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THE VEGETATION AND FLORA OF WETLANDS NEAR BUSSELTON

by

A. & S.R. Tingay, Wildlife Ecologists, 13 Kensitt St., Stoneville

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1.0 INTRODUCTION

1.1 Objective of the study: The objective of this study was to map the vegetation of wetlands near Busselton, Western Australia at three scales; 1:2,000; 1:5,000; and 1:10,000. In practice this involved compiling basic data on to a series of 53 large scale maps prepared by Markey, Campbell and Thomson Pty. Ltd., and later transferring this information onto the smaller scale maps. A folio of these maps accompanies this report.

1.2 General description of the study area: The study area comprises a series of major and associated wetlands running parallel to the coast from the vicinity of the town of Vasse eastwards and then northwards to the vicinity of Forrest Beach and Ludlow. The major wetlands comprise consecutively Taylors Swamp, the Broadwater, New River, Vasse River, Vasse Estuary, the Deadwater, and the Wonnerup Estuary. Higher land adjacent to these wetlands is also included on the vegetation maps and thus in the study area.

Wetlands were specifically identified as those areas liable to regular (i.e., annual) inundation plus areas subject to periodic inundation (i.e., during years of relatively high rainfall). These areas were located from black-and-white aerial photographs taken during September, 1973 following the heaviest rainfall on record for the area (748 mm April to July, 1973), (WA 1479 Coastal Run: Moore River - Cape Naturaliste, Scale 1:15840). The areas of regular inundation are generally below the 1 metre contour and those of periodic inundation are generally below the 2.5 metre countour.

1.3 Methods: Basic data was collected in the field during March-April, 1980 by transects on foot and by vehicle together with interpretation of colour aerial photographs covering the entire study area (Aerial Surveys Pty. Ltd. Busselton Runs 1 to 14, Scale 1:6400, Dates 16.2.77, 28.7.78 and 31.8.78).

Plant specimens were collected intensively in wetland areas (i.e., below the 2.5 metre contour) but less intensively from vegetation associations on higher land. All specimens were identified by M.E. Trudgen, Consultant Botanist, of 266 York Street, Subiaco using reference material of the Western Australian Herbarium. These specimens are now held at

the Western Australian Wildlife Research Centre, Mullaloo Drive, Wanneroo.

Vegetation was mapped on the basis of structural criteria of the tallest stratum. The criteria adopted for this study consisted of life-form, height and density (Table 1). Life forms recognised were trees, shrubs and sedges. Trees were defined as perennial plants with signle woody stems usually unbranched for some distance above the ground, whereas shrubs were perennial plants usually divided into many separate stems close to the ground. Trees were divided into three height classes, under 10 metres, 10-30 metres, and over 30 metres. Shrubs, which included samphire, were divided into two height classes, less than 2 metres and over 2 metres. Sedges and rushes were not divided into height classes. Four density classes were recognised, under 10 percent, 10-30 percent, 30-70 percent, and 70-100 percent. Estimates of height and density were subjective and were based on ground observation and interpretation of aerial photographs.

Structural formations are indicated on the maps by colours and plant associations by symbols. This schema has been applied to vegetation surveys of Western Australia and for consistency the colours and symbols used by Smith (1973) have been adopted in the present map (as far as possible with available colour markers). Vegetation dominated by tall trees is shown with purple, by medium trees with brown, by small trees with red, by tall shrubs with yellow, by small shrubs with green, and by sedges (herbs) with grey.

2.0 THE FLORA AND VEGETATION

2.1 Previous studies: The present study area was a component of the vegetation map of Busselton and Augusta prepared by Smith (1973) at a scale of 1:250,000. At this small scale only broad detail can be shown. The dunes near the coast are shown as supporting open forest and low open forest of Peppermint *Agonis flexuosa* and low shrubland, while the wetlands are shown as cleared with remnant stands of *Melaleuca spp.* or Flooded Gum *Eucalyptus rudis* or with areas of closed scrub of Melaleucas and Peppermint (New River) and of open heath of Samphire species (Particularly the Vasse and Wonnerup Estuaries).

TABLE 1: Categories of vegetation associations

Life form	Height	Projective foliage cover of tallest stratum			
		Dense (70-100%)	Mid-dense (30-70%)	Sparse (10-30%)	Very sparse (less than 10%)
Trees	30m	Tall closed forest	Tall open forest	Tall Wood-land	Tall open wood-land
	10-30m	Closed forest	Open forest	Woodland	Open woodland
	10m	Low closed forest	Low open forest	Low wood-land	Low open wood-land
Shrubs	2m	Closed scrub	Open scrub	Tall shrub-land	Tall open shrubland
	2m	Closed heath	Open heath	Low shrub-land	Low open land
Herbs - Sedges and Rushes		Closed herb-land	Herbland	Open herb-land	-

2.2 Flora: A total of 106 species were collected during the present study. Some common species were identified in the field with no specimens being obtained. A list of species together with notes on distribution and status is provided on Table 2. With one exception, the flora consisted of common species typical of the Darling Botanical District (Beard, 1980). The exception was a *Leptomeria sp.* of which nothing is known and which may be an undescribed species. Common wetland species are illustrated in Appendix 1.

2.3 Vegetation:

2.3.1 Non-wetland vegetation: The study area consists of three basic units: (a) a series of low dunes running parallel to the coast of Geographe Bay; (b) an extensive low lying depression south of the dunes which includes the major Busselton wetlands; and (c) land which rises in height southwards of the depression. Units (a) and (c) were of subsidiary interest in this study as they are not subject to inundation and do not support wetland vegetation. However, segments of these units occur on many of the maps and their vegetation is shown.

The dunes support Peppermint *Agonis flexuosa* associations of various densities and heights. Both west and north of Busselton the dunes have been developed for agriculture and for housing estates and as a consequence only remnant Peppermints occur. However in places more extensive stands survive as low closed forest, low open forest and low woodland with occasional taller stands of closed and open forest. The understorey of these associations include introduced pasture plants and weeds and typical dune shrubs: *Acacia littorea, Acacia cyclopis, Adriana quadripartita, Hibbertia cuneiformis, Eremophila glabra, Lepidosperma gladiatum, Trachyandra divaricata, Spyridium globulosum, Diplolaena dampieri* and *Hardenbergia comptoniana.*

Depressions between the parallel dunes are occasionally low enough to collect water and to support wetland vegetation. Apart from the Wonnerup Inlet and the Deadwater which are described below in detail and which are actually penetrations through the dunes, these small wetlands occur west of Busselton. Generally they have been cleared and support only remnant Swamp Paperbarks *Melaleuca rhaphiophylla*, Flooded Gum *Eucalyptus rudis* and various rushes and sedges. However, a more complex

TABLE 2: List of plant species.

The species are arranged alphabetically and by family.

APIACEAE
**Centella cordifolia* (Hook.f.) Nann f.

ARACEAE
**Zantadeschia aethiopica* (L.) Spreng.
Arum Lily

ASTERACEAE
Actites megalocarpa (Hook.f.) N.Lander
Cotula coronopifolia L.
Water buttons
**Dittrichia graveolens* (L.) W.Greuter
**Leontodon taraxacoides* (Villars)Mérat
**Sonchus oleraceus* L.emend Govan.
Common sowthistle

CHENOPODIACEAE
**Chenopodium glaucum* L.
Pale goosefoot
Halosarcia pergranulata (Black) P.Gleuts
Halosarcia syncarpa P.G. Wils.
Rhagodia baccata Labill.
Seaberry saltbush
Sarcocornia blackiana (Ulbrich) A.J. Scott
Suaeda australis (R.Br.) Moq.
Seablite

CONVOLVULACEAE
**Calystegia sepium* (L.) R.Br.
Milk convolvulus
Wilsonia humilis R.Br.

CUCURBITACEAE
**Citrullus lanatus* (Thunb.) Mansf.
Wild watermelon

CUPRESSACEAE
Callitris preissii Miq.
Rottnest cypress pine

CYCADACEAE
Macrozamia reidlei (Gaud.) C.A. Gardn.
Zamia palm

CYPERACEAE
Baumea articulatum (R.Br.) S.T. Blake
Jointed twig rush
Baumea vaginalis (Benth.) S.T. Blake
Sheath twig rush
Carex divisa Huds.
Cyperus? alterniflorus R.Br.
Gahnia trifida Labill.
Coast saw sedge

Lepidosperma gladiatum Labill.
Coast sword sedge
Lepidosperma cf leptostachyum Benth.
Lepidosperma ? longitudinale Labill.
Lepidosperma sp.
Scirpus maritimus L.
Marsh club rush
**Scirpus prolifer* Rottb.
Budding club rush
Scirpus sp.

DILLENIACEAE
Hibbertia cuneiformis (Labill.) Gilg.
Cut-leaf hibbertia
Hibbertia racemosa (Endl.) Gilg.
Stalked guinea flower

EPACRIDACEAE
Leucopogon propinquus R.Br.

