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The Vegetation at the Lake Connewarre State Game Reserve

J.Z. Yugovic

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SUMMARY

The vegetation at the Lake Connewarre State Game Reserve, Victoria, is described and mapped. The conservation significance of the vegetation is assessed and the implications for management are discussed.

The 3300 ha reserve contains an extensive wetland ecosystem showing a gradual progression from saline to freshwater conditions with distance from the sea. The reserve is characterised by large areas of diverse and unusual native vegetation interspersed with bodies of open-water. Much of the vegetation is in natural or relatively natural condition.

Over twenty floristic associations were identified within the reserve; these were grouped into 15 vegetation units for mapping purposes. A total of 137 native and 78 exotic vascular plants were recorded for the reserve, indicating a very high species-richness for wetland vegetation. Of these, 18 are considered to have conservation significance. Grey Glasswort (*Halosarcia halocnemoides*) and Tangled Lignum (*Muehlenbeckia cunninghamii*) reach their southern limit within the reserve.

The estuary of the Barwon River comprises the major part of the reserve and is one of Victoria's largest estuaries. It supports exceptionally diverse estuarine vegetation. Eighty-five per cent of the indigenous Victorian salt marsh flora is represented here. A number of plant associations, whilst extensive in the reserve, are rare elsewhere in Victoria. These include Australian Salt-grass (*Distichlis distichophylla*) grassland, which is well developed along the levees of the Barwon River, and an extensive, spectacular area of Silky Wilsonia (*Wilsonia humilis*) herbland at Salt Swamp. Both of these associations are of outstanding scientific interest.

Freshwater marsh vegetation is extensively developed in areas beyond tidal influence. Reedy Lake is the largest freshwater swamp in central Victoria (L.C.C. Melbourne Study Area) and is therefore of considerable conservation importance. It supports a particularly rich flora. Hospital Swamp is characterised by a mosaic of freshwater, subsaline and saline plant communities. It is undergoing rapid floristic change following artificial modifications to the hydrology of the swamp in 1983.

Land management practices having potential impacts on vegetation in the reserve include grazing by domestic stock, water engineering works, and recreational activities. Damage to vegetation and the ingress of weeds associated with grazing present serious problems in several parts of the reserve. Engineering works which alter the hydrology of particular areas can have dramatic effects on the vegetation. Recreational activities such as fishing, duck shooting and nature study have minimal impact on the vegetation at present.

The Lake Connewarre State Game Reserve is of major importance in the conservation of wetland ecosystems in Victoria. The reserve has considerable scientific and educational value as an example of hydrosere succession under various salinity and water regimes. Future management should recognise the conservation significance of the vegetation, and should accordingly be aimed at maintaining or improving its condition. Future proposed developments within the reserve should be carefully assessed for their potential impact on flora conservation values.

INTRODUCTION

The Lake Connewarre State Game Reserve, gazetted in 1961, is managed by the Department of Conservation, Forests and Lands. The 3300 ha reserve is of major importance in the conservation of wetland ecosystems in Victoria, and is the largest area of native vegetation remaining on the Bellarine Peninsula.

The reserve consists of a large freshwater swamp and an extensive estuarine lagoon and marsh system drained by the Barwon River and its subsidiary tidal creeks.

Parts of the reserve are intensively used for boating, fishing, hunting, nature study and other recreational activities. Grazing is permitted in some areas. The hydrology of part of the swamp system (Hospital Swamp) was modified in 1983 by the Geelong branch of the Victorian Field and Game Association in co-operation with the Fisheries and Wildlife Service to increase the area of freshwater wetland.

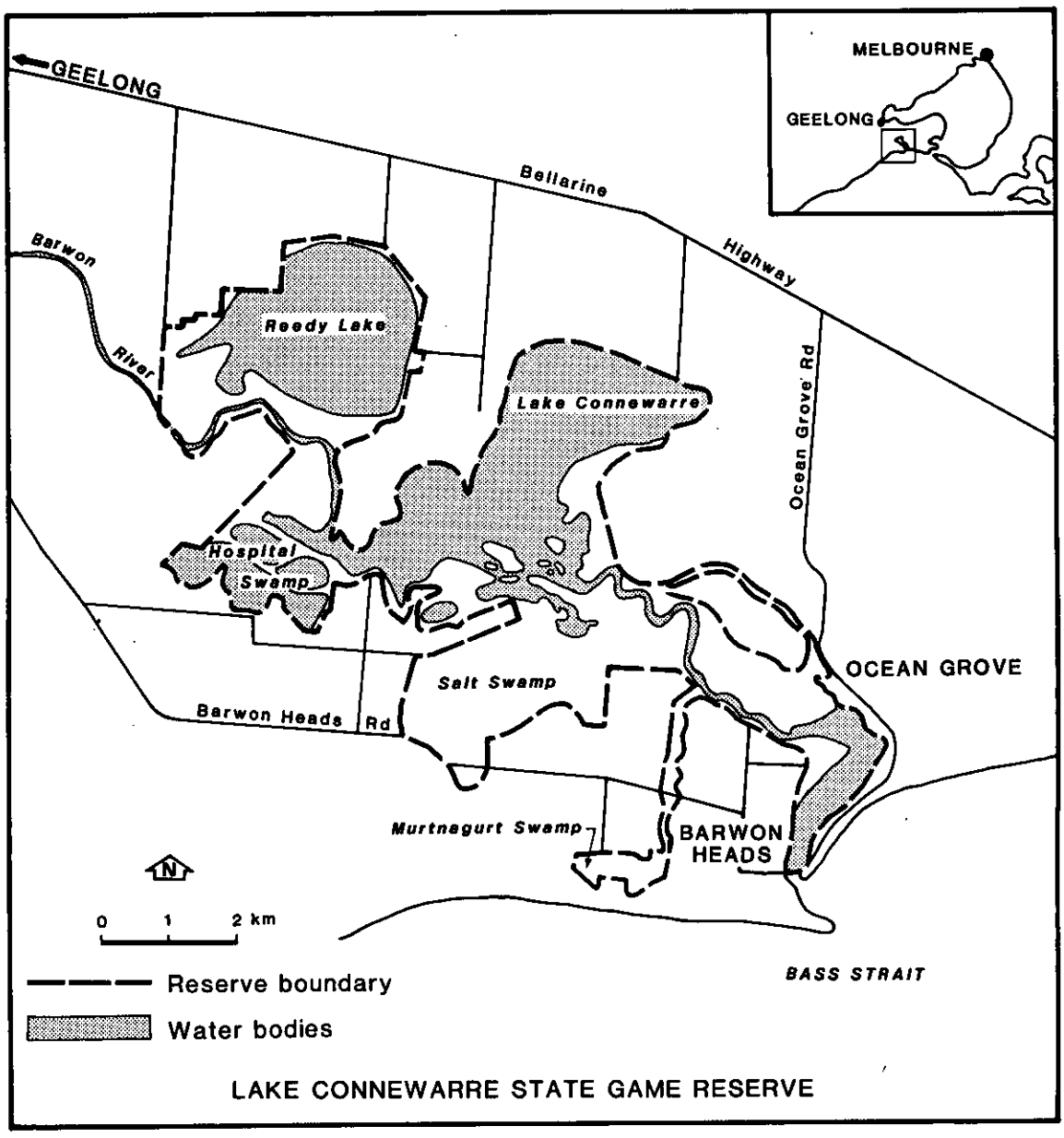
The reserve is situated in an agricultural area close to a major urban centre and will undoubtedly come under increasing pressures in future. Sensitive management is therefore required to ensure that it continues to sustain viable, representative examples of native plant and animal communities. As an aid to management, this study was undertaken to characterise and map the vegetation of the reserve, and to identify areas of importance in flora conservation.

THE STUDY AREA

Location

The Lake Connewarre State Game Reserve is situated on the Bellarine Peninsula, approximately 65 km south-west of Melbourne (Fig. 1). The reserve is within the Geelong region of the Department of Conservation, Forests and Lands.

Fig. 1. Location of the Lake Connewarre State Game Reserve



Climate

The Bellarine Peninsula has a temperate climate with warm dry summers and a winter rainfall maximum. The sea exerts a moderating influence on the climate, which is relatively dry for coastal Victoria due to the rainshadow effect of the Otway Ranges (40-120 km south-west of Lake Connewarre).

Available rainfall, temperature and surface wind data for stations close to the reserve are given in Fig. 2. These data can be extrapolated to give approximate conditions in the reserve. The mean annual rainfall for the reserve varies from about 630 mm at Barwon heads to about 580 mm at the northern end of Reedy Lake. At Pt Lonsdale (11 km west of Barwon Heads), the mean daily maximum and minimum temperatures in summer are 22°C and 14°C respectively, while the corresponding values in winter are 14°C and 7°C. The prevailing wind direction varies seasonally from north in winter to south-west in summer.

Geology and geomorphology

Reedy Lake and the Barwon estuary are part of the Moolap Lowland, a low, extremely flat area extending from Corio Bay through the Barwon estuary to Bass Strait (Gill & Collins 1983). The area is bounded by hilly terrain at Geelong to the west and by the Bellarine Plateau to the east. To the south is a ridge of basalt rising to over 15 m, derived from Mt Duneed (10 km to the west). The basalt has deflected the Barwon River eastwards to reach the sea through a narrow gap between the basalt and the Bellarine Plateau. Overlying the basalt along the coast is an area of dune calcarenite partly capped by unconsolidated sand dunes to 30 m high.

The Moolap Lowland was partly submerged by the sea c. 6000 years ago. Gill & Collins (1983) suggested that the sea reached c. 2 m above its present level. The reserve was at that time a large coastal embayment, as evidenced by the presence of fine shelly sand at depth in most soil profiles examined during the present survey. Following or during the marine regression to present sea level, the embayment was enclosed by the development of barrier dunes along the present coast. The enclosed basin has been largely infilled by silty clay (Recent alluvium) deposited by the Barwon River, leaving a large freshwater marsh (Reedy Lake), a large estuarine lagoon (Lake Connewarre), and extensive areas of saline marsh.

The Barwon River enters the reserve from the west and flows across the southern part of the Reedy Lake basin. Downstream the river channel deepens and narrows before flowing into the western arm of Lake Connewarre through a small fan delta. The main body of open-water forming Lake Connewarre occurs to the east of a basalt ridge (Tait Pt), and has a mean depth of 1 m (Rosengren 1973). The lake is bordered on the north and west sides by steep bluffs cut into the Bellarine Plateau.

West of Lake Connewarre is Hospital Swamp, which appears to have been part of the lake last century (Geol. Surv. Vic. map), and to have been subsequently isolated by a combination of deltaic growth of the Barwon at its entrance into the lake and siltation in the northern section of the swamp. South of Lake Connewarre is Salt Swamp, a former estuarine lagoon as evidenced by the presence of contraction ridges (see Salt Swamp sector description) but now almost completely infilled.

