly cause erosion.

12. For general rehabilitation and beautification works, the species listed in Appendix 2 are recommended for planting. The list is broken down to give the suitable species for the different environments found along the rivers.

    Any plantings should use the species given in this list. They are indigenous to the rivers and will create a landscape which is unique to this part of Australia, and which visitors to Perth could find much more interesting than the present parkland landscapes.

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Appendix 1
PLANT SPECIES CURRENTLY USED IN VEGETATION REHABILITATION

Foreshore
Juncus kraussii
Casuarina obesa
Paspalum distichum (Upper estuary level)
Schoenoplectus validus

Beach Ridge
Carpobrotus edulis

Beach Ridge and Adjacent Areas
Casuarina obesa
Eucalyptus rudis
Eucalyptus camaldulensis
Eucalyptus sargentii
Eucalyptus platypus
Eucalyptus robusta
Eucalyptus nutans
Leptospermum grandiflora
Leptospermum scoparium
Leptospermum laevigatum
Melaleuca cuticularis
Melaleuca lanceolata

Appendix 2
PLANT SPECIES RECOMMENDED FOR VEGETATION REHABILITATION

Below Foreshore
Schoenoplectus validus (Upper-estuarine level only)

Foreshore*: Lower-Estuarine Level
(Downstream of Burswood Island and downstream of Riverton Bridge).

Juncus kraussii
Suaeda australis (seed)
Sarcocornia quinqueflora (seed)
Sporobolus virginicus
Casuarina obesa
Melaleuca cuticularis
Atriplex hypoleuca
Samolus repens

Foreshore: Mid-Estuarine Level
(Between Burswood Island and Bayswater, and between Riverton Bridge and the Weir)

As above and
Melaleuca rhaphiophylla
Melaleuca hamulosa
Baumea juncea
Paspalum distichum

Foreshore: Upper-Estuarine Level
(Between Bayswater and Guildford)

Eucalyptus rudis
Juncus kraussii
Casuarina obesa
Melaleuca rhaphiophylla
Melaleuca hamulosa
Paspalum distichum

Tidal Flats
Halosarcia halocnemoides (seed)
Halosarcia indicia subsp. *bidens* (seed)
Frankenia pauciflora
Angianthus micropodioides (seed)
Angianthus preissianus (seed)

OR

Sarcocornia quinqueflora (seed)
Suaeda australis (seed)
Samolus repens
Triglochin striata

Beach Ridge
Carpobrotus edulis
Casuarina obesa
Halosarcia indica subsp. *bidens*
Cynodon dactylon
Gahnia trifida
Baumea juncea

Adjacent Areas (Above beach ridge)
Eucalyptus rudis
Melaleuca preissiana
Eucalyptus calophylla
Astartea fascicularis
Acacia saligna (short term use only)

Riverine Foreshore.
(Fresh water environment)
Eucalyptus rudis
Melaleuca rhaphiophylla
Paspalum distichum
Juncus pallidus
Juncus pauciflorus

Swampy Areas
Inundated: *Baumea articulata*
Schoenoplectus validus
Seasonally inundated: *Melaleuca rhaphiophylla*
Alternanthera nodiflora
Hemarthria uncinata
Agonis linearifolia
Eucalyptus rudis
Lepidosperma longitudinate
Oxylobium linearifolium
Juncus planifolius

* Note: Foreshore also includes the area between tidal flats and higher ground.

Appendix 3

Latin Names, Vernacular Names and Short descriptions of Plant Species Commonly Found Along the Swan and Canning Rivers.

A

Acacia saligna — Wattle, small tree
Agonis linearifolia — Ti Tree, small tree
Alternanthera nodiflora — Joyweed, ground creeping herb
Angianthus micropodioides — Angianthus, ephemeral tiny herb (Asteraceae)
Angianthus preissianus — Angianthus, ephemeral tiny herb (Asteraceae)
Apium prostratum — Sea Celery, ephemeral herb
**Arctotheca calendula* — Cape Weed, ephemeral herb (Asteraceae)
**Arundo donax* — Giant Reed (known incorrectly as bamboo), large grass
**Asparagus asparagoides* — Asparagus, climber
Astartea fascicularis — large shrub
**Aster subulatus* — Bushy Starwort, perennial herb (Asteraceae)
**Atriplex hastata (previously A. patula)* — ephemeral small shrub
Atriplex hypoleuca — perennial shrub, small shrub
**Avena barbata* — Bearded Oat, ephemeral grass