EUPHORBIACEAE
Adriana quadripartita (Labill.) Gaud.
Rare bitter bush

GOODENIACEAE
Dampiera alata Lindl.
Winged-stem dampiera
Dampiera linearis R.Br.
Narrow leaved dampiera

HAEMODORACEAE
Conostylis aculeata aculeata R.Br.
Haemodorum spicatum R.Br.

IRIDACEAE
Patersonia occidentalis R.Br.
Purple flag
**Romulea rosea var. australis* (Ewart) DeVos.
Guildford grass

JUNCACEAE
Juncus ? holoschoenus R.Br.
Joint leaf rush
Juncus krausii ssp. australiensis Hochst.
Sea rush
Juncus pallidus R.Br.
Giant rush

LAMIACEAE
**Menthapulegium* L.
Pennyroyal

LAURACEAE
Cassytha sp.
Dodder

TABLE 2: continued

LILIACEAE
Tracyandra divaricata (Jacq.) Kunth.

LOBELIACEAE
Lobelia alata Labill.
Angled lobelia

LYTHRACEAE
**Lythrum hyssopifolia* L.
Lesser Loose Strife

MIMOSACEAE
Acacia cyclopis A.Cunn. ex G.Don.
Acacia littorea Maslin
Acacia pulchella R.Br.
Prickly moses
Acacia saligna (Labill.) H.Wendl.
Orange wattle
Acacia stenoptera Benth.

MYOPORACEAE
Eremophila glabra (R.Br.) Ostf.
Tar bush

MYRTACEAE
Agonis flexuosa (Spreng.) Schau.
Peppermint
Eucalyptus calophylla R.Br.
Marri
Eucalyptus gomphocephala DC.
Tuart
Eucalyptus patens Benth.
Swan River blackbutt
Eucalyptus rudis Endl.
Flooded gum
Kunzea priessiana Schau.
Melaleuca cuticularis Labill.
Saltwater paperbark
Melaleuca hamulosa Turcz.
Melaleuca incana R.Br.
Grey honey-myrtle
Melaleuca lateritia Otto
Robin red-breast bush
Melaleuca rhaphiophylla Schau.
Swamp paperbark
Melaleuca uncinata R.Br.
Broom honey myrtle

ONAGRACEAE
Epilobium billardierianum billardierianum Ser.
Glabrous willow herb
Epilobium billardierianum cinereum (A.Rich) Raven & Engelholm
Glabrous willow herb
Epilobium hirtegerum A. Cunn.
Willow herb

TABLE 2: continued

ORCHIDACEAE
Prasophyllum sp.
Leek orchid

PAPILIONACEAE
Gompholobium ? capitatum A. Cunn.
Hardenbergia comptoniana (Andr.) Benth.
Native wistaria
Kennedia prostrata R.Br.
Running postman
**Medicago sp.*
Medick
**Melilotus indica* (L.) All.
Common melilot
**Trifolium fragiferum* L.
Strawberry clover
Viminaria juncea (Schrad.) Hoffman
Native broom

POACEAE
Agrostis avenacea Gmel.
**Avena ? fatua* L.
Wild oat
**Briza maxima* L.
Large quaking grass
**Hordeum glaucum* Stend.
Lagurus ovatus L.
Harestail grass
**Lolium perenne* L.
Perennial rye grass
**Paspalum dilatatum* Poiret
Paspalum
**Paspalum paspalodes* (Michx.) Scribn.
**Polypogon monspeliensis* (L.) Desf.
Beard grass
**Stenotaphrum secundatum* (Walt.) Kunze
Buffalo grass

POLYPODIACEAE
Pteridium esculentum (Forst.f.) Nakai
Bracken fern

POLYGONACEAE
**Rumex conglomeratus* Murray
Clustered dock

PROTEACEAE
Adenanthos meissneri Lehm.
Banksia grandis Willd.
Bull banksia
Banksia littoralis R.Br.
Swamp banksia
Conospermum petiolare R.Br.

TABLE 2: continued

Hakea prostrata R.Br.
Harsh hakea
Hakea varia R.Br.
Variable-leaved hakea
Persoonia longifolia R.Br.
Long-leaf persoonia

RESTIONACEAE
Leptocarpus ? canus Lindl. et Nees.
Hoary twine rush
Loxocarya fasciculata (R.Br.) Benth.

RHAMNACEAE
Spyridium globulosum (Labill.) Benth.

RUTACEAE
Diplolaena dampieri Desf.
Southern diplolaena

SALICACEAE
**Populus alba* L.
Silver poplar

SANTALACEAE
Leptomeria sp. (possibly nov.sp.)

SOLANACEAE
**Solanum nigrum* L.
Black nightshade

THYMELAEACEAE
Pimelea cf. suaveolens (Endl.) Meissn.
Scented banjine

TYPHACEAE
Typha orientalis Presl.
Bulrush

XANTHORRHOEACEAE
Xanthorrhoea priessii Endl.
Grass tree

remnant of this vegetation occurs on the upper section of Map 20.34 adjacent to the Bussell Highway. This supports Swamp Paperbark *Melaleuca rhaphiophylla* low open forest with an understorey of dense *Gahnia trifida*, and on slightly higher ground occasional Flooded Gums *Eucalyptus rudis* and Peppermint *Agonis flexuosa*, low open forest and low closed forest with an understorey principally of *Lepidosperma gladiatum*.

The rising land south of the low-lying depression supports Marri *Eucalyptus calophylla* open forest to the west and south of Busselton and Tuart *Eucalyptus gomphocephala* high woodland and high open woodland west of the Vasse and Wonnerup estuaries. The understorey of the Marri open forest consists of medium and low trees and shrubs including Bracken fern *Pteridium esculentum*, Zamia Palm *Macrozamia reidlei*, Bull Banksia *Banksia grandis*, *Persoonia longifolia*, *Acacia pulchella*, *Acacia cyclopis*, *Acacia saligna*, *Hibbertia cuneiformis*, *Hakea prostrata*, and *Xanthorrhoea priessii*. Much of the original Marri open forest has been cleared leaving remnant trees for shade and isolated understorey shrubs.

The Tuart high woodland occurs from just south of the Abba River, northwards to the vicinity of Ludlow. The understorey consists principally of dense Peppermints *Agonis flexuosa* growing to 5-10 metres and numerous but sparsely distributed low species. Much of this high woodland is leased for grazing stock and no doubt influence the abundance and distribution of the lowest stratum. The high woodland is immediately adjacent to the eastern edge of the Vasse and Wonnerup Estuaries, but it is confined to land above the 2.5 metre contour. Below this contour, and on the banks of the Abba River, it is replaced by Flooded Gum *Eucalyptus rudis* open forest and Swamp Paperbark *Melaleuca rhaphiophylla* low open forest.

Pasture grasses and weeds found on cleared land including wetlands and as intruders in many indigenous associations include: *Polypogon monspeliensis*, *Rumex conglomeratus*, *Trifolium fragiferum*, *Paspalum paspaloides*, *Zantadeschia aethiopica*, *Stenotaphrum secundatum*, *Lolium perenne*, *Hordeum glaucum*, *Citrullus lanatus*, *Sonchus oleraceus*, *Solenum sp.*, *Dittrichia graveolens*, *Leontodon taraxocoides*, *Solanum nigrum*, *Melilotus indica*, *Avena sp.*, *Briza maxima*, *Lagurus ovatus*, *Mentha pulegium*, *Medicago sp.*, and *Paspalum dilatatum*.

2.3.2 Wetland vegetation:

(i) Taylor's Swamp (Figure 1): This swamp is located on maps 20.33 and 20.32. It is bounded by the 1 metre contour and in general is lower than 0.5 metres. North of the actual swamp is an area of land below the 2.5 metre contour which supports Flooded Gum *Eucalyptus rudis* open forest and Swamp Paperbark *Melaleuca rhaphiophylla* low open woodland (regeneration). The former has an understorey of Swamp Paperbark, Peppermint *Agonis flexuosa*, Swamp Banksia *Banksia littoralis*, *Melaleuca incana* and *Gahnia trifida*. The low open woodland has a similar understorey but also includes *Hakea varia*.

The northern edge of the swamp above the 1 metre contour is fringed by Flooded Gum *Eucalyptus rudis* open woodland with an understorey which has been considerably disturbed by stock and fire and which is similar to the associations described in the previous paragraph. In addition, there are several rushes and shrubs: *Juncus krausii*, *Lepidosperma ?longitudinale*, *Haemodorum spicatum*, *Leptomeria sp.*, Robin Red-breast Bush *Melaleuca lateritia*, a Leek Orchid *Prasophyllum sp.*, *Patersonia occidentalis*, *Pimelea cf. suaveolens*, *Rhagodia baccata*, and *Kunzea priessiana*.

Below the 1 metre contour are *Melaleuca rhaphiophylla* low woodland and low open woodlands and on lower ground generally less than 0.5 metres, *Melaleuca hamulosa* low closed forest with an understorey of samphires *Halosarcia pergranulata* and *Sarcocornia blackiana*. The low closed forest is more extensive in the eastern portion of the swamp which is less disturbed and here the samphires occur as a mixed samphire open heath (Plate 1).