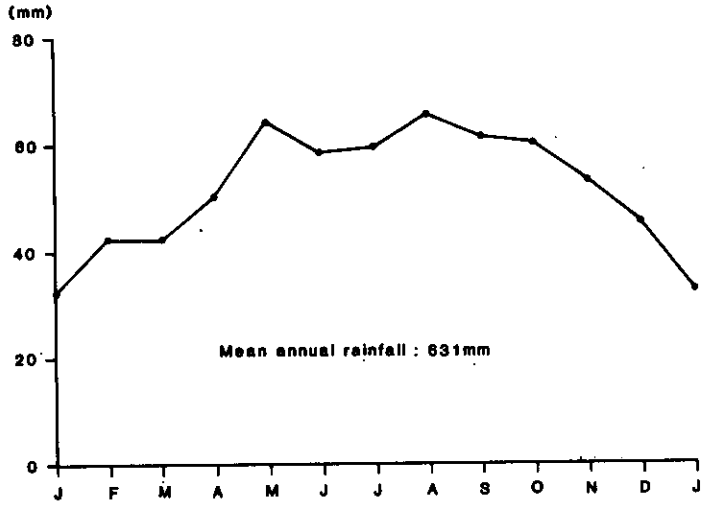


Fig. 2a. Mean monthly rainfall: Barwon Heads
(Source: Melbourne Bureau of Meteorology records)

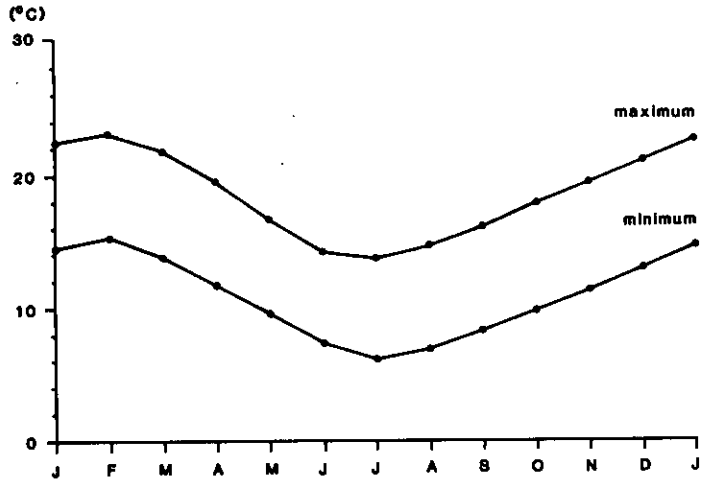


Fig. 2b. Mean daily maximum and minimum temperatures: Pt Lonsdale Lighthouse (Source: Melbourne Bureau of Meteorology records)

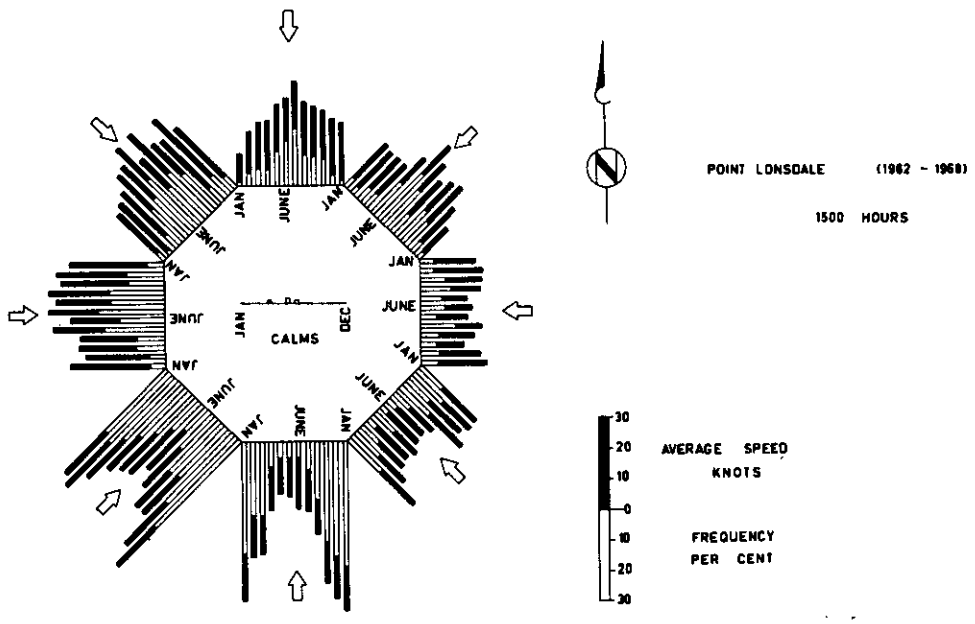


Fig. 2c. Wind rose: Pt Lonsdale Lighthouse
(Source: Environmental Study of Port Phillip Bay 1973)

At the outlet of the Barwon River from Lake Connewarre, a large tidal delta has formed on a basalt basement, part of the Mt Duneed flow. The delta is comprised of numerous islands of silty clay separated by shifting shoals of sand and silty clay. Downstream the river enters a long sinuous channel lined by low levees (the Lower Barwon). The course of the Lower Barwon has been determined largely by flood action, tidal action, and encroachment by vegetation. There is evidence that the river has changed course across the estuary, leaving abandoned channels (now tidal creeks) and levees. Near the sea the river opens into a wide bend of shoals and channels.

The processes determining the physical characteristics of the reserve are dynamic. Rosengren (1973) reported the marked extension of the tidal delta into Lake Connewarre between 1947 and 1970. There appears to have been a reduction in the depth of the lake during the present century, possibly due to land clearance in the catchment of the Barwon River and of the slopes bordering the lake (Rosengren op. cit.). To some extent these changes reflect human activities in the catchment area. However it is evident that natural geomorphic processes have been and still are major factors which produce, modify and eliminate areas of substrate suitable for the development of terrestial vegetation.

Hydrology

The reserve is situated in the lower reaches of the Barwon River system which comprises the Barwon, Moorabool and Leigh Rivers and associated tributaries. The system drains an area of approximately 4300 km^2, with headwaters in the Western Highlands to the north and the Otway Ranges to the south-west, and discharges into Bass Strait at Barwon Heads (Natural Resources and Environment Committee 1984).

The mean annual flow for the Barwon River at Geelong is 237 000 ML (Geelong and District Water Board, stream flow records). Reservoir construction in the headwater regions and water diversion schemes have reduced the discharge of water to the Barwon estuary, although this effect has been partly offset by increased runoff from the rest of the catchment, which is primarily cleared agricultural land. Major freshwater floods occur in the estuary between June and December of most years, while in summer flows are typically low (D. White, FWS, pers. comm.).

Lake Connewarre is subject to tidal influence, but tides transmitted along the Lower Barwon are much reduced in amplitude. Spring tides with a range of 2 m at Barwon Heads are reduced to 0.3 m in the lake. Wind action and inflow from the Barwon also influence tidal movement in the lake (Rosengren 1973).

The hydrology of Hospital Swamp was modified in 1983 by the installation of regulators and a water supply channel from the Barwon River. Prior to these works, the swamp would only hold water temporarily after heavy winter rain or when flooded by the Barwon River, due to drainage many years ago. The swamp now holds water for most of the year.

The southern part of Salt Swamp is characterised by prolonged inundation following major floods of the Barwon alternating with dry periods in summer and autumn. Tides evidently do not reach this area (D. White, FWS, pers. comm.). Murtnagurt Swamp no longer receives tidal or freshwater input due to the construction of a levee near the Barwon River.

Fresh conditions prevail in Reedy Lake although spring tides occasionally enter the lake via its outlet channel. The water level in the lake is kept artificially high throughout the year by use of regulators (D. White, FWS, pers. comm.). Prior to European settlement, tidal influence extended as far upstream as Geelong, however a barrage across the river between the inlet and outlet channels of Reedy Lake now prevents this.

Salinities in the estuary are determined by factors such as inflow and salinity of water from the Barwon, tidal inundation, atmospheric conditions, evapotranspiration, cyclic salt and water circulation. After prolonged periods of evaporation and low rainfall, Lake Connewarre is more saline than the sea (Rosengren 1973). This is particularly so in the northern arm of the lake during summer when the prevailing south-westerly winds reduce circulation. During floods the estuary is inundated with freshwater, however a salinity gradient from seawater at Barwon Heads to freshwater upstream of Lake Connewarre is eventually re-established.

METHODS

The field survey was undertaken from September to December 1983. Data were obtained by inspecting most areas of the reserve, and recording vegetation structure and floristics at 87 sites selected from aerial photographs. Sites were selected to ensure that the maximum diversity evident on the photos was sampled. At each site, a 10 x 10 m quadrat was positioned so that it was within visually uniform vegetation. All vascular plant species within the quadrat were listed and given a cover estimate using a modification of the cover abundance scale recommended by Bridgewater (1971). Cover refers to the percentage of ground directly below all aerial plant tissue, and is synomonous with the term 'foliage cover' of Walker & Tunstall (1981):

+	< 1% cover
1	1-5% cover
2	5-20% cover
3	20-50% cover
4	50-75% cover
5	75-100% cover

The vegetation structure at each site was described using the system of Specht (1981). The substrate was also examined and classified using Northcote's (1970) system.

As the field work was conducted during the period of maximum floral activity (spring and summer), it was possible to identify and include all observed species in the analysis. Taxonomic nomenclature follows Forbes et al. (1984).

The floristic data were analysed using the Zurich-Montpellier system of phytosociology (see Bridgewater 1971), in which a classification is obtained by examining the floristic composition of all quadrats displayed in a two-way table (Appendix 1). A two-way table is a plot of species (with their cover values) against the quadrats in which they occur. It is a concise tabulation of the quadrat data in which quadrats with similar floristic compositions and species with similar quadrat occurrences are grouped, thereby displaying floristic trends in the data. The table was derived by hand sorting coupled with the Land Protection Service computer program P2WAY, which enabled rapid rearrangement of the data.

For the purposes of this report an 'association' is defined as a group of quadrats with a similar floristic composition, and is identical to the 'nodum' of Poore (1955), the 'sub-community' of Gullan et al. (1979), and the 'association' of Bridgewater (1971; 1982). Due to the limited number of quadrats used in this study, some associations observed in the field and referred to in the map unit descriptions are under-represented on the two-way table. In these cases, the classification of Bridgewater (1982) and visual impressions of the vegetation were used to delineate associations.

Fifteen vegetation map units were chosen on the basis of the associations revealed by the floristic analysis. For mapping purposes, it was necessary to simplify the data by grouping related associations into single units (complexes). The two-way table presented in Appendix 1 is arranged so that the composition and inter-relationships of the vegetation map units are shown.

Mapping was performed using stereoscopic interpretation of 1:18 500 colour aerial photography in combination with ground truthing. The photography was flown for this project in May 1983 by the Arthur Rylah Institute.

A checklist of vascular species was compiled for the reserve, based on collections or observations made during the survey. The list, together with the estimated frequency of each species in each vegetation unit, is presented in Appendix 2. Voucher specimens are lodged at the Arthur Rylah Institute and at the National Herbarium of Victoria.

The conservation significance of the vegetation was then examined, and the impacts of various forms of development and land use were considered. Areas of particular importance for flora conservation are summarised in Appendix 3.

VEGETATION MAP UNIT DESCRIPTIONS

The following is a description of the vegetation map units. The unit names are based on structure and dominant species, but are descriptive terms only and are not intended to form a basis for a formal nomenclature. The method of Gullan et al. (1979) was used to calculate mean weed composition. Introduced species are indicated by an asterisk preceeding the species name. 'Q' refers to quadrat number. Disturbance susceptibility refers to the likelihood of a unit not returning to its original structural and floristic condition following physical disturbance to soils or vegetation.

A summary of the characteristics of each unit is given in Table 1.

Table 1. Summary of vegetation map units

Unit	Usual structure	Usual dominant	Av. cover	Av. spp./site	Av. weed compos. % spp.	Av. weed compos. % cover	Disturbance susceptibility	Area (ha)
1	herbland	*Wilsonia humilis*	4	2	0	0	moderate	65
2	shrubland	*Avicennia marina*	4	4	0	0	low	48
3	grassland	*Juncus kraussii*	4	6	0	0	low	164
4	herbland	*Sarcocornia quinqueflora*	3	7	18	negl.	mod. to high	374
5a	shrubland	*Sclerostegia arbuscula*	4	6	9	negl.	high	
b	"	*Halosarcia pergranulata*	3	9	19	3	"	128
c	"	*H. halocnemoides*	2	1	0	0	"	
6	sedgeland	*Gahnia filum*	5	9	15	1	mod.	297
7	grassland	*Poa poiformis*	4	9	52	5	high	1.5
8	grassland	*Distichlis distichophylla*	5	7	38	1	mod. to high	65
9	shrubland	*Muehlenbeckia cunninghamii*	2	13	13	4	high	45
10	sedgeland	*Eleocharis acuta*	4	8	26	negl.	low	60
11	sedgeland	*Schoenoplectus pungens*	5	14	16	negl.	low	50
12	grassland	*Phagmites australis*	4	11	15	negl.	low	254
13	scrub	*Melaleuca lanceolata*	4	22	52	43	high	1.3
14	grassland	variable	3	14	55	86	low	188
15	bare	variable	-	-	-	-	-	1560

Unit 1. *Wilsonia humilis* herbland

Major component species	% Freq.	Cover
Wilsonia humilis	100	4

Distribution : Restricted to Salt Swamp where extensive
Area : 65 ha (2% of total area)
Substrate : Grey silty clay (Ug1)
Structure : Herbland 15-20 cm
Mean floristic richness : 2 species per site
Mean weed composition : 0
No. of sites : 5

Unit characteristics

The extensive *Wilsonia humilis* herbland at Salt Swamp is one of the reserve's outstanding botanic features. The large expanse of this low, glaucous vegetation is spectacular, and is the largest occurrence of this previously unreported association in Victoria.

The floristics of the association are remarkable. It consists of the State's three *Wilsonia* species to the virtual exclusion of other terrestial plants. *W. humilis* is overwhelmingly dominant, forming extensive almost-pure stands. *W. backhousei* and *W. rotundifolia* are common in depressions at the southern end of the herbland (Q 11). *Wilsonia* species, particularly *W. humilis*, are generally uncommon in Victoria (A.C. Beauglehole pers. comm.).