B

Baumea articulata — Jointed Twig Rush, large rush
Baumea juncea — Twig Rush, rush
Briza maxima — Large Quaking Grass, ephemeral grass
Bulboschoenus caldwellii — Marsh Club Rush, small ephemeral sedge

C

Carex inversa — Knob Sedge, small sedge
**Carpobrotus edulis* — Pigface, small herb, ground creeping
Casuarina obesa — Saltwater She-oak, small tree (rarely medium tree)
Centella cordifolia — Indian Pennywort, herb
Chenopodium melanocarpum — herb
**Conyza bonariensis* — Tall Fleabane, ephemeral herb
**Cortaderia selloana* — Pampas Grass, tall hummock grass
Cotula coronopifolia — Water-buttons, small ephemeral herb
Cynodon dactylon — Couch, perennial grass, ground creeping
Cyperus alterniflorus — small sedge

E

**Ehrharta calycina* —Perennial Veldt Grass, perennial grass
**Ehrharta erecta* — Panic Veldt Grass, ephemeral grass
Eucalyptus calophylla — Marri, medium to large tree
Eucalyptus rudis — Flooded Gum, small to large tree
**Erodium cicutarium* — Common Crowfoot, tiny ephemeral herb
**Erythrina caffra* — Kaffir Coral tree, Coral tree (commonly and incorrectly known as Flame Tree), medium tree
Eutaxia virgata — small shrub

F

Ficus sp. — Fig, small tree
Frankenia pauciflora — Common Sea Heath, shrub

G

Gahnia trifida — Coast Saw Sedge, tall sedge
**Gomphocarpus fruticosus* — Narrowleaf Cotton Bush, herb

H

Hakea varia — Variable-leaved Hakea, large tall shrub
Halosarcia halocnemoides — Glasswort, shrub
Halosarcia indica — Shrubby Glasswort, shrub
Hemarthria uncinata — Mat Grass, perennial creeping grass
**Homeria collina* — One-leaved Cape Tulip, ephemeral herb
Hypocalymma angustifolium — small shrub
**Hypochoeris radiata* — Flatweed, ephemeral small herb

I

Isolepis marginata — tiny sedge
Isolepis nodosa — Knotted Club Rush, sedge

J

Jacksonia sternbergiana — large tall shrub
Jacksonia furcellata — large tall shrub
Juncus kraussii — Shore Rush, rush
Juncus pallidus — Giant Rush, large rush
Juncus pauciflorus — Loose-Flower Rush, rush
Juncus planifolius — Broad-leaf Rush, rush

L

**Lactuca serriola* — Prickly Lettuce, ephemeral herb (Asteraccae)
Lepidosperma longitudinale — Common Sword Sedge, sedge
**Lolium multiflorum* — Italian Rye Grass, ephemeral grass
**Lolium rigidum* — Wimmera Rye Grass, ephemeral grass
**Lotus uliginosus* — Bird's Foot Trefoil, tiny ephemeral herb

M

Melaleuca cuticularis — Salt-water Paper-bark, small tree
Melaleuca hamulosa — Paper-bark, small tree
Melaleuca lanceolata — Rottnest tea-tree, large shrub
Melaleuca leptoclada — shrub

Appendix 3 (continued)

Melaleuca preissiana — Moonah Paper-bark, small to large tree
Melaleuca rhaphiophylla — Swamp Paper-bark, small tree
Myoporum caprarioides — shrub

N

**Nasturtium officinale* — Watercress, small emergent herb

O

**Oxalis pes-capra* — Sour grass, sour sob, ephemeral herb
Oxylobium linearifolium — Narrow-leaved Oxylobium, small tree

P

Parapholis incurva — Curly Barb Grass, grass
Paspalum dilatatum — Paspalum, perennial grass
Paspalum distichum — Water Couch, perennial grass
Patersonia umbrosa — Shade Patersonia, perennial herb
**Pennistum clandestinum* — Kikuyu, perennial ground creeping grass
**Polypogon monspeliensis* — Annual Beard Grass, ephemeral grass
Polygonum minus — ephemeral grass
Pteridium aquilinum — Bracken Fern, fern