The southern edge of the swamp is fringed with *Melaleuca hamulosa* low closed forest and small areas of *Melaleuca incana* low closed forest below the 1 metre contour which mixes with *Melaleuca rhaphiophylla* on slightly higher land (Plate 2). There are also areas of *Melaleuca rhaphiophylla* low open forest which to the south-east of the swamp is mixed with *Melaleuca hamulosa* with an understorey of *Juncus kraussii*, *Lepidosperma ?longitudinale*, *Juncus pallidus*, *Leucopogon propinquus*, and *Leptocarpus ?canus*.

PLATE 1: Mixed *Sarcocornia blackiana* (green) and *Halosarcia pergranulata* (red) open heath with dead *Melaleuca hamulosa* in background, eastern part of Taylor's Swamp.

PLATE 2: Mixed *Melaleuca hamulosa* - *Melaleuca rhaphiophylla* low open forest southern margin of Taylor's Swamp.

On land between the 1.5 metre and 2.5 metre contour to the south-west of the swamp is a remnant of Flooded Gum *Eucalyptus rudis* open forest which exis now as solitary trees, and as Flooded Gum open woodland with pasture understorey.

(ii) Broadwater River: South of Taylor's Swamp in an area covered by maps 19.32 and 20.32 is a depression which eventually runs into the south-west corner of Broadwater Lake for which reason we named it Broadwater River. One branch of this depression runs southwards and terminates in a series of small swamps. This branch is well vegetated and supports Flooded Gum *Eucalyptus rudis* open forest and Swamp Paperbark *Melaleuca rhaphiophylla* low closed forest and low open forest.

Most of the vegetation of the main channel which runs to the Broadwater Lake has been cleared within the past few years and is now regenerating as a mixed Flooded Gum and Swamp Paperbark low open forest (Map 20.32). There are also areas of Flooded Gum closed forest with Peppermint *Agonis flexuosa* understorey, Flooded Gum open woodland and Swamp Paperbark low closed forest and low open woodland. The main channel narrows to a river as it runs northward (Map 20.33) past a well vegetated small swamp immediately north of the old railway line.

This swamp supports a mixed *Melaleuca hamulosa, Melaleuca incana, Melaleuca rhaphiophylla* low closed forest with the first species predominating and with a low sparse understorey of *Gahnia trifida, Leptocarpus canus, Scirpus sp.,* and *Sarcocornia blackiana.* The river banks support a narrow rim of Swamp Paperbark low open forest with occasional patches of *Melaleuca hamulosa,* emergent Flooded Gums and a sparse understorey of *Juncus krausii, Epilobium hirtigerum, Lepidosperma cf. leptostachyum,* and *Sarcocornia blackiana.*

(iii) Broadwater Lake (Figure 2): This is an extensive depression within the eastward flowing drainage area covering approximately 160 hectares (Maps 21.33 and 21.34). Most of this area is devoid of vegetation apart from aquatics when the lake contains water. However the margins particularly at the western end are fairly well vegetated.

The northern margin (Map 21.34) supports small areas of *Melaleuca rhaphiophylla* low open forest to about 10 metres in height and *Juncus krausii*

sedgeland both generally below the 1 metre contour, and on even lower ground a narrow rim of mixed *Sarcocornia blackiana, Suaeda australis* open heath with the latter species further out in the lake. The western margin supports a complex of associations with *Melaleuca hamulosa* low closed forest, *Melaleuca uncinata* low closed forest, mixed Melaleuca low closed forest comprising the two former species and occasional *Melaleuca cuticularis* all of which grow to about 3 metres in height and mixed *Sarcocornia blackiana, Halosarcia pergranulata* open heath (generally below 0.5 metres contour).

The south-west corner of the lake is densely vegetated with mixed Melaleuca low open forest *Melaleuca hamulosa, Melaleuca incana, Melaleuca cuticularis* and *Melaleuca rhaphiophylla* (Plate 3) growing to about 4 metres in height and with an understorey of *Juncus krausii, Lepidosperma cf. leptostachyum, Leptocarpus ?canus* and *Centella cordifolia* plus a low open forest of mature *Melaleuca rhaphiophylla* growing to 10 metres in height with *Melaleuca incana* and the former rushes as understorey (Plate 4). Penetrating these formations on low ridges above 1 metre are small stands of Flooded Gum *Eucalyptus rudis* open woodland with a medium understorey of *Agonis flexuosa, Banksia littoralis* and *Viminaria juncea.* Standing out in the lake in this area there are also two small areas of *Juncus krausii* sedgeland (Plate 5).

Much of the southern edge of the lake has been cleared and/or burnt and is now regenerating as a mixed *Eucalyptus rudis, Melaleuca rhaphiophylla, Melaleuca hamulosa, Viminaria juncea, Acacia saligna* low open woodland on ridges above the 1 metre contour, and *Melaleuca rhaphiophylla* low open woodland below this contour. There are also considerable areas of sedgeland particularly adjacent to the open water (Plate 6). *Lepidosperma cf. leptostachyum, Juncus krausii* and *Cyperus ?alterniflorus* are particularly common either as single species stands or mixed, and there are lesser areas of *Juncus pallidus, Baumea vaginalis, Gahnia trifida, Carex divisa, Lepidosperma ?longitudinale, Lepidosperma gladiatum, Scirpus prolifer* and *Typha orientalis.*

These sedges also form the understorey of the low open woodlands in this location but also present are *Centella cordifolia, Pimelea suaveolens, Melaleuca incana, Lobelia alata, Leptomeria sp., Haemodorum spicatum, Suaeda australis, Sarcocornia blackiana, Epilobium billardierianum,* plus

PLATE 3: Mixed *Melaleuca cuticularis, M. hamulosa, M. rhaphiophylla* low open forest with *Juncus krausii* understorey, south-west margin of Broadwater Lake.

PLATE 4: *Melaleuca rhaphiophylla* low open forest to 10 metres in height south-west margin of Broadwater Lake.

PLATE 5: *Juncus krausii* sedgeland in bed of Broadwater Lake with margin of *Melaleuca rhaphiophylla* low open forest in background. The small sedgeland is an important nesting area for Black Swans (*Cygnus atratus*).

PLATE 6: Sedgelands on southern margin of Broadwater Lake (view to west).

introduced species *Paspalum dilatatum, Lythrum hyssopifolium, Calystegia sepium* and various pastures species.

The sedgelands extend to the eastern fringe of the lake where also occur *Sarcocornia blackiana* open heath, *Melaleuca hamulosa* low closed forest and a small area of *Melaleuca cuticularis* low open forest.

(iv) Long Swamp: This long narrow swamp is located to the north-east of the Broadwater Lake. Most of the original rush vegetation has been cleared with only *Juncus krausii* open sedgeland remaining and a small clump of *Melaleuca rhaphiophylla* low open forest on the southern edge (Plate 7).

(v) New River: The New River is the section of the low lying depression between the Broadwater Lake and the Vasse River (Maps 22.34, 23.34, 23.35, 24.34, 24.35). It consists of a relatively narrow river channel with adjacent small swamps and flood plains. The vegetation is diverse and complex.

On the margin of the river and swamps it generally consists of *Melaleuca rhaphiophylla* low open forest, *Melaleuca hamulosa* low open and low closed forests, *Melaleuca cuticularis* low open and low closed forests and mixtures of these associations (Figure 3, Plates 8 and 9; Figure 4, Plate 10). *Juncus krausii* sedgelands and *Sarcocornia blackiana* open heath are also common.

East of this avenue and south of the river (Maps 23.34, 23.35, 24.34, 24.35) is a relatively undisturbed Flooded Gum woodland with a low understorey of *Acacia saligna, Hakea varia, Viminaria juncea, Gahnia trifida, Carex divisa* and *Lepidosperma cf. leptostachyum*. This open woodland is surrounded by a large area of mixed low woodland and low open woodland much of which is regeneration. The major plants of the upper stratum are those of the open woodland with occasional *Melaleuca hamulosa* and *Melaleuca priessiana*. The understorey is diverse and includes several species not found in wetlands elsewhere in the study area: *Xanthorrhoea priessii, Hibbertia racemosa, Kennedia prostrata, Acacia littorea, Acacia stenoptera, Conostylis aculeata, Dampiera alata, Dampiera linearis, Loxocarya fasciculata, Conospermum petiolare, Adenanthos meisneri,* and *Gompholobium capitatum*.

PLATE 7: General view of Long Swamp. Many of the smaller wetlands around Busselton such as this have been cleared of most of their original vegetation but nevertheless remain important to fauna. The small stand of *Melaleuca rhaphiophylla* low open forest in the centre background is a year round roost site for Pied Cormorants *(Phalacrocorax varius)* and a nest site during spring for Little Pied Cormorants *(Phalacrocorax melanoleucos)*, Black Swans *(Cygnus atratus)*, Pink-eared Duck *(Malacorhynchus membranaceus)* and Coot *(Fulica atra)*.

PLATE 8: Margins of western New River, *Melaleuca rhaphiophylla* low open forest backed by *Eucalyptus rudis*.