The herbland occupies the centre of a broad shallow basin, the relict of a former tidal lagoon. The basin is not affected by tides, however a shallow brackish lake forms over the herbland for several months following major floods of the Barwon (2 km to the north). Flooding occurs in most but not all years, and generally takes place between June and December (D. White, FWS, pers. comm.). While the lake is present, the aquatic angiosperms, *Ruppia maritima* and *Lepilaena preissii*, and the alga, *Chara* sp., develop, reproduce and die off, creating a valuable food resource for waterfowl. In contrast, at most times the herbland is continually exposed, and deep cracks may form in the substrate. *W. humilis* is clearly well adapted to this extreme environment, reflecting very wide moisture tolerances.

An isolated stand of the unit, in the centre of a small basin 1.5 km north-east of the main occurrence, may have arisen through artificial changes in local hydrology as the site receives runoff from adjacent agricultural land via a drain.

Disturbance susceptibility

Moderate. Grazing is detrimental to *W. humilis* as evidenced by large bare patches that have developed in the north-east outlier.

Past shell-grit extraction has disturbed parts of the herbland. The disused quarries are still largely bare of terrestial vegetation (due to prolonged annual inundation), and the associated spoil deposits support *Sarcocornia* herbland (Unit 4) due to their slight elevation. Most quarries were established towards the periphery of the unit (where extraction could occur over longer periods) leaving the central area relatively undisturbed.

Unit 2. *Avicennia marina* shrubland

Major component species	% Freq.	Cover
Avicennia marina	100	4
Samolus repens	80	3
Sarcocornia quinqueflora	80	1
Juncus kraussii	60	3

Distribution	: Frequent in lower sections of estuary
Area	: 48 ha (1% of total area)
Substrate	: Grey silty clay (Ug1)
Structure	: Low to tall shrubland/open-scrub 1.4-2.5 m
Mean floristic richness	: 4 species per site
Mean weed composition	: 0
No. of sites	: 5

Unit characteristics

Avicennia marina var. *resinifera* (White Mangrove) occurs along the Lower Barwon and its subsidiary tidal creeks. Maximum development occurs at Barwon Heads with a broad belt up to 150 m wide. Mangrove stands occur up to 4 km inland in areas receiving regular tidal inundation. Isolated seedlings and stunted shrubs of *A. marina* (not mapped) occur as far inland as the tidal delta.

A. marina dominates a relatively simple community characterised by species tolerant of near-continual saline waterlogging. Two variants occur; these may form sharp, microtopographically determined boundaries. On the lowest sites, *A. marina* occurs in relatively tall (to 2.5 m) open-scrub formation (e.g. Q 4). The herbaceous stratum is sparse and limited to relatively well drained areas. There is much bare ground, often covered with thick mats of brown algae. On slightly higher sites, *A. marina* occurs in stunted (as low as 1.4 m) shrubland formation (e.g. Q 1). The herbaceous stratum is well developed and *Juncus kraussii* is typically abundant. Boundaries between this variant and *J. kraussii* rushland (Unit 3) are often diffuse.

A. marina is a primary coloniser of bare substrates, establishing at or just below mid tide level, and extending to about mean spring high tide level (Ashton 1971). It extends inland through salt marsh wherever tidal creeks are well developed. As an accumulator of fine sediment, *A. marina* is a major geomorphological agent in the shaping of intertidal topography (Bird 1971; 1980). Once the depositional level of the marsh has been built-up by accretion to a level suitable for salt marsh species, these invade and establish in the mangrove zone. The *J. kraussii* variant probably represents a seral stage in the succession to salt marsh.

A. marina has a salt-requiring metabolism (Clarke & Hannon 1970), but cannot tolerate hypersalinity and is consequently restricted to the zone of frequent tidal wash where the effects of evapotranspiration are minimised. Its extension upstream is limited by prolonged periods without seawater and by frost damage. Its seaward extension is limited by the removal of seedlings by strong currents and wave action.

Disturbance susceptibility

Low. The unit is free of weeds, and buffered by large areas of native vegetation and bodies of open-water. See note on *Spartina* spp. on p. 39.

Unit 3. *Juncus kraussii* rushland

Major component species	% Freq.	Cover
Juncus kraussii	100	4
Sarcocornia quinqueflora	100	2
Samolus repens	83	2
Distichlis distichophylla	67	3

Distribution : Extensive on salt marshes associated with the Lower Barwon; also occurs along the shores of Lake Connewarre and at Murtnagurt Swamp
Area : 164 ha (5% of total area)
Substrate : Grey silty clay (Ug1)
Structure : Open- to closed-grassland c. 1 m
Mean floristic richness : 6 species per site
Mean weed composition : 0
No. of sites : 6

Unit characteristics

Juncus kraussii is a cosmopolitan rhizomatous rush forming dense swards of rushland c. 1 m tall. It is the dominant species within a relatively simple association characterised by waterlogging-tolerant halophytes.

The unit occupies large areas of the estuary and also fringes the shores of Lake Connewarre and the unnamed lagoon immediately south. It is largely restricted to areas of moderate salinity which are regularly flooded by brackish tidal water. Boundaries between this and adjacent communities are frequently diffuse.

Disturbance susceptibility

Low. The unit is extensive, resilient to invasion by exotic species, and buffered by large areas of native vegetation or bodies of open-water.

Unit 4. Samphire herbland

This unit is a complex of several associations. The following data are intended to characterise the broad attributes of the unit rather than component associations.

Major component species	% Freq.	Cover
Sarcocornia quinqueflora	100	3
Triglochin striata	53	2
Samolus repens	47	1

Distribution : Frequent in low-lying areas throughout the reserve
Area : 374 ha (11% of total area)
Substrate : Grey silty clay (Ug1), fine sand (Uc1.2) for Q 5
Structure : Herbland to closed-herbland 1-15 cm
Mean floristic richness : 7 species per site
Mean weed composition : 18% of species, negligible cover
No. of sites : 15

Unit characteristics

Sarcocornia quinqueflora is a leafless succulent herb found in all salt marsh communities, but reaching its maximum development in this unit. The unit is a complex of several ecologically related associations grouped for mapping purposes. Most of these are of restricted distribution and cannot be readily distinguished on the available aerial photography. Further data are required to fully characterise each association. However the following observations were made.

Salinity and waterlogging are the main factors affecting the distribution of the unit. It is particularly abundant along drainage lines and on flats and depressions where sheets of water are left by high tides, but also occurs in saline non-tidal areas e.g. Hospital Swamp. A complex mosaic is often formed with units such as *Juncus* rushland (Unit 3) or *Distichlis* grassland (Unit 8), the latter associations occupying relatively elevated sites.

The most widespread and extensive association is characterised by *Sarcocornia* providing complete cover (e.g. Qs 17, 23). *Frankenia pauciflora* or *Cotula coronopifolia* are prolific wherever salinities are reduced, such as in the Reedy Lake and Hospital Swamp areas (e.g. Qs 32, 84). The uncommon *Triglochin striata* association is restricted to the estuary where it occupies localised depressions subject to frequent tidal immersion (Q 27). The *Suaeda australis* association was recorded once on a sandy strand line (chenier) at Barwon Heads (Q 5), and is related to the deposition of organic debris washed ashore.

Angianthus preissianus dominates a distinctive association of diminutive annuals and ephemerals restricted to the middle section of Murtnagurt Swamp (Q 41). This is the most species-rich salt marsh community in the reserve, and several component species are uncommon to rare in coastal salt marsh viz. *Triglochin minutissima, T. mucronata* and *Cotula vulgaris* var. *australasica*. Maximum diversity occurs on slightly elevated sites where salinities are reduced due to leaching by precipitation.

Disturbance susceptibility

Moderate to high. Areas where vegetation cover is removed by vehicles or domestic stock can remain bare for many years following their initial formation. Weeds are generally absent from tidal areas, however large areas at the rear of salt marshes are susceptible to invasion by exotic annual grasses initiated by grazing. An important management concern is the restricted *Angianthus* herbland, currently being invaded by the annual grass *Parapholis incurva*.

Unit 5. Samphire shrubland

This unit is a complex of 3 structurally similar associations grouped for mapping purposes. The total area occupied by the unit is 128 ha (6% of the reserve's total area).

5a *Sclerostegia arbuscula* shrubland

Major component species	% Freq.	Cover
Sclerostegia arbuscula	100	4
Frankenia pauciflora	100	3
Sarcocornia quinqueflora	100	2

Distribution : Frequent in wetter tidal areas
Substrate : Grey silty clay (Ug1)
Structure : Low shrubland c. 1 m
Mean floristic richness : 6 species per site
Mean weed composition : 9% of species, negligible cover
No. of sites : 3

5b *Halosarcia pergranulata* shrubland

Major component species	% Freq.	Cover
Halosarcia pergranulata	100	3
Cotula coronopifolia	100	2
Sarcocornia quinqueflora	100	2
Triglochin striata	100	+
Frankenia pauciflora	75	2
Samolus repens	75	+
**Polypogon monspeliensis*	75	1

Distribution : Widespread in elevated saline areas
Substrate : Grey silty clay (Ug1)
Structure : Low shrubland c. 50 cm
Mean floristic richness : 9 species per site
Mean weed composition : 19% of species, 3% of cover
No. of sites : 4

5c *Halosarcia halocnemoides* shrubland

Major component species	% Freq.	Cover
Halosarcia halocnemoides	100	2

Distribution : Rare and localised (Murtnagurt Swamp)
Substrate : Shallow peaty clay over calcarenite
Structure : Dwarf shrubland 10-15 cm
Mean floristic richness : 1 species per site
Mean weed composition : 0
No. of sites : 1

Unit characteristics

Samphire shrubland is widespread and frequent on saline sites of variable elevation. For mapping purposes, the unit is a complex of three associations, each adapted to a particular salinity and water regime.

In areas receiving regular tidal inundation, *Sclerostegia arbuscula* dominates a relatively simple association tolerant of waterlogging. Annuals are typically absent. *Halosarcia pergranulata* shrubland occurs in elevated areas flooded only by spring tides. Species-richness is enhanced by the presence of annuals such as *Apium annum* and *Isolepis marginata*. These can be seasonally prolific. The association reaches its maximum development at Salt Swamp where it frequently occupies broad, winding pathways taken by spring tides through *Gahnia* sedgeland (Unit 6). *Halosarcia halocnemoides* is restricted to Murtnagurt Swamp where it forms dwarf shrubland on sites characterised by prolonged periods of exposure and hypersalinity. The population of *H. halocnemoides* appears to have been considerably depleted by past shell-grit extraction.

H. halocnemoides reaches its southern limit at Murtnagurt Swamp and is therefore of biogeographic significance. The species fringes salt lakes and marshes throughout much of mainland Australia, but in coastal Victoria is limited to the Port Phillip region (Yugovic 1984).

Disturbance susceptibility

High. Samphires are vulnerable to damage by stock and vehicles as the shrubs are brittle and slow growing. In some sections of the reserve e.g. Salt Swamp, substantial areas of samphire shrubland have been damaged or destroyed by stock. Exotic grasses such as *Polypogon monspeliensis* and *Hordeum marinum* rapidly establish in such areas and become prominent components of the vegetation. Where the samphire has been completely destroyed, there is no evidence of recovery. The botanically significant *Halosarcia*-dominated associations require stringent protection from grazing and other forms of disturbance.

Unit 6. *Gahnia filum* sedgeland

Major component species	% Freq.	Cover
Gahnia filum	100	5
Suaeda australis	100	+
Sarcocornia quinqueflora	75	1
Distichlis distichophylla	75	3

Distribution : Widespread and often extensive at the rear of salt marshes; rare at Reedy Lake
Area : 297 ha (9% of total area)
Substrate : Grey silty clay (Ug1)
Structure : Open- to closed-sedgeland c. 150 cm
Mean floristic richness : 9 species per site
Mean weed composition : 15% of species, 1% of cover
No. of sites : 4

Unit characteristics

Gahnia filum sedgeland chiefly occurs on elevated, moderately saline sites that are rarely inundated by floods or tides, but which are seasonally saturated by the lateral seepage of saline groundwater. The unit appears to be the subclimax association in the succession from salt marsh to *Poa poiformis* grassland (Unit 7). Enclaves of *Poa* or *Stipa stipoides* occasionally occur on slightly elevated sites within *Gahnia* stands.

On favourable sites, *Gahnia* forms dense, robust tussocks about 1.5 m in height; these are separated at the base but intermesh at the top. Between the tussocks is a dense herbaceous stratum. On less favourable sites and/or in disturbed areas, the tussocks are well spaced and do not overlap. In these situations, the shrub *Halosarcia pergranulata* may be frequent. Exotic species (mainly annuals) are common throughout the association but are not prominent except in severely disturbed areas.