R

**Raphanus raphanistrum* — Wild Radish, ephemeral herb
**Ricinus communis* — Castor Oil Bush, small tree
**Rubus selmerii* — Bramble, thorny shrub
**Rumex crispus* — Dock, perennial herb

S

Samolus junceus — small herb
Samolus repens — small herb
Sarcocornia blackiana — Samphire, decumbent small shrub
Sarcoconia quinqueflora — Samphire, decumbent small shrub
**Shinus terebinthifolius* — Pepper Tree, small tree
Solanum nigrum — Black Nightshade, small shrub
**Sonchus asper* — Prickly Sow Thistle, ephemeral herb (Asteraceae)
**Sonchus oleraceus* — Sow Thistle, ephemeral herb (Asteraceae)
Sporobolus virginicus — Saltwater Couch, Sand Couch, perennial grass
**Stachys arvensis* — Stagger-weed, herb
Suaeda australis — Seablite, small shrub
**Stenotaphrum secundatum* — Buffalo grass, perennial grass, ground creeping

T

**Taraxacum officinale* — Dandelion, ephemeral herb (Asteraceae)
Triglochin mucronata — Prickly Arrowgrass, tiny ephemeral herb
Triglochin procera — Water Ribbons, herb
Triglochin striata — Streaker Arrow-grass, small herb
Typha domingensis — Cumbungi, Bulrush,, tall bulrush (>1m)
Typha domingensis — Cumbungi, Bulrush, tall bulrush (>1m)

V

U

**Ursinia anthemoides* — Ursinia, ephemeral herb (Asteraceae)

W

**Watsonia bulbilifera* — Watsonia, herb

Z

**Zantedeschia aethiopica* — Arum Lily, herb

*** Denotes exotic species**

Size	Scale
Small tree	<10 m
Medium tree	10-30 m
Large tree	>30 m
Small shrub	<0.25 m
Shrub (medium)	0.25-2 m
Large shrub	2 m
Herb	0.25-1 m
Small herb	0.1-0.25 m
Tiny herb	<0.1 m
Small sedge	<0.5 m
Sedge	0.5-1 m
Tall sedge	>1 m
Rush	<1 m
Large rush	>1 m
Grass	<1 m
Tall grass	>1 m

Appendix 4

Summary Table of the Composition of the Communities of the Peripheral Vegetation of the Swan and Canning Estuaries (Pen 1981).

This table summarises the composition of each community. Communities were produced by grouping similar quadrats using floristic criteria. The figures represent the presence of each species within each community, as shown below:

+ = found in 1-5% of the quadrats of the community
1 = found in 6-20% of the quadrats of the community
2 = found in 21-40% of the quadrats of the community
3 = found in 41-60% of the quadrats of the community
4 = found in 61-80% of the quadrats of the community
5 = found in 81-100% of the quadrats of the community.

SUMMARY TABLE OF THE COMPOSITION OF THE COMMUNITIES OF THE PERIPHERAL VEGETATION OF THE SWAN AND CANNING ESTUARIES (PEN 1981)