PLATE 9: *Melaleuca hamulosa - Melaleuca cuticularis* low closed forest western New River.

PLATE 10: *Juncus krausii* sedgeland backed by *Melaleuca cuticularis* low closed forest, eastern New River.

(vi) Butter Factory Swamp (Figure 5): The Vasse River enters the Vasse Estuary behind an old butter factory now converted into a museum. Although this area is really the southern end of the estuary, it is known locally as the Butter Factory swamp (Map 25.35). South of the swamp the banks of the Vasse River support developed parklands with planted trees and remnant *Eucalyptus rudis*, *Agonis flexuosa*, and *Melaleuca rhaphiophylla* and areas of *Eucalyptus rudis* open forest, woodland and low open woodland and mixed *Acacia saligna*, *Agonis flexuosa*, and *Melaleuca hamulosa* low closed forest. The understorey of these associations is sparse and consists of occasional *Viminaria juncea*, *Juncus krausii* and *Juncus pallidus*.

The edges of the swamp support *Melaleuca cuticularis* and *Melaleuca hamulosa* low closed and low open forests which are continuous on the southern bank. On land below 0.5 metre, *Juncus krausii* sedgeland occurs. South of the swamp to Causeway Road is an area of low lying grazing land which is dominated by *Halosarcia pergranulata* open heath and *Juncus krausii* sedgeland.

(vii) Vasse Estuary: East of the Butter Factory Swamp is an area of *Carex divisa* sedgeland and *Halosarcia pergranulata* open heath on either side of Ford Road with small areas of *Melaleuca hamulosa* low woodland and *Melaleuca cuticularis* low woodland (Map 25.35).

Beyond this the estuary rapidly widens (Maps 26.35 and 26.36, Figure 6). The lowest part of this depression (below the 0 metre contour) is bare. North of this the ground rises quickly to 0.5 metres and this narrow bank supports a long strip of *Sarcocornia blackiana* open heath backed by *Halosarcia pergranulata* open heath and *Carex divisa* sedgelands which in places are extensive and grow back to the 1 metre contour but elsewhere have been cleared and replaced by pasture grasses.

South of the bare ground the same pattern is repeated. Between 0 and 0.5 metres extensive *Sarcocornia blackiana* open heath occur with very large areas of *Halosarcia pergranulata* open heath and higher ridges supporting *Melaleuca cuticularis* low open forest, low woodland and *Melaleuca hamulosa* low open woodland. *Halosarcia pergranulata* grows on slightly higher land than *Sarcocornia blackiana* and is thus found further from the centre of the estuary. Toward the 1 metre contour *Melaleuca rhaphiophylla* occurs

either as low open forest or mixed with *Melaleuca cuticularis* and *Melaleuca hamulosa* in low open forest and low open woodland. *Melaleuca cuticularis* low woodland also occurs near the 1 metre contour in long narrow strips. Above the 1 metre contour are relatively small areas of *Juncus krausii* open sedgeland and above the 1.5 metre contour are occasional remnant stands of Flooded Gum *Eucalyptus rudis* woodland.

This pattern of vegetation continues northwards over the entire estuary giving a general impression of a broad open area fringed with extensive samphire associations and open sedgelands and with low Melaleuca associations as strips along the eastern rim. *Halosarcia pergranulata* open heath are particularly extensive west of the estuary (Figure 7, Maps 27.36, 27.37, 27.38, 28.37, 28.38) whereas *Sarcocornia blackiana* open heath are most extensive to the east (Maps 27.36, 28.36). The eastern shore vegetation appears complex near the mouth of the Sabina River with an intermingling of several associations. This is due to the river delta which has created low ridges in the estuary. On the slightly higher ground *Halosarcia pergranulata* open heath and *Melaleuca cuticularis* low open forests and low open woodlands grow with *Juncus krausii* sedgelands. On higher ground and along the banks of the Sabina River these associations are replaced by *Eucalyptus rudis* open forest with *Melaleuca rhaphiophylla* the dominant component of the understorey. In turn, these formations give way to Tuart *Eucalyptus gomphocephala* high open woodland above the 2.5 metre contour.

The vegetation also becomes more variable around the mouth of the Abba River at the northern end of the estuary (Figure 8, Maps 29.37, 29.38). Here samphire associations are uncommon except west of the Malbup creek where they are extensive. Instead there are *Juncus krausii* open sedgelands (Plate 11) backed by *Eucalyptus rudis* open forest (Plate 12) with an understorey of *Melaleuca rhaphiophylla, Agonis flexuosa* and pasture grasses together with small areas of *Melaleuca rhaphiophylla* low open forest. The *Eucalyptus rudis* open forest extends along the banks of the Abba River and there is a small area of *Typha orientalis* sedgeland about 200 metres upstream from the river mouth. These wetland associations are replaced above the 2.5 metre contour by Tuart *Eucalyptus gomphocephala* high woodland.

PLATE 11: Northern end of Vasse Estuary looking south. In the foreground *Juncus krausii* open sedgeland, backed by the open estuary. The wide flat appearance of the estuary is noticeable with margins of *Melaleuca rhaphiophylla* low open forest and *Eucalyptus rudis* open forest backed by Tuart *Eucalyptus gomphocephala* high woodlands to the east (left of photograph) and low lying land supporting *Halosarcia pergranulata* open heath to the west.

PLATE 12: Flooded Gum *Eucalyptus rudis* open forest with *Juncus krausii* understorey near the Abba River at the northern end of the Vasse Estuary.

(viii) Wonnerup Inlet (Figures 7 and 9): The Vasse Estuary runs to the sea through a relatively narrow channel called the Wonnerup Inlet (Maps 28.38, 28.39, 29.39, 29.40). The southern margin of the inlet supports a narrow belt of *Gahnia trifida* and *Juncus krausii* sedgelands backed by Peppermint *Agonis flexuosa* low open forest and low woodland. Toward the Layman Road bridge there are also fringing *Sarcocornia blackiana* closed heaths.

The northern margin similarly consists of a narrow edge of sedgeland and *Sarcocornia blackiana* closed heath backed by *Agonis flexuosa* low closed forest or low woodland and *Melaleuca hamulosa* low closed forest or, on the higher dune close to the coast, by a mixed closed heath in which shrubby *Agonis flexuosa, Acacia cyclopis, Diplolaena dampieri, Hibbertia cuneiformis* and *Lepidosperma gladiatum.*

The inlet also includes two small islands. The southernmost of these supports a small stand of *Melaleuca hamulosa* low closed forest, a patch of *Agonis flexuosa* low open forest on a small ridge above 1.5 metres and areas of *Juncus krausii* closed sedgeland, *Halosarcia pergranulata* closed heath and *Sarcocornia blackiana* closed heath. These two latter formations cover the northernmost island apart from a small area of *Melaleuca hamulosa* low open forest. The Wonnerup Inlet continues north of the Layman Road bridge to the beginning of the Wonnerup Estuary (Map 29.40). In this section the western margins support *Sarcocornia blackiana* closed heath below the 0.5 metre contour, *Juncus krausii* closed sedgeland between the 0.5 and 1 metre contour, and the mixed closed heath on the dune above the 1 metre contour. North of the outlet to the sea, the dune vegetation becomes a low open shrubland. The eastern margin of the inlet is bordered by a narrow strip of *Sarcocornia blackiana* open heath backed by high land on which grows a closed heath the species composition of which is the same as the dune heath on the opposite bank.

(ix) The Deadwater (Figures 10 and 11): This is a long narrow interdune wetland which runs north from the Wonnerup Inlet at the mouth of the Wonnerup Estuary (Maps 29.40, 29.01, 30.01, 30.02). The Deadwater ends in a cul-de-sac (Map 30.02) and appears to be a perennial wetland filled with inflowing sea-water or saline ground-water. On both sides it is bounded by steeply rising and relatively high dunes which on the sea-side

support a low open shrubland of typical dune plants and, on the estuary side, *Agonis flexuosa* low open forest with an understorey of the same dune plants particularly *Lepidosperma gladiatum, Hibbertia cuneiformis, Diplolaena dampieri* and *Acacia cyclopis*.

Below the dunes as a narrow margin are *Sarcocornia blackiana* closed heath and *Juncus krausii* closed sedgeland both of which become more extensive in the upper reaches of the Deadwater.

(x) Wonnerup Estuary: The vegetation of the Wonnerup Estuary is relatively simple and similar to that of the Vasse Estuary. There are small areas of bare ground (Maps 31.01, 3102) below the 0 metre contour which are surrounded by extensive *Sarcocornia blackiana* open heath and low shrubland and, particularly to the west and north of the estuary, by large areas of *Halosarcia pergranulata* open heath (Plate 13), and low shrubland (Maps 30.01, 30.02, 31.02, 31.03, 31.04, 32.04).