Gahnia sedgeland is the only salt marsh unit affected by fire. A fire at Salt Swamp in April 1984 was observed to completely burn several hectares and to spread at the rate of 1 m/min. *Gahnia* regenerates readily from rootstocks after fire.

Disturbance susceptibility

Moderate. Grazing of fire regrowth may have led to the replacement of this association by exotic vegetation (Unit 14) in some areas.

Unit 7. *Poa poiformis* grassland

Major component species	% Freq.	Cover
Poa poiformis	100	4
**Sonchus oleraceus*	100	1
Distichlis distichophylla	75	3
Disphyma clavellatum	75	+
**Medicago polymorpha*	75	+

Distribution : Rare and localised; mainly at or near the reserve boundary in the Salt Swamp area; also on an isolated chenier near the Lower Barwon (Q 26) and at Murtnagurt Swamp

Area : 1.5 ha (<1% of total area)

Substrate : Grey silty clay (Ug1)

Structure : Closed (tussock) grassland c. 1 m

Mean floristic richness : 9 species per site

Mean weed composition : 52% of species, 5% of cover

No. of sites : 4

Unit characteristics

Poa poiformis forms closed tussock grassland with dense, regularly spaced tussocks up to 1 m high. These are separated at the base, but intermesh at the top. Between the tussocks, herbs such as *Distichlis distichophylla*, *Disphyma clavellatum* and *Sonchus oleraceus* provide complete cover. Exotic herbs (mainly annuals) are common throughout the association.

Poa grassland appears to be the climax formation for subsaline silty clays beyond the influence of floods or tides (cf. Unit 9). Sea levels were c. 2 m higher 6000 years ago (Gill & Collins 1983), and sites now supporting *P. poiformis* would therefore have been below mid tide level and bare of terrestial vegetation. This interpretation is supported by the occurrence of shells at 60 cm in the soil profile of Q 10. During the subsequent marine regression there was a succession of halophytic associations on these sites, leading to *Poa* grassland.

Disturbance susceptibility

High. The original distribution and abundance of *Poa* grassland has been modified by grazing and competition with exotic herbs from adjacent pastures. The community appears to have been eliminated from the majority of sites that once supported it. These areas are now vegetated by an almost completely alien flora (Unit 14).

Unit 8. *Distichlis distichophylla* grassland

Major component species	% Freq.	Cover
Distichlis distichophylla	100	5
Sarcocornia quinqueflora	63	1
Phragmites australis	50	3
Juncus kraussii	50	+
**Rumex crispus*	50	+
Triglochin striata	38	+
**Sonchus oleraceus*	38	+
Muehlenbeckia cunninghamii	25	5
Atriplex paludosa	25	4

Distribution : Widespread; major occurrences in tidal delta area
Area : 65 ha (2% of total area)
Substrate : Grey silty clay (Ug1)
Structure : Closed-grassland/tall shrubland/open- to closed-scrub c. 2 m
Mean floristic richness : 7 species per site
Mean weed composition : 38% of species, 1% of cover
No. of sites : 8

Unit characteristics

This is a variable unit which may warrant division into separate associations. The unit is characterised by an abundance of *Distichlis distichophylla*, a rhizomatous grass forming dense hummocky swards up to 1 m high. On relatively elevated sites, *Muehlenbeckia cunninghamii* occurs in shrubland or scrub formation (Qs 35, 77).

The unit mainly occurs in flood-prone, subsaline sites in the tidal delta and Lower Barwon areas. Only the lowest sites are affected by tides. The unit is well developed on low (c. 40 cm high) levees lining the Lower Barwon and its associated tidal creeks (Qs 30, 31). *Atriplex paludosa* is prominent on the levees, but does not occur elsewhere in the unit. Isolated stands of *Phragmites australis* occur in zones of reduced salinity, such as along the banks of the Lower Barwon.

Disturbance susceptibility

Moderate to high. Weeds are of minor importance in wetter areas, but are prominent on relatively elevated sites subject to sustained and/or heavy disturbance e.g. grazing. The botanically significant occurrences in the tidal delta area are well buffered by large areas of native vegetation and bodies of open-water.

Unit 9. *Muehlenbeckia cunninghamii* shrubland

This unit is a complex of several associations. The following data are intended to characterise the broad attributes of the unit rather than component associations.

Major component species	% Freq.	Cover
Muehlenbeckia cunninghamii	100	2
**Rumex crispus*	100	+
**Polypogon monspeliensis*	100	+
Senecio lautus	75	+
Urtica urens	75	+
**Rumex conglomeratus*	75	+
Poa labillardieri	50	5

Distribution	: Restricted to area south of Reedy Lake
Area	: 45 ha (1% of total area)
Substrate	: Grey silty clay (Ug1)
Structure	: Tall shrubland/open- to closed-scrub c. 2 m
Mean floristic richness	: 13 species per site
Mean weed composition	: 13% of species, 4% of cover
No. of sites	: 4

Unit characteristics

This is a floristically variable unit based on the presence of *Muehlenbeckia cunninghamii*, but excluding saline areas in which *M. cunninghamii* occurs over *Distichlis distichophylla*-dominated understories (Unit 8). *M. cunninghamii* is a globular-shaped shrub about 2 m in height with dense, entangled branchlets. Individual plants may be separated or contiguous, forming inpenetrable thickets. The species can withstand prolonged drought, but is dependent on occasional flooding (Beadle 1981).

Understories vary with moisture relations and grazing history. On relatively wet sites *Eleocharis acuta* is prominent, and is replaced by *Schoenoplectus pungens* in brackish situations. On well-drained undisturbed sites, large (c. 150 cm) robust russocks of *Poa labillardieri* dominate the ground stratum (Qs 71, 74), and *M. cunninghamii* is sparsely distributed in tall shrubland formation. This association is restricted to the eastern levee of the Barwon River, and appears to be the climax formation for silty clays subject to periodic freshwater flooding. Open areas within the unit support a rich though weedy flora, and may have arisen through disturbance of the *P. labillardieri* association.

M. cunninghamii reaches its southern limit within the reserve, and is consequently of biogeographic significance. The species ranges widely over mainland Australia in association with watercourses. The stands of Lignum within the reserve are the largest and least disturbed south of the Great Dividing Range, and are therefore of considerable conservation importance.

Disturbance susceptibility

High. The unit has been severely degraded by grazing in several areas, and in some sites has been replaced by exotic vegetation (Unit 14). Most stands have a significant number of weed species (e.g. Qs 72, 75). *P. labillardieri* has been virtually eliminated from some sites. However both Lignum and *Poa* are colonising weed infested areas following the cessation of grazing, hence the unit has some regeneration potential.

Unit 10. *Eleocharis acuta* sedgeland

Major component Species	% Freq.	Cover
Eleocharis acuta	100	4
Paspalum distichum	100	3
Rumex bidens	100	1
Crassula helmsii	75	1
Triglochin procera	75	1

Distribution	: Restricted to southern shore of Reedy Lake
Area	: 60 ha (2% of total area)
Substrate	: Peaty silty clay (Ug1)
Structure	: Open- to closed-sedgeland c. 1 m
Mean floristic richness	: 8 species per site
Mean weed composition	: 26% of species, negligible cover
No. of sites	: 4

Unit characteristics

Eleocharis acuta is a rhizomatous sedge forming dense swards of sedgeland about 1 m high. *Paspalum distichum*, a rhizomatous hummock-forming grass, is generally codominant with *E. acuta*, but tends to replace it on wetter sites.

Unit 10 is a pioneering association restricted to the southern shore of Reedy Lake. Floristic data suggest that salinities are lower than for other wetland communities in the reserve. Several component species (*Marsilea hirsuta, Montia australasica* and *Myriophyllum propinquum*) are indicative of freshwater conditions, and were not recorded in other associations fringing the lake.

Stands of *P. distichum* occur in the south-west sector of the lake lodged against stands of *Phragmites australis* (Unit 12). The proximity of these stands to one of the lake's entrance channels suggests that they originated along the lake's southern shore, and were subsequently dislodged and transported to their present location by floodwaters.

The occurrence of *M. hirsuta* (Short-fruit Nardoo) in this community is of botanic interest. The nearest records of this rare fern are from Carisbrook (Willis 1970) and Sale (Aston 1973).

Disturbance susceptibility

Low. The unit is resilient to invasion by exotic species, and is well buffered by areas of open-water and native vegetation.

Unit 11. *Schoenoplectus pungens* sedgeland

Major component species	% Freq.	Cover
Schoenoplectus pungens	100	5
Cotula coronopifolia	100	+
C. reptans	75	3
Ranunculus rivularis	75	2
Crassula helmsii	75	1
Eleocharis acuta	75	1
Rumex bidens	75	+
Paspalum distichum	75	+
Lilaeopsis polyantha	75	+

Distribution : Restricted to Reedy Lake/Hospital Swamp area
Area : 50 ha (2% of total area)
Substrate : Peaty silty clay (Ug1)/fine sand (Uc1) at 10-20 cm
Structure : Closed-sedgeland c. 80 cm
Mean floristic richness : 14 species per site
Mean weed composition : 16% of species, negligible cover
No. of sites : 4

Unit characteristics

Schoenoplectus pungens sedgeland is a pioneer association growing over shallow brackish water along the shores of Reedy Lake and Hospital Swamp. Occurrences vary in width from a few metres to over 100 m according to groundslope. At Hospital Swamp, *S. pungens* appears to be colonising areas previously vegetated by Unit 4 in response to the artificial increase in the swamp's water levels in 1983. The unit is absent from the relatively saline shores of Lake Connewarre, where it is replaced by *Juncus* rushland (Unit 3) in similar hydrological situations.

Disturbance susceptibility

Low. The community is resilient to weed invasion, and is well buffered by native vegetation and bodies of open-water. Physical disturbance of the substrate e.g. ditch construction, may reduce or eliminate areas of suitable elevation for the development of this unit. Future earthworks should be carefully controlled to minimise the degree and extent of disturbance.

Unit 12. *Phragmites australis* reedswamp

This unit is a complex of several associations. The following data are intended to characterise the broad attributes of the unit rather than component associations.

Major component species	% Freq.	Cover
Phragmites australis	75	4
Cotula coronopifolia	75	2
Crassula helmsii	75	3
Lemna minor	75	2
Triglochin procera	63	+
Azolla filiculoides	63	+

Distribution	: Widespread and extensive in the fresh and marginally brackish sections of the reserve
Area	: 254 ha (8% of total area)
Substrate	: Grey silty clay (Ug1)
Structure	: Closed-grassland/open-sedgeland c. 2 m
Mean floristic richness	: 11 species per site
Mean weed composition	: 15% of species, negligible cover
No. of sites	: 8

Unit characteristics

This unit is a complex of ecologically related freshwater associations grouped for mapping purposes. It consists mainly of dense *Phragmites australis* grassland, but also includes structurally open associations dominated by sedges or bulrushes. It should be noted that isolated stands of *P. australis* also occur in Unit 8.

P. australis is a robust, cosmopolitan grass 2-3 m tall. Individual plants consist of numerous cane-like stems interconnected by rhizomes. Photo interpretation suggests that plants may exceed 100 m in diameter. The species has an annual growth rhythm, dying-back in autumn and re-shooting in spring. The dense reedswamp formed by this species provides excellent cover for fauna.

The unit is widespread in the fresh and marginally brackish sections of the reserve. It reaches its maximum development at Reedy Lake, where under favourable conditions of low salinities and low current scour, it has spread across the shallow (c. 1 m deep) waters of the lake. *P. australis* is limited by high salinities (Clucas & Ladiges 1980), which may explain its virtual absence from the Reedy Lake shoreline despite its abundance over much of the lake surface.

Forming an intricate mosaic with *Phragmites* at Reedy Lake is a structurally open association in which *Typha orientalis* is dominant (Q 62). Individuals of *T. orientalis* are characteristically circular in outline, and (unlike *P. australis*) tend to die-out in the centre with maturity, leaving expanding rings of living plant. Rings may exceed 200 m in diameter before eventual disintegration or fusion with other rings. Protected by the rings is an association in which the succulent herb *Crassula helmsii* is typically abundant. Diversity is high in this well-lit association, and floating species such as *Azolla filiculoides* and *Lemna minor* can form extensive sheets providing complete cover.