COMPLEXES		S				J		H				CM					MJ		EM			MS			SF
COMMUNITIES / SPECIES	SV	S1	S2	S3	S4	J1	J2	H1	H2	H3	SB	CM1	CM2	CM3	CM4	B	MJ	T	EM1	EM2	EM3	MS1	MS2	MS3	SF
Schoenoplectus validus	5																	2							
Sarcocornia blackiana		1	+					2			4		3												1
Frankenia pauciflora		1						+	5	1															
Triglochin mucronata					5			1		2															
Isolepis marginata			+		4					2		1							2						
Cotula coronopifolia			2	1	5			1	1	2		1					+		1						
Angianthus micropodioides										3															
Angianthus preissianus			+							5															
Halosarcia indica subsp. bidens		1	+		1			3	5	5															
Halosarcia halocnemoides		1	+		1			3	2	3	1														
Homeria collina		+								2		+			+				1						
Triglochin striata		3	1	1	1	+	+			1		+			2										
Polypogon monspeliensis		1	2	1	5		+	3	2	3	5	1	1	1			+	1	1		+				
Lolium multiflorum		1	1	1	2			1	2	2	1	2		1					3	2					1
Atriplex hypoleuca		1	+			1	1	1	1	+		+	1	1	1										1
Juncus kraussii		3	3	2		5	5	2	1	2		4	5	5	4		5	1	2		1	2	2		3
Atriplex hastata		1	2	2	4	1	2	1	2	2	1	4	3	1	3	2	2	1	1	3	1	1			2
Aster subulatus		1	+	2		2	2	1		1	1	3	2	1	3	2	1	2	1	3	1	1	+		1
Suaeda australis		4	4	4	5	3	2	2	4	3	2	1	4	1	2		1								1
Sarcocornia quinqueflora		5	5	2	5	2	1	4	4	5		+	4		1	2	1								2
Samolus repens		3	4	1	4	2	3	+		3		3		1	2	4	1								
Bulboschoenus caldwellii			5	5	3	2	+	1		1	3	3		3	5	2	+	3	1		1				
Myoporum caprarioides						+						2	1				+		+			+	+		
Apium prostratum			+	1		1	1			1		3	2		2	2	1		+						
Casuarina obesa		+	1	2			2			1		4	2		5		+				+	1			1
Melaleuca cuticularis			+			+	2			1		+	3	2			+								3
Melaleuca leptoclada							+															+			3
Melaleuca hamulosa			+			+	1					1	2		1		1				+	+			1
Melaleuca rhaphiophylla			1			+	2					5	1	4			5	2	5	5	4	5	5	3	2
Rumex crispus						+	1					3		2	2		1	3	3	3	3		2		+
Cynodon dactylon								+				1		1	1		+	1	4	4	1	3			
Baumea juncea			+	1		1				1		1	5			5	1	1	2	+		3	+		1
Juncus pallidus																			5						
Lotus uliginosus													+						2		1				
Paspalum distichum			+		+	+		+		+		+							4	3					
Alternanthera nodiflora												+					1	1		2	+		2		
Astartea fascicularis													1							1	+	2	2		1
Conyza bonariensis													1							2	+	2			+
Cyperus alterniflorus																		1		2					
Centella cordifolia						+						+					+		5	2	1	2	1		+
Chenopodium melanocarpum																				2					
Solanum nigram																		1		1	+	2	1		
Typha orientalis			+	1		1		1				1		5			1	5	4	1	2				
Eucalyptus rudis						+						+					+	1	4	5	5	2	5	5	
Paspalum dilatatum						+											+	1	3	4	5	3	3	3	
Acacia saligna							+						+				+			1		3	2		1
Agonis linearifolia																						1	5	1	
Hemarthria uncinata						+											+	1				+	3	3	
Lepidosperma longitudinale												+	1				+					4	4	5	
Melaleuca preissiana																				+		3	1	5	
Pteridium aquilinum																				+	1	+	3	3	
Zantedeschia aethiopica																	+			1	+	1	3		
Eucalyptus calophylla																								5	
Oxylobium linearifolium																						1	1	5	
Jacksonia sternbergiana																						+			2
Patersonia umbrosa																									2
Schoenus subfascicularis							+																		5
Ehrharta calycina																				2		+	+		3
Hakea varia																									1
Hypocalymna angustifolium																									1
Jacksonia furcellata																									+
Asparagus asparagoides																				+	+				
Baumea articulata																								2	
Briza maxima																				1		1			1
Carpobrotus edulis							1																		1
Carex inversa		1				+						1			+		1	2			+				
Eutaxia virgata												+													
Ehrharta erecta																					1				
Gahnia trifida						+	+			1			3			2	+					1			1
Lactuca serriola																				1					
Nasturtium officinale																							1		
Oxalis pes-caprae												+								1					
Polygonum minus																			1		1				
Parapholis incurva			+		+			+		3															
Sonchus asper																	+	1			+				
Isolepis nodosa						+	+										+						+		2
Sporobolus virginicus						+	1		1	1		+	4			2	1					+			2
Gomphocarpus fruticosus																				+	1				
Stenatoprum secundatum						1						+		1			+			1	+				
Triglochin procera				1							3						+				+				
Watsonia bulbilifera																				1	1				
Iridaceae sp												+									1				
Cortaderia selloana																	+	1		1					
Ursinia anthemoides																								2	
Samolus junceus										1															

SWAMP SHE-OAKS.
ON THE SWAN RIVER
AT REDCLIFFE

Fringing forest of *Casuarina obesa* and *Melaleuca rhaphiophylla* along the Canning River, at Riverton. The waterbirds are black ducks.