The eastern edge of the estuary also supports a continuous strip of *Sarcocornia blackiana* open heath and low shrubland backed by a belt of *Juncus krausii* sedgeland which in places is extensive (Map 31.02). On slightly higher ground beyond this are fringing belts of Melaleuca associations. At the southern end of the estuary *Melaleuca rhaphiophylla* low open forest is most common with occasional patches of *Melaleuca hamulosa* (Figure 12, Maps 30.39, 30.40).

At the northern end *Melaleuca rhaphiophylla* is confined to the margins of rivers and drains entering the estuary and *Melaleuca cuticularis* low open forest and low open woodland with *Juncus krausii* as understorey fringe the estuary (Maps 32.03, 32.04).

Beyond these associations are remnant Flooded Gums *Eucalyptus rudis*, sometimes as open woodland (Map 32.03) or as open forest with *Melaleuca rhaphiophylla* understorey, and above the 2.5 metre contour, Tuart *Eucalyptus gomphocephala* high open woodland both with pasture understorey and clumps of *Agonis flexuosa* and *Juncus krausii*. This Tuart association is in turn replaced by the Tuart high woodland and pine plantations of the Ludlow State Forest. Figure 13 shows a transect of the north end of this estuary.

PLATE 13: Extensive areas of *Halosarcia pergranulata* open heath occur at the northern end of both the Vasse and Wonnerup Estuaries. This photograph illustrates the general appearance of the Wonnerup Estuary from the north. Melaleuca associations backed by *Ecualyptus rudis* and *Eucalyptus gomphocephala* occur on the eastern margin whereas to the west is a low dune supporting *Agonis flexuosa* low open forest.

PLATE 14: Eastern margin of Wonnerup Estuary with *Sarcocornia pergranulata* open heath backed by *Juncus krausii* sedgeland and *Melaleuca rhaphiophylla* low open forest with Tuart *Eucalyptus gomphocephala* high woodland in the background.

2.3.3 Characteristics of the vegetation

(i) Wetland vegetation and contours: Consideration of the vegetation maps suggests that the species composition of wetland vegetation associations in the study area is correlated with topographic contours. Principal species can therefore be used as a guide to the height of land and to the likely extent and duration of inundation.

Characteristic wetland plants such as *Melaleuca spp.* and *Eucalyptus rudis* are all restricted to land lower than the 2.5 metre contour. *Eucalyptus rudis* and *Melaleuca rhaphiophylla* associations are largely restricted to land beteen the 1 and 2.5 metre contours although the latter may grow just below the 1 metre contour. *Melaleuca hamulosa* and *Melaleuca cuticularis* associations are generally found below the 1 metre contour becoming less common to about the 0.5 metre contour. *Melaleuca cuticularis* also appears to be restricted to soils where limestone is evident.

Sedges also tend to replace one another as the height of the land falls. Between 2.5 and 1 metres *Gahnia trifida* is most common either as sedgeland or as a component of the understorey of *Eucalyptus rudis* and *Melaleuca rhaphiophylla* associations. *Juncus pallidus* is also found between these contours but is less common than the former species. Just above and below the 1 metre contour *Juncus krausii* becomes predominant with *Lepidosperma leptostachyum* and *Carex divisa* also common.

The two principal samphire species are also separated by the height of the land and thus presumably by their ability to tolerate submersion. *Halosarcia pergranulata* generally grows between the 1 and 0.5 metre contours while *Sarcocornia blackiana* grows between the 0.5 and 0 metre contour. Below the 0 metre contour perennials are very sparse or absent.

(ii) Condition of vegetation: Wetland vegetation in the study area has been disturbed to varying degrees and is thus of variable condition (Plates 15 and 16). The western part of Taylor's Swamp has been cleared and/or burnt and heavily grazed as a result of which it supports scant vegetation. The eastern portion of this swamp was cultivated for potatoes in the 1920s, but apparently has been little used even for grazing in the past 10 years. This section supports healthy stands of *Melaleuca hamulosa* low closed forest and a large area of mixed samphire heath composed of *Halosarcia pergranulata* and *Sarcocornia blackiana*.

PLATE 15: Effect of stock grazing on *Juncus krausii* sedgeland and *Sarcocornia blackiana* open heath on the southern margin of Broadwater Lake. The mixed *Melaleuca rhaphiophylla-Banksia littoralis* association on the left of the fence has been cleared and burnt to the right but some regeneration is occurring.

PLATE 16: Stock and wind damage to *Melaleuca cuticularis* and *Melaleuca rhaphiophylla* along the margins of the western New River. Such damage is common in the wetlands on private land west of Busselton

The western part of the Broadwater Lake is in reasonable condition with a very fine stand of *Melaleuca rhaphiophylla* low open forest growing to 10 metres in height near the south-west corner and smaller stands of *Melaleuca hamulosa* low closed forest. However there is evidence of progressive damage to the *Melaleuca hamulosa* caused by trampling by stock and there are areas of old dead trees which older residents claim date from the early 1920s when the major drains were dug in the area.

The vegetation of the eastern part of this lake is in a degraded state although there are some fine remnant *Melaleuca rhaphiophylla* just north of the lake margins. Elsewhere on this margin, are dead *Melaleucas* and heavily grazed sedges *(Juncus krausii)*. The southern margin has been cleared and burnt and is now a complex of regenerating shrub and tree associations and sedgelands. Old accounts suggest that these sedgelands (probably *Lepidosperma leptostachyum* or even *Baumea articulatum)* extended across the Broadwater Lake and Long Swamp until the 1920s.

The fringes of the New River are in generally good condition particularly to the east of Queen Elizabeth Avenue (Plates 9 and 10) where there are fine stands of *Melaleuca cuticularis* low closed forest and *Juncus krausii* sedgeland. South of these is an extensive low lying area of mixed shrub low open woodland and *Eucalyptus rudis* open woodland, some of which has been disturbed and is regenerating. This is the only relatively undisturbed flood plain vegetation in the study area and contains many plant species which are uncommon or not found in the more disturbed areas elsewhere.

The samphire associations of the estuaries particularly the *Halosarcia pergranulata* open heath which grows on slightly higher ground have been cleared, grazed and ploughed in many places, but they are nevertheless extensive and vigorous particularly toward the northern end of both estuaries. The fringing Melaleuca associations and sedgelands on the eastern margins of the estuaries are also in generally good condition although much of the former have been cleared.

2.3.4 Vegetation as waterbird habitat: The Busselton wetlands are known for the diverse and large waterbird populations they support. These populations are all dependent on the wetland vegetation to some extent either for food, nest sites, or roost sites and shelter, but there is little published information on such uses in the study area.

A detailed analysis of the use of the wetland vegetation by fauna would require an annual survey to establish nesting and feeding habitats and this was not possible in the present study. However, some information is available from the author's previous experience in the area. Known fauna habitats are as follows:

(i) Taylor's Swamp: Occasional Black Swan *(Cygnus atratus)* nest among *Melaleuca hamulosa* low closed forest. Pied Stilts *(Himantopus himantopus)* occasionally nest in the mixed samphire heath in spring.

(ii) Broadwater Lake: Numerous Black Swan nests occur among *Melaleuca hamulosa* associations, occasional nests of this species are found under *Melaleuca rhaphiophylla* low open forest. Musk Duck *(Biziura lobata)* and White-faced Heron *(Ardea novae-hollandiae)* were also recorded as nesting in low *Melaleuca rhaphiophylla* trees, together with occasional Swamphen *(Porphyrio porphyrio)* nests among *Melaleuca hamulosa* low closed forest and a few nests of Shoveller *(Anas rhynchotis)* among clumps of *Juncus krausii* on the margins of the lake. Shovellers are also known to nest among hay in low lying paddocks north of the lake.

(iii) Long Swamp: The stand of *Melaleuca rhaphiophylla* on the southern margin of this swamp is used throughout the year as a roosting site for Pied Cormorants *(Phalacrocorax varius)* and during spring as a nesting site by many Little Pied Cormorants *(Phalacrocorax melanoleucos)* in the trees and occasional Coots *(Fulica atra)*, Pink-eared Ducks *(Malacorhynchus membranaceus)* and Black Swans *(Cygnus atratus)* beneath. Black Swans and Coots also nest among clumps of *Juncus krausii* in other parts of the swamp and a Little Grebe *(Tacybaptus novaehollandiae)* nest has been found among Dock *(Rumex conglomeratus)*.

(iv) New River: Old nests of Black Swans were located in New River vegetation during the present study. Small pools of water in the river bed during April were inhabited by Black Duck *(Anas superciliosa)*, Shoveller *(Anas rhynchotis)*, Mountain Duck *(Tadorna tadornoides)*, Pied Stilt *(Himantopus himantopus)*, and Black-fronted Dotterels *(Charadrius melanops)*.

(v) Butter Factory Swamp: This swamp has some water in it throughout most of each year probably as a result of the small barrage across the Vasse River just to the west. The shallow water makes it an important summer refuge for many species.

(vi) Vasse Estuary: There is a small colony of Black Swan nests at the northern end of this estuary which are used each year. The shallow nature of the estuary makes it an important feeding habitat for many species.