Another association within the complex at Reedy Lake is dominated by *Schoenoplechus validus*, or rarely, *Eleocharis sphacelata* (Qs 61, 64). Small (5-15 m diam.) clumps of this association are scattered across the lake surface. As in *T. orientalis* open-sedgeland, species diversity is generally higher than in well-shaded *P. australis* grassland.

Disturbance susceptibility

Low. The unit is resilient to invasion by exotic species, and is well buffered by large areas of native vegetation or open-water. See note on *Eichhornia crassipes* on p. 39.

Unit 13. *Melaleuca lanceolata* scrub

Major component species	% Freq.	Cover
Acacia retinodes	100	3
Tetragonia implexicoma	100	3
Rhagodia baccata	100	2
Leucopogon parviflorus	100	1
Pimelea serpyllifolia	100	1
Zygophyllum billardieri	100	1
Amyema preissii	100	+
Melaleuca lanceolata	80	4
**Oxalis pes-caprae*	80	2
**Lagurus ovatus*	80	2
Clematis microphylla	80	1
Stipa flavescens	80	1
**Lycium ferocissimum*	60	2
Threlkeldia diffusa	60	1
Leptospermum laevigatum	60	1
Dichondra repens	60	+
**Coprosma repens*	60	+
**Euphorbia peplus*	60	+
**Chysanthemoides monilifera*	60	+
**Sporobolus africanus*	60	+
**Sonchus oleraceus*	60	+

Distribution : Localised at Barwon Heads (The Sheepwash)
Area : 1.3 ha (<1% of total area)
Substrate : Dark brown fine sand (Uc1.13)
Structure : Open- to closed-scrub c. 8 m
Mean floristic richness : 22 species per site
Mean weed composition : 52% of species, 43% of cover
No. of sites : 5

Unit characteristics

Melaleuca lanceolata scrub occurs on unconsolidated aeolian sand, a substrate of different origin to the alluvial silty clays found elsewhere in the reserve. The vegetation is markedly different to the adjacent salt marsh and adds considerable diversity to the reserve. Eighteen indigenous vascular species are restricted to this association. The vegetation has considerable scenic value and is situated in a section of the reserve which is popular with the public for recreation.

The occurrence of the extremely rare coastal shrub *Adriana quadripartita* (Rare Bitter-bush) in this association is of botanic importance. In Victoria, this species is only known from the Port Phillip Heads area. About 10 specimens were noted in the easternmost stand of the unit (Q 89).

Disturbance susceptibility

High. The combination of small size, linear shape, and heavy usage has led to serious degradation of the vegetation. There are a significant number of weed species throughout the unit. The long-term viability of the unit is doubtful without intensive management, e.g. weed control programs and hand planting of *M. lanceolata* and *Acacia retinodes* (the latter is the exclusive host of the interesting parasite *Amyema preissii*).

Unit 14. Exotic vegetation

Major component species	% Freq.	Cover
**Lolium perenne* X *rigidum*	71	3
**Polypogon monspeliensis*	71	2
**Rumex crispus*	71	1
**Bromus hordeaceus*	57	2

Distribution	: Largely restricted to peripheral areas of reserve where sometimes frequent
Area	: 188 ha (6% of total area)
Substrate	: Grey silty clay (Ug1)/fine sand (Uc1.13)
Structure	: Closed-grassland/closed-herbland c. 50 cm
Mean floristic richness	: 14 species per site
Mean weed composition	: 55% of species, 86% of cover
No. of sites	: 7

Unit characteristics

This is a floristically variable unit based on dominance by exotic species. Floristics vary according to site factors such as the nature and history of disturbance, prevailing salinity and hydrological regimes, and the availability of invasive propagules in adjacent freehold land. Pasture species (including agricultural weeds) are generally abundant. Small patches of variously degraded native vegetation may be interspersed with exotic vegetation.

The unit occurs in areas that have been subject to heavy and/or sustained disturbance. Grazing has been a particularly important agent of disturbance. Units 4 (elevated sites only), 5, 6, 7, 8, 9, and 13 (vegetation of relatively well-drained situations) are all susceptible to weed invasion and eventual elimination under sustained grazing pressure.

Areas of exotic vegetation pose a serious management problem since they act as reservoirs of exotic species for invasion into unaffected areas. Weeds initially introduced through grazing may spread even after cessation of grazing. A return to the original native vegetation is unlikely without intensive management e.g. hand planting.

Unit 15. Bare areas

This is a diverse unit comprised of areas without emergent vegetation i.e. bodies of open-water and disused shell-grit quarries. There are no natural salt pans within the reserve.

Apart from a localised occurrence of *Zostera muelleri* at Barwon Heads, no vascular plants were observed growing in Lake Connewarre or the Lower Barwon. This is presumably due to fluctuating salinities and wave action. In contrast, areas of open-water at Reedy Lake support a wide range of submergent aquatic species. These include *Myriophyllum* spp. (3 species), *Potamogeton* spp. (2 species), *Lepilaena* spp. (2 species), *Ranunculus trichophyllus*, *Ruppia maritima* and *Vallisneria gigantea*.

Disused shell-grit quarries support *Ruppia maritima*, *Lepilaena preissii* and *Chara* sp. whenever water is retained for long periods. These species die-off when salinities reach toxic levels as the quarries dry out, leaving abundant seed capsules on the quarry floors.

SECTOR DESCRIPTIONS

Introduction

The following description of the vegetation of the reserve should be read in conjunction with the vegetation map. For discussion purposes the reserve has been divided into six sectors; these form discrete, recognisable physical units.

Lower estuary

Extensive salt marsh has developed on the broad (c. 1 km wide) flood plain situated in the lower reaches of the Barwon estuary (the area extending from the tidal delta to Barwon Heads). The vegetation in this area is subject to high soil salinities, waterlogging and tidal scour, with the intensity of these influences varying seasonally over a wide range.

A characteristic feature of salt marsh vegetation in general is zonation, which is largely a function of elevation with respect to tidal inundation. Very minor changes in relief (a few cm or less) can affect vegetation patterns through changes in salinity and water regimes. The widths of the zones depend on local groundslopes, which are ultimately determined by sedimentation patterns. Zonation in the Barwon estuary is unusually complex due to the presence of geomorphic features associated with large estuaries. These include lagoons, levees, abandoned river channels, and an abundance of tidal creeks (related to strong ebb tide currents). By disrupting microtopographic gradients, these landforms have resulted in the development of a complex vegetation mosaic rather than the simple parallel zonation evident in many non-estuarine salt marshes.

Belts of White Mangrove (*Avicennia marina*), extending up to 4 km upstream, are freqent in areas receiving daily tidal inundation (Unit 2). Typically, *Avicennia* occurs in stunted shrubland formation 1.4-2.0 m high over swards of *Juncus kraussii*. Maximum development occurs at Barwon Heads where *Avicennia* occurs in open-scrub formation 2.0-2.5 m high over a sparse understorey. *Sclerostegia arbuscula* shrubland (Unit 5a) is fairly common in the lower estuary, on moderately elevated sites receiving regular tidal inundation. Samphire herbland (unit 4) occurs on flats and along drainage lines where pools and sheets of water are left by high tides.

The development of salt marsh (Unit 4) seaward of the mangrove zone at Barwon Heads is of considerable interest. This unusual reversal of zonation is not known to occur elsewhere in Victoria. The feature occurs on a spit which has developed on the lee side of a large meander in the river. The deposition of silty clay has resulted in slightly elevated marsh levels and colonisation by salt marsh. An almost-pure stand of *Sarcocornia*, with scattered mangrove seedlings, occupies most of the site (Q 6). *Suaeda australis* shrubland occurs on a stranded sand ridge (chenier) along the southern edge of the spit (Q 5). This association was not observed elsewhere in the reserve though it is locally common in Victorian salt marshes.

Juncus rushland (Unit 3) is extensive in parts of the estuary, particularly north of the river. It occupies areas subject to regular flooding by brackish tidal water, and imparts a distinctive estuarine character to the vegetation.

Of significance is the occurrence of *Distichlis* grassland (Unit 8) on the low levees lining the Barwon and its subsidiary tidal creeks upstream of the mangrove zone. The association also extends onto the broad, low-lying areas behind the levees where it occurs in a complex mosaic with *Sarcocornia* herbland (Unit 4). Silt and clay suspended in floodwaters are trapped and deposited on the levees, resulting in their gradual build-up. These impede the drainage of the backswamps behind them, resulting in the extensive development of *Sarcocornia* herbland in those areas. The levees are broken by deep, narrow tidal creeks connecting the backswamps with the river.

Tangled Lignum (*Muehlenbeckia cunninghamii*) occurs on non-tidal sites in tall shrubland or scrub formation over dense swards of *Distichlis* (a variant of Unit 8). Stands are best developed on low embankments lining abandoned river channels e.g. along the south-east shore of the lagoon south of Lake Connewarre.

Gahnia sedgeland (Unit 6) is abundant on elevated sites, particularly at the rear of the marsh. Stranded sandy ridges (cheniers) are locally common within the marsh and support *Stipa teretifolia* grassland or, rarely, *Poa poiformis* grassland (Unit 7). Degraded stands of *Melaleuca* scrub (Unit 13) occur along the southern bank of the Barwon River at The Sheepwash, adding considerable floristic and scenic diversity to the reserve.

The vegetation of the lower estuary is in good condition, and is an outstanding example of extensive, undisturbed estuarine vegetation. The pronounced change in vegetation as tidal influence decreases along the estuary is of considerable scientific interest.

Murtnagurt Swamp

Murtnagurt Swamp is a small (84 ha), isolated salt marsh situated south-west of Barwon Heads, immediately landward of barrier dunes and the coast. It is connected to the Barwon estuary via a long (2.5 km), narrow (80-250 m) corridor of salt marsh running through agricultural land.

Despite past hydrological and physical disturbance, the swamp supports a particularly rich flora. Thirty-seven (70%) of the species in the indigenous Victorian salt marsh flora are represented here, including several uncommon to rare species. Species-richness is enhanced by the presence of 14 of the State's 15 indigenous salt marsh annuals, 6 of which do not occur elsewhere in the reserve viz. *Agrostis billardieri, Centrolepis polygyna, Cotula vulgaris, Hydrocotyle capillaris, Sebaea albidiflora* and *Triglochin minutissima*. The swamp also contains the reserve's largest stands of *Lawrencia spicata* and *Sarcocornia blackiana* (both very rare elsewhere), and the only stands of *Halosarcia halocnemoides*.

Eight of the reserve's 15 vegetation units are represented at Murtnagurt Swamp. Samphire herbland and shrubland (Units 4 and 5a, b, c) are frequent in low-lying areas, while *Gahnia* sedgeland (Unit 6) is common on elevated sites along the reserve boundary. A stand of *Poa* grassland (Unit 7) occurs near the swamp entrance. Localised at the western end of the swamp are several stands of *Phragmites* over *Distichlis*-dominated understories (Unit 8) associated with a natural freshwater spring. There are unusual occurrences of *Juncus* rushland (Unit 3) at the southern boundary, on sand winnowed from the adjacent coastal dune and deposited on the marsh.

The swamp has been severely disturbed by past shell-grit extraction. The disused quarry is still largely bare of vegetation except for the aquatic angiosperms *Lepilaena preissii* and *Ruppia maritima* and the alga *Chara* sp.; these proliferate whenever water is retained after heavy rain (Unit 15).

At the eastern edge of the quarry, substrates are irregular and hummocky, providing habitat for *Angianthus* herbland (Unit 4), an association not found elsewhere in the reserve. This is the most species-rich salt marsh community in the reserve, and is characterised by a dense carpet of diminutive annuals and ephemerals providing complete cover in spring and early summer. These die-off after fruiting and germinate from soil-stored seed following autumn rains. Maximum diversity occurs on slightly elevated sites where salinities are reduced due to leaching by precipitation. The exotic annual grass, *Parapholis incurva*, is invading the area, presenting a long-term threat to the community.

Halosarcia halocnemoides shrubland (Unit 5c) is localised in the central section of the swamp, and was probably more extensive prior to the construction of the shell-grit quarry. There are two small stands separated by the quarry. *H. halocnemoides* reaches its southern limit in Australia here and is consequently of biogeographic significance.

The importance of Murtnagurt Swamp lies in its species-richness and in the biogeographically significant occurrence of *H. halocnemoides*. The combination of small size and past intensive use has led to profound vegetation change in parts of the swamp. Stringent protection is required to prevent any further degradation of this significant area.

Salt Swamp

Salt Swamp is a large (460 ha), unsually broad salt marsh situated south of Lake Connewarre, extending south-west from the Lower Barwon. It is traversed at its southern end by a causeway (the Geelong-Barwon Heads Rd). Despite a history of physical and hydrological disturbance, the swamp supports diverse and unusual vegetation, much of which is in natural condition. Nine of the reserve's 15 vegetation units are represented here, including one (*Wilsonia humilis* herbland) not found elsewhere in the reserve.

The most striking feature of Salt Swamp is the extensive (c. 65 ha.) *Wilsonia* herbland (Unit 1) north of the Geelong-Barwon Heads Rd. The large expanse of this low glaucous vegetation is spectacular, and is the largest occurrence of this unusual association in the State. The herbland is subject to major seasonal fluctuations in water relations, from prolonged inundation following major floods of the Barwon in winter or spring to continual exposure in summer and autumn. Shell-grit extraction has left large scars (Unit 15) in parts of the herbland.

Sarcocornia herbland (Unit 4) is widespread and common in low-lying areas, particularly on broad flats and along drainage lines. It surrounds the *Wilsonia* herbland on sites only briefly inundated by the lake that forms over the *Wilsonia* in winter or spring. A dynamic equilibrium operates between the two units in response to changes in the extent and duration of inundation.

Samphire shrubland is widespread and frequent on well-drained seasonally hypersaline sites. *Sclerostegia arbuscula* (Unit 5a) is localised in the northern section of the swamp. *Halosarcia pergranulata* (Unit 5b) is locally abundant and reaches its maximum development at Salt Swamp. It frequently occurs along broad spring tide channels winding through *Gahnia* sedgeland (Unit 6). The area of *H. pergranulata* shrubland south of the causeway provides spectacular wildflower displays in late spring, with mass blooms of *Disphyma clavellatum, Frankenia pauciflora* and *Cotula coronopifolia.*

Gahnia sedgeland (Unit 6) is the most abundant vegetation type at Salt Swamp, and is particularly well developed on elevated sites at the rear of the marsh. The occurrence of *Gahnia* sedgeland at Salt Swamp is one of the largest in Victoria.

Of interest is the development of contraction ridges at the rear of the marsh. These are low concentric ridges only a few cm high and separated by up to 20 m. They can be hundreds of metres in length. They were formed when Salt Swamp was an estuarine lagoon. Sediments on the lagoon floor were mobilised during floods and redeposited at the shore by wave action. The lagoon contracted in size as successive ridges were built-up and stabilised by vegetation. At some sites along the Victorian coast e.g. Lake Reeve, contraction ridges are being actively formed (Bird 1978; Rosengren et al. 1981), however at Salt Swamp their formation has long ceased.

Contraction ridges are stable microtopographic features which influence vegetation patterns. Dense *Gahnia* is developed on the ridge crests, whilst in the swales, which are presumably more saline, *Gahnia* is codominant with the shrub *Halosarcia pergranulata.* Ridges are well developed in the north-east of the swamp, where they form a concentric pattern around a local depression in which samphire shrubland, samphire herbland and *Wilsonia* herbland occur. A drain from adjacent private land runs into this area and has probably influenced vegetation patterns. In 1983 the area was in poor condition due to damage by stock and vehicles. Contraction ridges are sensitive landforms requiring protection from physical disturbance.

Poa poiformis grassland (Unit 7) occurs on elevated sites immediately landward of the *Gahnia* zone, and is the climax formation for the area. Grazing and other forms of disturbance have led to the replacement of this association by exotic vegetation (Unit 14) at several sites. Prior to European settlement, *Poa* grassland was probably abundant along the perimeter of Salt Swamp, however most of this vegetation type occurred on private land where it has been replaced by exotic pasture. The relicts within the reserve are therefore of considerable conservation importance.

Salt Swamp is an outstanding feature of the reserve. Its significance lies in its considerable size, and in the presence of unusual landforms and vegetation types. Much of the vegetation is in good condition, although some areas have been adversely affected by physical and hydrological disturbance. Sensitive management of the vegetation is required to maintain its condition.

Lake Connewarre

Lake Connewarre is a large (860 ha), irregularly shaped, shallow estuarine lagoon. No vascular plant growth was observed in the lake, presumably due to fluctuating salinities and wave action.

South and east of the lake are extensive areas of *Sarcocornia* herbland (Unit 4) and *Distichlis* grassland (Unit 8). *Halosarcia pergranulata* shrubland (Unit 5b) and exotic vegetation (Unit 14) occur in the vicinity of The Island. *Juncus* rushland (Unit 3) forms a pioneering community along parts of the lake shore.

The tidal delta at the outlet of the Barwon River from the lake is of considerable importance as it is one of the largest active tidal deltas supporting terrestial vegetation in Victoria (N. Rosengren, pers. comm.). The delta is comprised of numerous islands separated by an intricate network of shifting shoals and distributaries. The islands support a mosaic of *Sarcocornia* herbland and *Distichlis* grassland. Isolated specimens of *Muehlenbeckia* occur on some of the islands. Rosengren (1973) reported the marked growth of the delta between 1947 and 1970. Progradation is assisted by the vegetation, which traps and stabilises sediments deposited by tides and floodwaters.

A fringe of *Phragmites* reedswamp (Unit 12) occurs along the shoreline of the western arm of the lake at sites where salinities are reduced by dilution with freshwater from the Barwon. In the tidal delta area, *Phragmites* occurs sporadically over *Distichlis* grassland in zones of freshwater influence. *Phragmites* dies-out several kilometres before the river mouth.

A significant number of exotic species occur throughout much of the salt marsh accessible from The Island (privately owned). The adverse effects of grazing by domestic stock on salt marsh vegetation are clearly demonstrated here. Areas with similar vegetation that are not accessible e.g. the tidal delta, are largely free of weeds.

Much of the vegetation in this sector of the reserve is in good condition. The tidal delta area supports an excellent example of undisturbed estuarine salt marsh and subsaline marsh.

Hospital Swamp

Hospital Swamp is situated in the south-west of the reserve between Lake Rd and the western arm of Lake Connewarre. The swamp consists of a system of shallow basins separated by low rises, the southernmost basin being the largest and deepest.

A range of plant communities typical of saline, brackish and freshwater conditions occur within the swamp. Seven of the reserve's 15 vegetation units are represented here. The swamp contains the reserve's only known stand of *Chenopodium pumilio* as well its largest stands of the rare *Atriplex australasica*. Only a few specimens of *A. australasica* were observed elsewhere (north-west Salt Swamp).

The swamp appears to have been part of Lake Connewarre last century (Geol. Surv. Vic. map), and to have been subsequently isolated by siltation in the northern section of the swamp. Until water diversion works in 1983, the swamp's capacity to hold water had been low due to the blocking of its

entrance channel and associated drainage works many years ago. The swamp would only fill during heavy winter rain or when floodwaters overtopped the banks of the Barwon River (700 m north-west). The swamp was usually dry from late summer to spring. The construction in 1983 of a water supply channel from the Barwon upstream of the barrage and the installation of regulators have dramatically improved the swamp's water supply. This has induced rapid floristic change in the vegetation.

Residual salinity in the system has led to the persistence of salt marsh over considerable areas. Species-poor *Sarcocornia* herbland (Unit 4) is extensive in low-lying areas, particularly in the shallow northern basins. *Cotula coronopifolia* is abundant, indicating that salinities are relatively low for salt marsh. *Gahnia* sedgeland (Unit 6) occurs along the southern shores of the swamp.

Distichlis grassland with scattered Lignum (Unit 8) occurs on elevated ground in the north-east of the swamp. The reserve's largest stands of the rare *Atriplex australasica* occur in this association.

Schoenoplectus sedgeland (Unit 11) is well developed in wet brackish situations such as along the narrow rises separating the basins. The zonation is the reverse of that at Reedy Lake, where salt marsh occupies high ground relative to *Schoenoplectus*. This is presumably due to past periodic drying-out of the basins, accompanied by increases in salinity through evapotranspiration. *Phragmites* reedswamp (Unit 12) occurs on regularly inundated sites such as along the northern shore of the main basin. Exotic vegetation (Unit 14) occurs sporadically along the rises separating the basins, indicating past disturbance through grazing.

As a result of the engineering works in 1983, there has been a dramatic change in the condition and extent of salt marsh. At the time of survey, large patches of *Sarcocornia* were in decline or had recently died, leading to an increase in the area of bare ground (Unit 15). There was no evidence of regeneration. Floristic instability was indicated by unusual species combinations, such as depleted stands of *Sarcocornia* with the aquatic herbs *Ranunculus trichophyllus* and *Potamogeton pectinatus*, or with the minute terrestial herb *Eleocharis pusilla* providing complete cover.

Predictions of future change in the vegetation of the area depend on the depth and frequency of inundation, and are complicated by residual salinity in the system. It is likely that *Phragmites* reedswamp and *Schoenoplectus* sedgeland will spread at the expense of salt marsh, and that a situation similar to that along the west, north and east shores of Reedy Lake will eventually develop. *Phragmites* and *Typha* will spread into areas inundated for most or all of the year, particularly in the deeper, southern basin, where *Phragmites* already forms a narrow fringe along much of the shore. In brackish sites subject to regular but shallow inundation i.e. with elevations at or near the swamp's overflow level, *Schoenoplectus* sedgeland can be expected to replace areas of *Sarcocornia* and *Gahnia*.

The effect of the water diversion project on *A. australasica* and *C. pumilio* is difficult to predict without further investigation, although the occurrence of both species on elevated sites above the swamp's overflow level suggests that any detrimental effect will be minimal. The status of *A. australasica* should be monitored in future.

Future changes in the vegetation at Hospital Swamp should be monitored using aerial photography in combination with a series of permanent vegetation sampling plots. The vegetation map in this report is a base for use in the assessment of future vegetation change.

Reedy Lake

Reedy Lake is the largest freshwater wetland in central Victoria and is therefore of considerable conservation importance. Eight of the reserve's 15 vegetation units are represented in the Reedy Lake area, one of which (*Eleocharis* sedgeland) does not occur elsewhere in the reserve. The area has a particularly rich flora, including about 50 freshwater aquatic and semi-aquatic native vascular species. Thirty of these were not observed elsewhere in the reserve.

The vegetation at Reedy Lake is characterised by concentric zones of hydrophytic vegetation surrounding deeper, often open areas of water. The vegetation patterns result from an interaction of basin configuration, water and salinity regimes, plant species composition, and disturbance history.

Extensive areas of reedswamp (Unit 12) occur across the surface of Reedy Lake, providing excellent cover for wildlife. Tall, dense *Phragmites* grassland is prolific in areas, and appears to have developed on self-accumulated substrates of peaty silty clay. Stands of *Phragmites* have been observed to alter position in the lake during floods (D. White, FWS, pers. comm.). Forming a mosaic with *Phragmites* is a structurally open, species-rich association dominated by *Typha orientalis*, and characterised by the succulent herb *Crassula helmsii* together with floating species such as *Azolla filiculoides*, *Lemna minor* and *Wolffia australiana*. In areas of open-water, clumps of *Schoenoplectus validus* or rarely, *Eleocharis sphacelata*, are locally frequent.

Of considerable interest are stands of *Paspalum distichum* (a variant of Unit 10) lodged against reedbeds in the south-west sector of the lake. The proximity of these stands to one of the lake's entrance channels suggests that they originated along the lakeshore, and were subsequently dislodged and transported to their present locations by floodwaters.

'Bare' areas (Unit 15) within the lake are by no means unvegetated. Numerous submergent aquatic species are locally abundant throughout much of the lake. These include *Myriophyllum* spp. (3 species), *Potamogeton* spp. (2 species), *Lepilaena* spp. (2 species), *Ranunculus trichophyllus*, *Ruppia maritima* and *Vallisneria gigantea*.

The north, west and east shores of the lake support a narrow (80-250 m) zone of emergent vegetation. *Schoenoplectus* sedgeland (Unit 11) grows in shallow brackish water along the shoreline. Landwards, saline areas support depauperate salt marsh (Unit 4, rarely Units 5b or 6). A dynamic equilibrium operates between the sedgeland and salt marsh in response to the depth and periodicity of lake water levels. Degraded remnants of Lignum shrubland over *Distichlis*-dominated understoreys (Unit 8) occur intermittently on elevated sites, but are mostly restricted to private land. A variant of this unit in which *Paspalum distichum* is prominent occurs along the eastern shore.

Extending south from Reedy Lake to the Barwon River is an extensive area of diverse and unusual wetland vegetation. A broad zone of *Eleocharis* sedgeland occurs along the lake's southern shoreline (Unit 10). A geographically isolated population of Short-fruit Nardoo (*Marsilea hirsuta*) occurs here. Floristics indicate that salinities are low in this area, presumably due to the proximity of the Barwon River. Extensive *Muehlenbeckia* shrubland and scrub (Unit 9) occurs in elevated areas behind the *Eleocharis* sedgeland, extending south to the Barwon River. Understories vary with salinity, hydrology and disturbance history, and include *Eleocharis, Schoenoplectus, Poa* and exotic-dominated associations.