(vii) Wonnerup Estuary: There is a large nesting colony for Black Swans on the samphire heaths of the north-west and northern parts of this estuary. Details of a portion of this colony, which has been used annually for many years, are given in Tingay (1980). Pied Stilts *(Himantopus himantopus)* also nest on these heaths and White-fronted Chats *(Epthianura albifrons)* nest among the *Halsarcia pergranulata* shrubs.

3.0 REFERENCES

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Smith, F.G. (1973) Vegetation map of Busselton and Augusta. Western Australian Department of Agriculture, Perth.

Tingay, A. (1980) A study of the breeding biology and aggressive behaviour of Black Swans (*Cygnus atratus*, Latham) in south-western Australia. Ph.D. Thesis, University of Western Australia, (unpublished).

FIGURE 1 TAYLOR'S SWAMP (20.34–20.35 NW–SE)

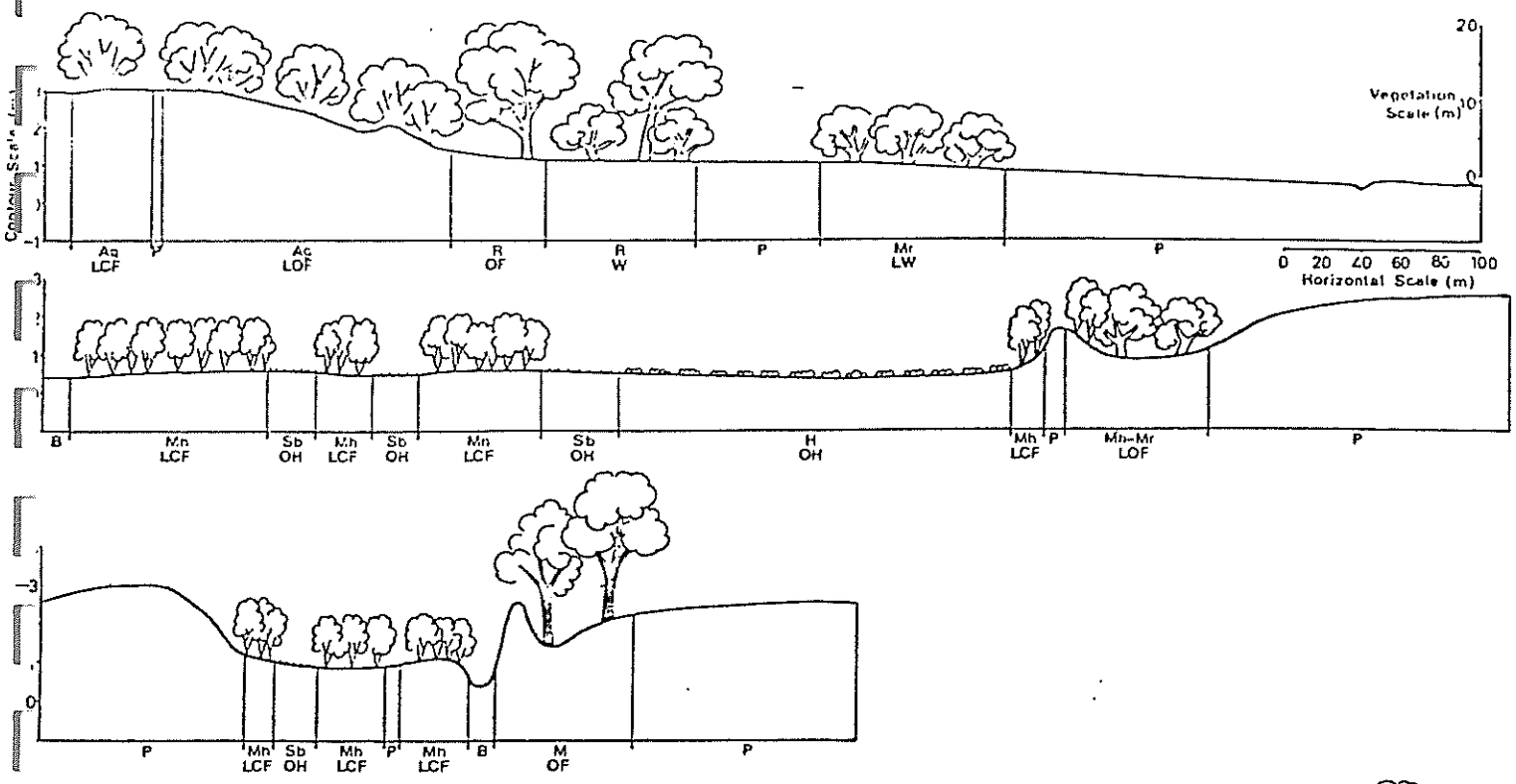

FIGURE 2 BROADWATER LAKE (21.33 NW–SE)

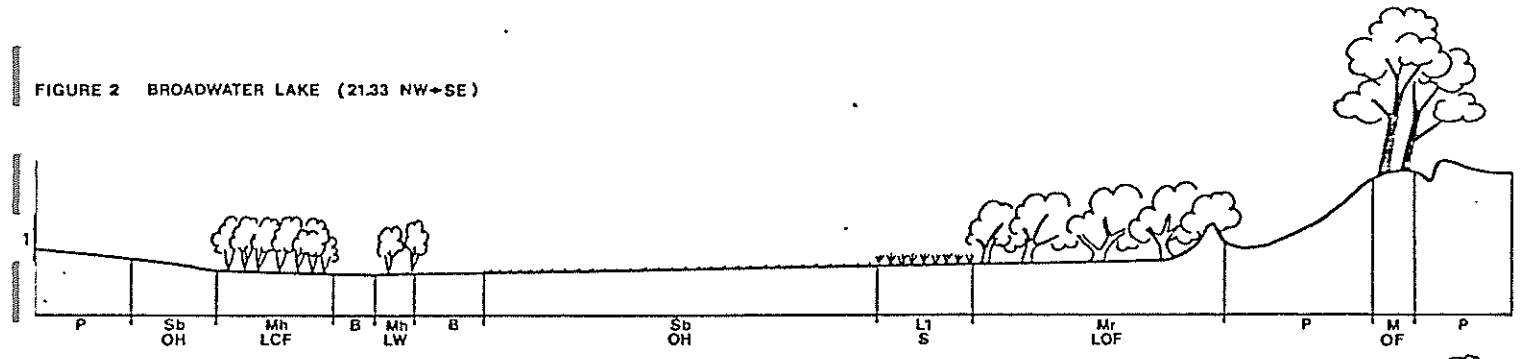

FIGURE 3 NEW RIVER – west (22.34 N–S)

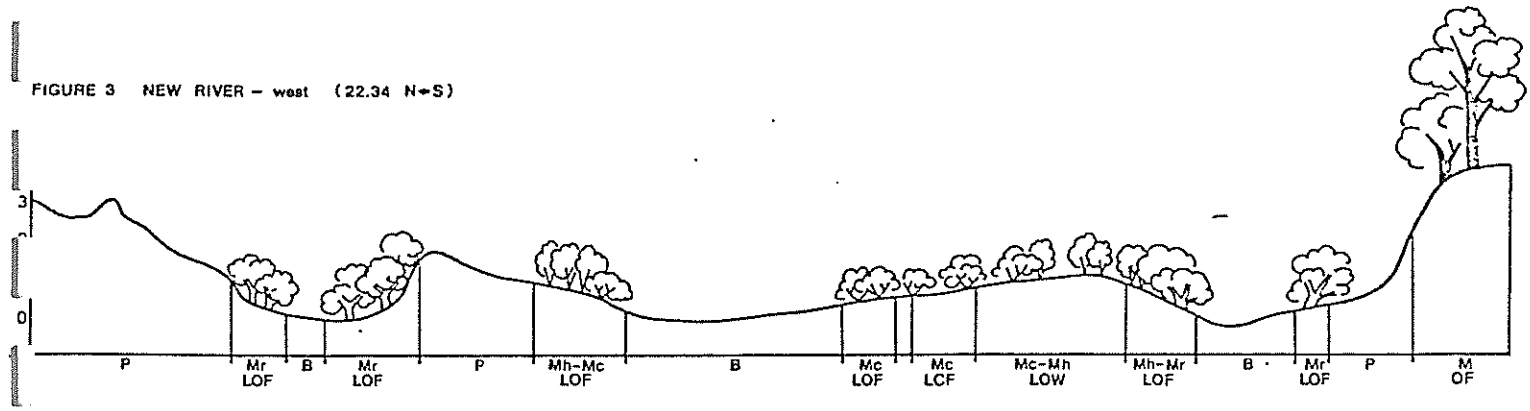

FIGURE 4 NEW RIVER – east (24.35–24.34 N–S)