Of interest are dense stands of *Poa labillardieri* with sparse *Muehlenbeckia* in tall shrubland formation on the broad levee lining the Barwon River. This association appears to be the climax formation for silty clays subject to periodic freshwater flooding (cf. Unit 7), and is an association which is now rare, if still present, elsewhere in the Melbourne region.

Reedy Lake is considered to be of outstanding botanic significance due to its large size, its rich flora, and the presence of restricted plant species and associations. It has considerable scientific and educational value as an example of hydrosere succession under various salinity and water regimes. Much of the native vegetation along the north-west, north and east shores of the lake is on private land, imposing a severe constraint on management.

VEGETATION SIGNIFICANCE

Salt marsh

Bridgewater (1982) published a floristic classification of coastal salt marsh vegetation in southern Australia in which a total of 22 associations were recognised. Fifteen of these were recorded for Victoria. Two associations recorded for South Australia extend into Victoria but were not recorded by Bridgewater: *Halosarcia halocnemoides* shrubland and *Halosarcia pergranulata* shrubland (Yugovic 1984). Of 17 associations known to occur in Victoria, 12 are represented at Lake Connewarre.

Bridgewater et al. (1981) produced a checklist of salt marsh species in southern Australia, in which 48 indigenous vascular species were recorded for Victoria. This list has been accepted, with some amendments, by the present author, giving a total of 53 species. Forty-five (85%) of these occur at Lake Connewarre, indicating a high species-richness. *Halosarcia halocnemoides* reaches its southern limit within the reserve (at Murtnagurt Swamp) and is consequently of biogeographic significance.

The reserve contains representative examples of 'dry' salt marsh (Units 5b and 5c), due to its location within the rainshadow of the Otway Ranges. Low summer rainfall is responsible for the hypersaline conditions with which this vegetation type is associated. 'Wet' salt marsh (typified by Units 3 and 5a) is also well represented in the Barwon estuary, wherever salinities are reduced by regular tidal inundation.

The combination of dry climate, estuarine influence and large area has led to the development of diverse, species-rich salt marsh vegetation at Lake Connewarre. The reserve is of considerable importance in the conservation of salt marsh vegetation in Victoria. Future management should accordingly be aimed at maintaining or improving the condition of the vegetation.

Subsaline marsh

Residual salinity in flood-prone areas beyond tidal influence has led to the extensive development of subsaline marsh vegetation within the reserve. Three associations are limited to brackish areas, *Wilsonia* herbland (Unit 1), *Distichlis* grassland (Unit 8) and *Schoenoplectus* sedgeland (Unit 11).

There is no comprehensive inventory of subsaline marsh vegetation in Victoria, making it difficult to compare the vegetation at Lake Connewarre to other areas. However the reserve contains the most extensive examples of *Wilsonia* herbland and *Distichlis* grassland in Victoria, and is therefore of considerable conservation importance. The occurrence of *Muehlenbeckia cunninghamii* at its southern range limit in *Distichlis* grassland (tidal delta area) is of biogeographic significance.

Freshwater marsh

There is no comprehensive inventory of freshwater wetland vegetation in Victoria, making it difficult to evaluate the vegetation of the reserve. However Reedy Lake is considered to be of outstanding significance due to its large size, floristic richness and structural diversity. It is one of the best examples of freshwater marsh vegetation in Victoria.

Dry coastal vegetation

Poa grassland and *Melaleuca* scrub add scenic and floristic diversity to the reserve, however these associations are fragmented and of very limited development. The presence of the rare coastal shrub *Adriana quadripartita* at The Sheepwash is significant.

Significant plant species

The Victorian distribution and abundance of all native vascular species recorded for the reserve was examined, using Willis (1970; 1973; 1978), Aston (1973) and Beauglehole (1980; 1983). Table 2 lists 18 species of particular interest, including species occurring at an extreme of their range, with a disjunct occurrence in the area, or that are relatively rare in the region. MSA refers to the L.C.C. Melbourne Study Area.

Table 2. Significant plant species

Species	Occurrence in reserve	Comments
Adriana quadripartita	Rare at the Sheepwash (Unit 13)	Rare and localised in Victoria; only known from Port Phillip Heads area
Atriplex australasica	Rare at Hospital Swamp, (Unit 11), Salt Swamp (Unit 6)	Rare in Victoria but precise range and status unknown due to previous confusion with *A. patula* (R. Parsons pers. comm.)
Avicennia marina	Locally abundant in lower sections of estuary (Unit 2)	Disjunct occurrence; nearest occurrence is in Port Phillip Bay
Cotula reptans var. *major*	Occasional in estuary (Unit 3)	Frequent in saline swamps of Tasmania; only other mainland record is from Wilsons Promontory
Cotula vulgaris var. *australasica*	Locally abundant at Murtnagurt Swamp (Unit 4)	Scattered in south-west and coastal Victoria
Eleocharis pusilla	Rare at Reedy Lake, abundant at Hospital (Unit 4)	Widespread in Victoria, but rare in central Victoria (MSA)

Table 2 (cont.).

Species	Occurrence in reserve	Comments
Halosarcia halocnemoides	Rare and localised at Murtnagurt Swamp (Unit 5c)	Southern limit in Australia
Juncus revolutus	Rare and localised south of Reedy Lake, near Barwon River (Unit 9)	Scattered in south-west and coastal Victoria
Lemna trisulca	Rare at Reedy Lake (Unit 12)	Scattered in Victoria
L. preissii	Localised at Salt Swamp (Unit 14)	Of restricted occurrence in coastal Victoria
Lepilaena bilocularis	Occasional at Reedy Lake (Units 10, 12, 15)	Scattered in Victoria; uncommon in central Victoria (MSA)
Marsilea hirsuta	Rare, south of Reedy Lake (Units 9, 10)	Very rare in southern Victoria; first record for MSA
Muehlenbeckia cunninghamii	Locally abundant in non-tidal, flood-prone areas (Units 8, 9)	Southern limit in Australia
Myriophyllum muelleri	Common at Reedy Lake (Unit 15)	Scattered in south-west Victoria
Pratia concolor	Rare at Reedy Lake (Unit 11)	Rare in southern Victoria
Schoenoplectus pungens	Abundant at Reedy Lake (Unit 11)	Scattered in west and coastal Victoria
Triglochin minutissima	Locally common at Murtnagurt Swamp (Unit 4)	Scattered in north-west and coastal Victoria
T. mucronata	Locally common at Murtnagurt and Salt Swamps (Units 4, 5)	Scattered in south-west and coastal Victoria

Of the above, *Adriana quadripartita* is considered 'extremely rare' by Willis (1978). The reserve does not contain any further species listed by Willis as rare, very localised or endangered, however it does have a sufficient number of botanically significant occurrences to justify sensitive management of the vegetation. Little is known of the autecology of these species, so that specific management guidelines cannot be formulated without further investigation.

Habitat value

The Lake Connewarre State Game Reserve contains large areas of diverse native wetland vegetation, and is therefore of considerable importance in terms of faunal habitat.

The reserve is one of Victoria's major waterbird habitats. Pescott (1983) recorded 135 bird species for the reserve, including 12 species of waterfowl. The reserve provides valuable feeding areas for intercontinental migratory waders during summer (L.C.C. 1973), as well as winter habitat for the endangered Orange-bellied Parrot, Victoria's only salt marsh dependent parrot (P. Brown, TNPWS, pers. comm.). Reedy Lake is a major breeding site for Sacred Ibis and Straw-necked Ibis (Cowling & Lowe 1981). The maintenance of (artificially) high water levels at Reedy Lake and Hospital Swamp makes the reserve an important drought refuge.

The value of the reserve lies in its size and habitat diversity. Corrick (1982; unpublished data) documented the number, area and type of wetland in west-central Victoria (Port Phillip Bay to Mt Emu Ck). Three wetland categories and seven subcategories were recorded for the reserve, which was found to contain the largest area of reed-dominated deep freshwater marsh, open-water deep freshwater marsh, and salt flat (categories 4.2, 4.5 and 6.3) in the study area (Table 3). Corrick reported that each wetland category in the study area supports a different suite of wetland bird species, with some species showing very specific habitat preferences. The range of habitats at Lake Connewarre is therefore conducive to a rich avifauna.

Table 3. Wetland categories and subcategories at the Lake Connewarre State Game Reserve (adapted from Corrick, unpublished data)

Category/subcategory	Location in reserve	Area (ha)	
4 Deep freshwater marsh			626
.2 Reed-dominated	Reedy Lake (Unit 12)	273	
.5 Open-water	" " (Unit 15)	353	
6 Semipermanent saline			998
.1 Salt pan	widespread (Unit 15)	59	
.2 Salt meadow	Salt Swamp (Units 1,4)	130	
.3 Salt flat	widespread (Units 3-6,8)	809	
7 Permanent saline			1066
.1 Shallow	Lake Connewarre, Hospital Swamp (Unit 15)	1045	
.3 Intertidal flat	Lake Connewarre (Unit 15)	21	
Total			2690

VEGETATION MANAGEMENT

Grazing

The most serious threat to the native vegetation of the reserve is grazing and trampling by domestic stock. From general observations it is clear that these lead to the disturbance of native vegetation, the establishment and spread of exotic species, and in some cases, the eventual replacement of native vegetation by exotic vegetation.

The evidence of this is most clear at Salt Swamp where there has been damage to vegetation in an area leased for grazing. In Dec 1983, the exotic annual grasses, *Polypogon monspeliensis* and *Hordeum marinum*, were invading bare areas in which samphire shrubland had been completely destroyed by stock. There was no evidence of samphire recovery. An associated easement for an electric fence had been colonised by these grasses, resulting in their introduction to the central area of the swamp. The easement has left a long-term scar in the vegetation.

Exotic species become incorporated in the flora to form a mixed ground cover which may persist for many years. As there are no effective means of controlling these infestations, and as substantial areas of vegetation are susceptible to this form of degradation, stock access to areas of importance for flora conservation (see Appendix 3) should be prevented in future.

Engineering works

Engineering works which alter the hydrology of particular areas for game production purposes can have dramatic effects on the vegetation. The conservation values of the reserve were probably enhanced by the Hospital Swamp water diversion project, which has, to some extent, restored the original hydrology of the swamp. However diversion projects involve the retention of water that would normally pass into the lakes and swamps of the Barwon estuary. Freshwater flooding is essential for the viability of *Wilsonia humilis* herbland (Unit 1) and may be required for the long-term viability of *Juncus krausii* rushland (Unit 3) and *Distichlis distichophylla* grassland (Unit 8). Future engineering works that would take the peak off major freshwater floods should be carefully assessed for their possible impact on flora conservation values. In general, any artificial change in the hydrology of areas of importance for flora conservation (see Appendix 3) is undesirable.

Recreational use

Recreational activities such as fishing, duck shooting and nature study have minimal impact on the vegetation of the reserve at present. The reserve is of sufficient size for these forms of land use to be compatible with flora conservation.

The possible erosion of river banks caused by power boats requires monitoring. The policy of discouraging public access to areas of Moonah (Unit 13) in need of regeneration at The Sheepwash should be maintained. The access of vehicles, particularly trail bikes, to areas other than defined tracks should be prevented.

Weeds

Exotic species present an important management problem in several parts of the reserve. Annual herbs and grasses such as *Polypogon monspeliensis, Hordeum marinum, Atriplex hastata, Sonchus oleraceus* and *Rumex crispus* are widespread and common in relatively elevated areas. *Parapholis incurva* is a problem at Murtnagurt Swamp. Control measures are not practicable for most species. The prevention of physical disturbance to soils and vegetation is the best means of minimising the spread of exotic species within the reserve.

Spartina spp. (Cord-grasses) have an enormous potential to invade and profoundly alter Units 1 and 4 if introduced. *S. townsendii* is well established at estuaries in Western Port (Bridgewater 1975), Anderson Inlet (Boston 1973) and Corner Inlet (Rosengren et al. 1981), highlighting the conservation value of the unaffected Barwon estuary. Under no circumstances should *Spartina* be introduced (as an erosion preventative or as a pasture plant), and any spontaneous infestations should be promptly destroyed.

Reedy Lake should be regularly checked for the presence of *Eichhornia crassipes* (Water Hyacinth). A major outbreak of this noxious weed, which has been recorded for southern Victoria (Parsons 1973), would be disastrous.