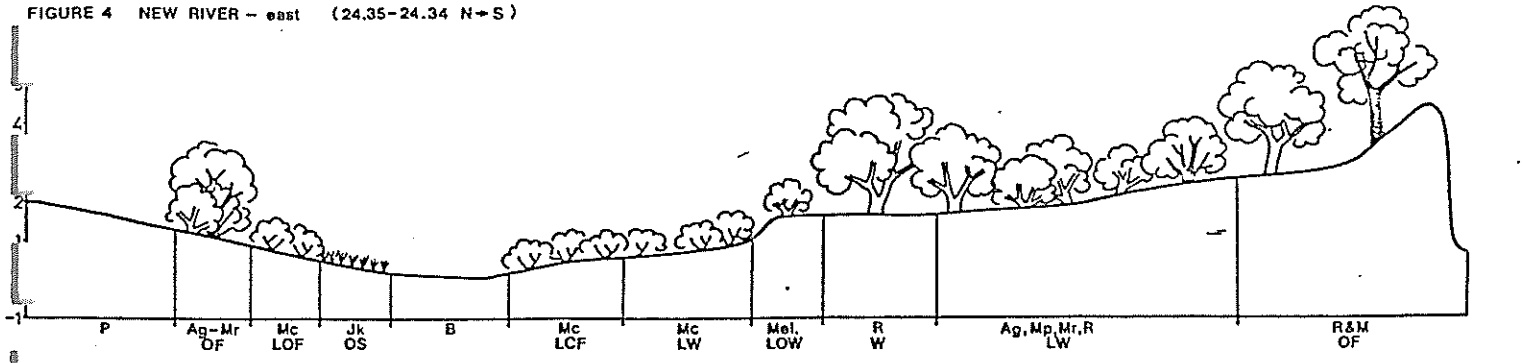

FIGURE 5 BUTTER FACTORY SWAMP (25.35 N–S)

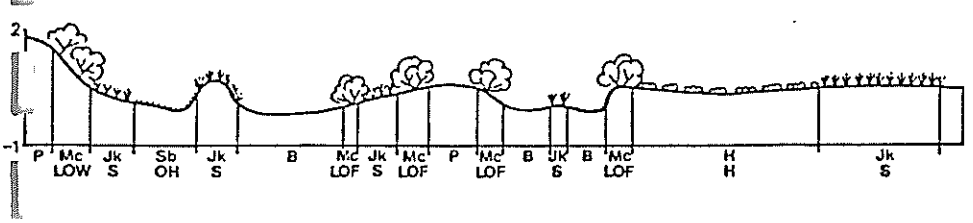

FIGURE 6 VASSE ESTUARY – south (28.30-28.35 N→S)

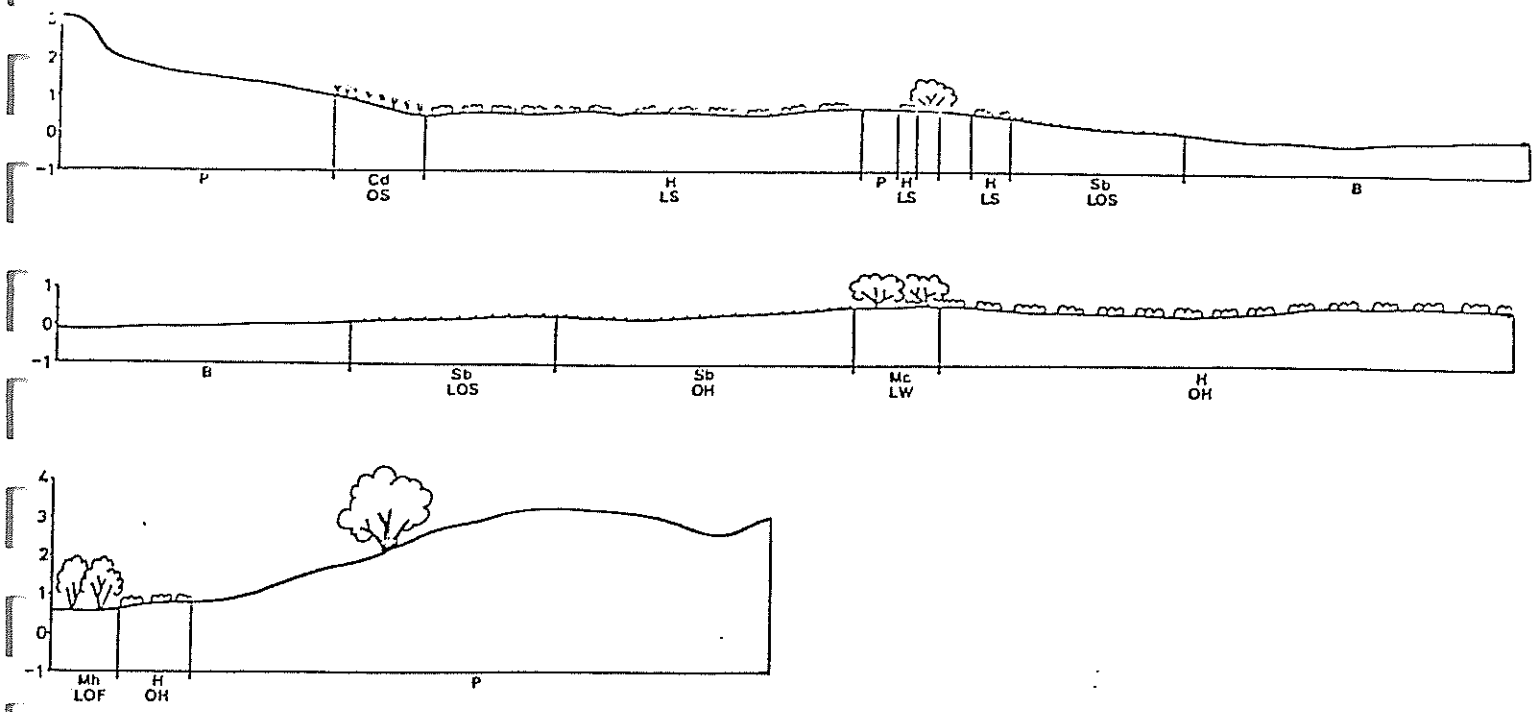

FIGURE 7 VASSE ESTUARY – north (28.38-28.37 N→S)

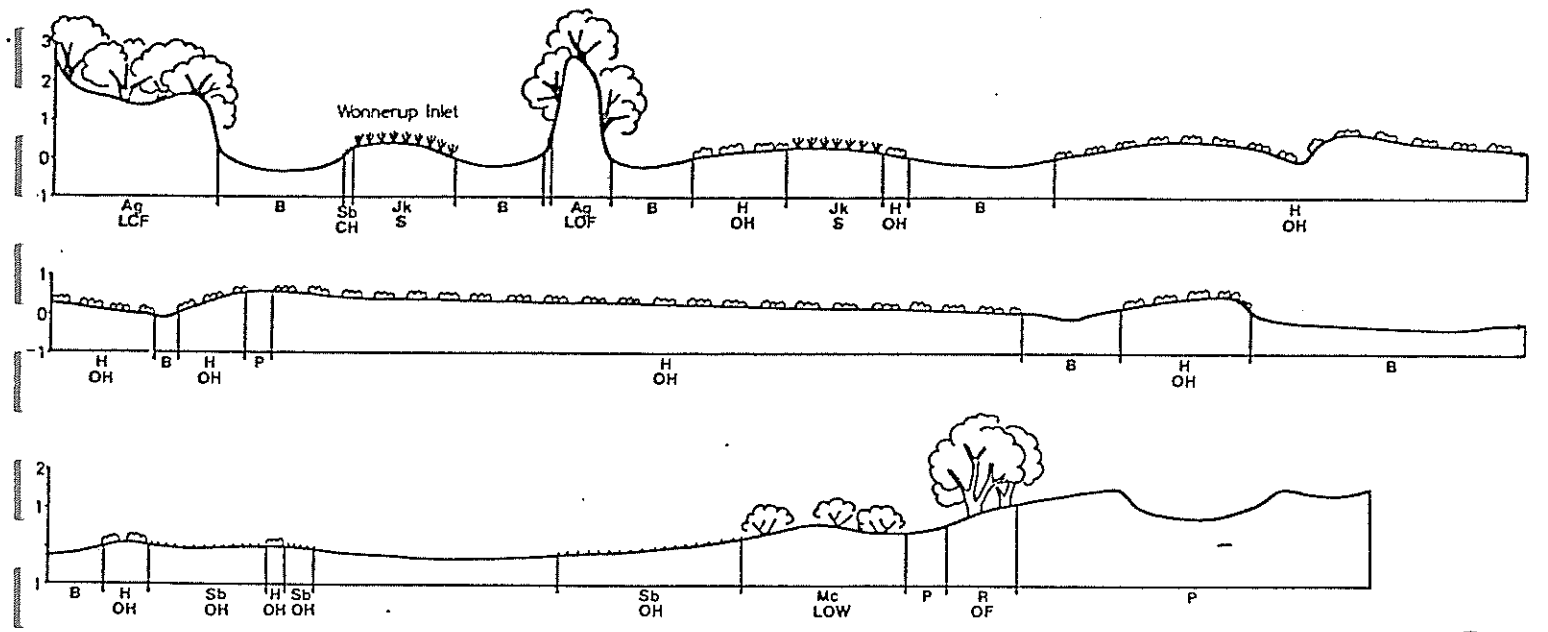

FIGURE 8 MALBUP CREEK (29.38 N→S)

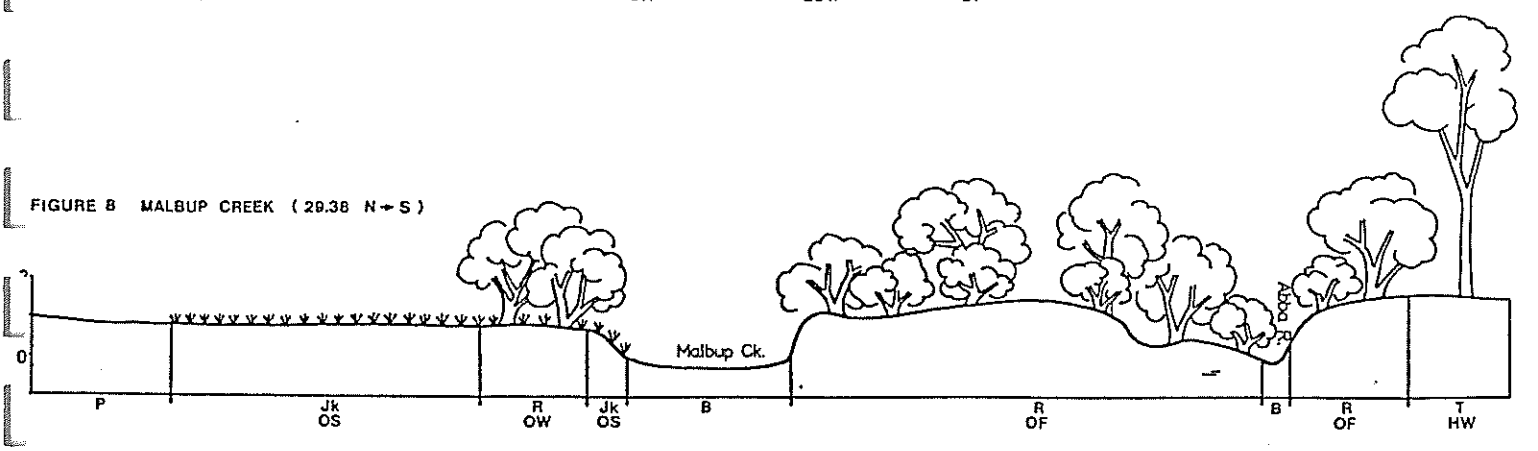

FIGURE 9 WONNERUP INLET – north (29.40 NW→SE)

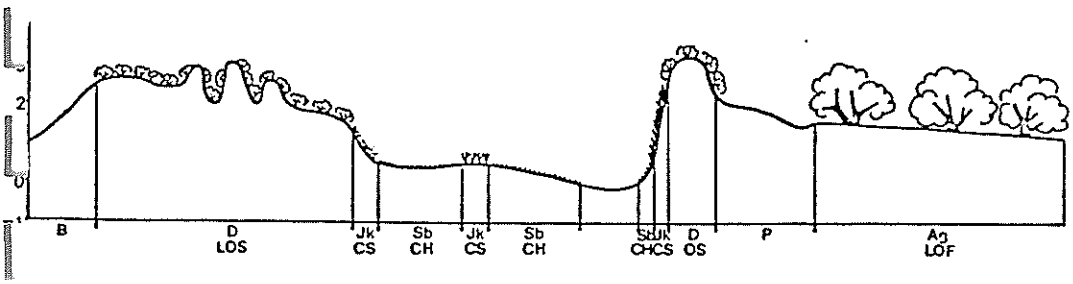

FIGURE 10 THE DEADWATER – south (29.40 NW → SE)

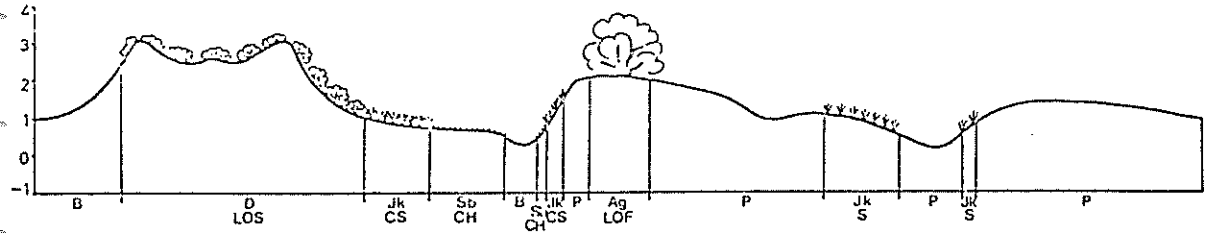

FIGURE 11 THE DEADWATER – north (30.01 W → E)

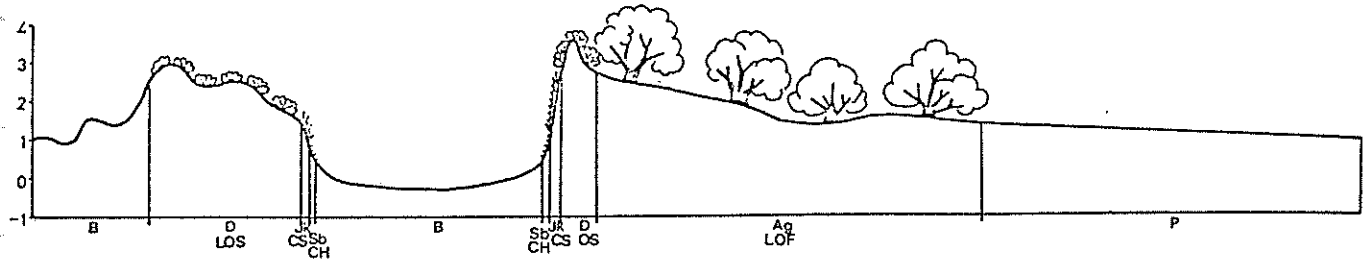

FIGURE 12 WONNERUP ESTUARY – south (30.40 NW → SE)

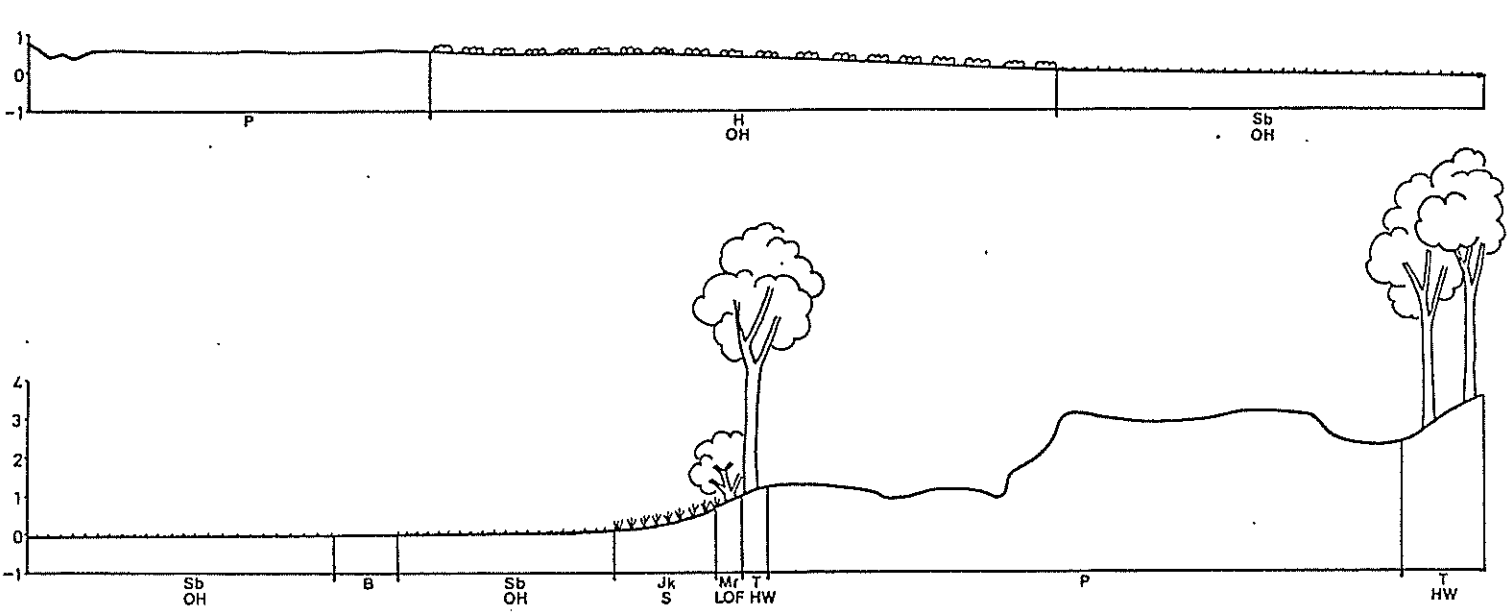

FIGURE 13 WONNERUP ESTUARY – north (31.03 W → E)