Noxious weeds recorded within the reserve include:

Chrysanthemoides monilifera	Common in *Melaleuca* scrub (The Sheepwash)
Cirsium vulgare	Common in *Poa* grassland; occasional in exotic vegetation (widespread)
Homeria miniata	Rare in *Distichlis* grassland (The Island)
Lycium ferocissimum	Common in *Melaleuca* scrub (The Sheepwash); occasional in exotic vegetation (widespread)
Marrubium vulgare	Rare in exotic vegetation (Murtnagurt Swamp)
Oxalis pes-caprae	Common in *Melaleuca* scrub (The Sheepwash)

The noxious species found in the *Melaleuca* scrub are the most serious as they threaten the long-term viability of this association.

FURTHER INVESTIGATIONS

From the work undertaken in this study, possibilities arise for a number of further investigations:

1. Further quadrat sampling is required to fully characterise some of the more rare plant associations within the reserve e.g. *Stipa* grassland.

2. A detailed investigation of the effects of grazing on wetland vegetation is required, particularly with respect to the ingress of alien species.

3. The regeneration requirements of the shrubby samphire species (*Sclerostegia arbuscula, Halosarcia pergranulata* and *H. halocnemoides*) need to be determined. These species exhibit poor regeneration capabilities after disturbance.

4. An ecological study of the dynamics of the unusual *Wilsonia humilis* herbland at Salt Swamp would be of scientific interest. This would include an investigation of the microdistributional relationships between the three *Wilsonia* species.

5. The dynamics of the vegetation at Reedy Lake require detailed investigation. The area has considerable potential for studies of hydrosere succession under various salinity and water regimes.

6. A detailed faunal survey should be conducted to determine the relationships between floristic associations and specific faunal preferences.

7. All artificial changes to the vegetation should be monitored, particularly in areas affected by water engineering works or in areas close to existing or potential sources of chemical, physical or biological pollution.

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Appendix 1. Two-way table

Species	Quadrat No.	1 18881 16872	2 132 49911	3 32322 798402	4 22 31242188554 623527867341411	5 8 834 44 59040384	6 2113 5456	7 152 0268	8 33443737 10323857	9 7777 5241	10 6666 5689	11 7585 6825	12 66665618 14029763	13 89999 92013	14 4555777 9036903	Quadrat No.	Species
98	Wilsonia rotundifolia	2															Wilsonia rotundifolia
96	Wilsonia backhousei	2			+												Wilsonia backhousei
97	Wilsonia humilis	35554			1												Wilsonia humilis
9	Avicennia marina		54432		++												Avicennia marina
41	Juncus kraussii		+45	353555	+	+	+		++++								Juncus kraussii
68	Samolus repens		+421	+1+13	2++ ++ 2 +	+ ++++	+		++						+ +		Samolus repens
91	Triglochin striata	+	1+	+++	2+++ 113+	++++ +	+ +		+ ++		1	+ +			+ +		Triglochin striata
70	Sarcocornia quinqueflora	+2	+++ 1	33+1+1	535+1454+533333	4+1+22+	11+	+	2++ ++	+		+			+3		Sarcocornia quinqueflora
86	Suaeda australis		+ 2	++ +	324+2 +	1 2	++++										Suaeda australis
34	Hemichroa pentandra		++	+	+ 1+ 2 41	+	+	+							+		Hemichroa pentandra
76	Selliera radicans			+ ++	+		++	+	+ +			+ +					Selliera radicans
65	Puccinellia stricta	+			+++4 +3	++ +									+		Puccinellia stricta
26	Frankenia pauciflora				51 +23	1+ 4+34	3								+ +		Frankenia pauciflora
3	Apium annuum				++ + +2	+	++	+	+						+		Apium annuum
64	*Polypogon monspeliensis				++ +++	++2 +			+	++++		+			++ 25+		*Polypogon monspeliensis
17	Cotula coronopifolia				+ + 244	+13+	++			1+		++++	++4++ +		13		Cotula coronopifolia
71	Isolepis marginata				+4++	1+	+			++					3 +		Isolepis marginata
30	Halosarcia pergranulata					3443	+ 2	+									Halosarcia pergranulata
74	Sclerostegia arbuscula			1		434									+		Sclerostegia arbuscula
29	Halosarcia halocnemoides					2											Halosarcia halocnemoides
103	*Atriplex hastata				+	+			+	+		+	+ +		+		*Atriplex hastata
36	*Hordeum marinum				++		++		+					+	2 2		*Hordeum marinum
28	Gahnia filum			+			5553	+	+ 1								Gahnia filum
82	*Sonchus oleraceus				+	+	++	+1++	++ +	++				++ +	++ +		*Sonchus oleraceus
62	Poa poiformis						+	555+									Poa poiformis
22	Disphyma clavellatum						+	+++	+						+		Disphyma clavellatum
52	*Medicago polymorpha							+++	+					+	++ +		*Medicago polymorpha
60	*Plantago lanceolata							+ +						+	+		*Plantago lanceolata
94	*Vicia sativa							++							++		*Vicia sativa
16	*Cirsium vulgare							++		+					3+		*Cirsium vulgare
7	Asperula conferta							+ +									Asperula conferta
8	Atriplex paludosa			1	2	+			44								Atriplex paludosa
23	Distichlis distichophylla			4+3+	++++11	+	5 ++	1 35	55555555			+			3 ++		Distichlis distichophylla
66	*Rumex crispus						+	+	++++	++++		+		+	+++ +2		*Rumex crispus
54	Muehlenbeckia cunninghamii						+		55	33++		+			2 +		Muehlenbeckia cunninghamii
104	*Callitriche hamulata									1+	+						*Callitriche hamulata
79	Senecio lautus									+++	+	+		+	+ +		Senecio lautus
136	Urtica urens									+++				+			Urtica urens
61	Poa labillardieri									55					+		Poa labillardieri
24	Eleocharis acuta								+	++	4553	+2+	+ +		3		Eleocharis acuta
133	Rumex bidens										++1+	++ +	1 +				Rumex bidens
58	Paspalum distichum										53+4	++ +	++ 1 +				Paspalum distichum
139	Crassula helmsii										++1	+2 +	2+451+				Crassula helmsii
131	Ranunculus rivularis										+	+2 3	2 3 1				Ranunculus rivularis
114	Lilaeopsis polyantha				+	+						++ +	++				Lilaeopsis polyantha
84	Stellaria palustris								+		+	++					Stellaria palustris
18	Cotula reptans								+			+4 3	1 1				Cotula reptans
72	Schoenoplectus pungens				+ +				+	1	+	5555	+		+		Schoenoplectus pungens
112	Lepilaena cylindrocarpa				+							++	+				Lepilaena cylindrocarpa
102	*Aster subulatus								+	3		++			++		*Aster subulatus
137	Villarsia reniformis											+	3 1				Villarsia reniformis
138	Wolffia australiana												++++				Wolffia australiana
118	Mimulus repens											+	+ ++				Mimulus repens
119	Myriophyllum salsugineum											+	+ ++				Myriophyllum salsugineum
121	Myriophyllum verrucosum										+		+ +				Myriophyllum verrucosum
73	Schoenoplectus validus											+	35				Schoenoplectus validus
134	*Rumex conglomeratus									+++			++				*Rumex conglomeratus
127	Polygonum lapathifolium										+	+	++ +				Polygonum lapathifolium
106	Calystegia sepium										++		+ 3				Calystegia sepium
10	Azolla filiculoides										+	+	+1 + ++				Azolla filiculoides
44	Lemna minor											++	+1++5 +				Lemna minor
90	Triglochin procera									+	+ +1		+ ++++				Triglochin procera
59	Phragmites australis								++55				+ + 5555				Phragmites australis
117	Acacia retinodes													42112			Acacia retinodes
187	Amyema preissii													1++++			Amyema preissii
87	Tetragonia implexicoma													32232	+		Tetragonia implexicoma
172	Rhagodia baccata													+2+21			Rhagodia baccata
183	Leucopogon parviflorus													+11++			Leucopogon parviflorus
173	Pimelia serpyllifolia													+1++2			Pimelia serpyllifolia
55	Zygophyllum billardieri													111+1			Zygophyllum billardieri
162	Melaleuca lanceolata													4553			Melaleuca lanceolata
175	Clematis microphylla													111+			Clematis microphylla
174	Stipa flavescens													1+1 2			Stipa flavescens
123	*Oxalis pes-caprae									+				3+ +3			*Oxalis pes-caprae
161	*Lagurus ovatus													1+1 3			*Lagurus ovatus
208	Dichondra repens													+ ++			Dichondra repens
180	Threlkeldia diffusa													1+ +			Threlkeldia diffusa
184	Leptospermum laevigatum													11 1			Leptospermum laevigatum
49	*Lycium ferocissimum													3+1	+		*Lycium ferocissimum
189	*Coprosma repens													++ +			*Coprosma repens
185	*Euphorbia peplus													++ +			*Euphorbia peplus
176	*Chrysanthemoides monilifera													++ +			*Chrysanthemoides monilifera
186	*Sporobolus africanus													+++			*Sporobolus africanus
1	*Anagallis arvensis													+	++		*Anagallis arvensis
12	*Bromus sterilis													+	3+		*Bromus sterilis
81	*Sonchus asper				+										++		*Sonchus asper
11	*Bromus hordeaceus							+							++4+		*Bromus hordeaceus
53	*Melilotus indica							+1							+53		*Melilotus indica
33	*Picris echioides									+					+ +		*Picris echioides
48	*Lolium perenne X rigidum							+	+	+ +				+	1155+		*Lolium perenne X rigidum
100	Agrostis avenacea									+					43		Agrostis avenacea
116	Lythrum hyssopifolia									+					++		Lythrum hyssopifolia
77	Senecio biserratus	+															Senecio biserratus
47	Limonium australe				+												Limonium australe
129	Potamogeton pectinatus				+							+					Potamogeton pectinatus
78	Senecio glomeratus				+	+											Senecio glomeratus
2	Angianthus preissianus				2												Angianthus preissianus
19	Cotula vulgaris				1												Cotula vulgaris
75	Sebaea albidiflora				+												Sebaea albidiflora
38	Hydrocotyle capillaris				+												Hydrocotyle capillaris
39	*Hymenobolus procumbens				+												*Hymenobolus procumbens
89	Triglochin mucronata				+												Triglochin mucronata
93	Veronica gracilis							+									Veronica gracilis
27	*Fumaria vaillantii							+							+		*Fumaria vaillantii
14	*Cerastium glomeratum							+							+		*Cerastium glomeratum
13	*Bromus catharticus							+ +									*Bromus catharticus
85	Stipa stipoides							1							+		Stipa stipoides
20	*Crepis foetida							+									*Crepis foetida
109	*Homeria miniata								+								*Homeria miniata
125	*Phalaris minor								+								*Phalaris minor
108	Epilobium billardierianum									+					+		Epilobium billardierianum
126	*Plantago coronopus									+				+			*Plantago coronopus
135	*Trifolium cernuum									+					+		*Trifolium cernuum
107	Carex appressa									+							Carex appressa
124	*Phalaris aquatica									++							*Phalaris aquatica
113	Lepilaena bilocularis										+		+				Lepilaena bilocularis
105	*Callitriche sp.										+		+				*Callitriche sp.
122	Montia australasica										+						Montia australasica
56	Myriophyllum propinquum										+						Myriophyllum propinquum
130	Pratia concolor											+					Pratia concolor
110	*Hordeum geniculatum											+					*Hordeum geniculatum
128	Potamogeton ochreatus												+				Potamogeton ochreatus
92	Typha orientalis												2 +				Typha orientalis
4	Apium prostratum												+				Apium prostratum
198	Adriana quadripartita													1			Adriana quadripartita
158	Acaena anserinifolia													+			Acaena anserinifolia
179	Acacia paradoxa													1			Acacia paradoxa
42	*Hedypnois cretica													+			*Hedypnois cretica
197	*Minuartia hybrida													+			*Minuartia hybrida
196	*Catapodium rigidum													+ +			*Catapodium rigidum
182	Dianella revoluta													+ +			Dianella revoluta
188	Schoenus nitens													+ +			Schoenus nitens
181	Danthonia setacea													+ +			Danthonia setacea
196	*Catapodium rigidum													+ +			*Catapodium rigidum
210	*Hypochoeris radicata													+			*Hypochoeris radicata
209	*Asparagus asparagoides													++			*Asparagus asparagoides
211	*Stenotaphrum secundatum													3			*Stenotaphrum secundatum
177	*Ehrharta erecta													2			*Ehrharta erecta
202	Cynodon dactylon													+			Cynodon dactylon
21	*Cuscuta epithymum														+		*Cuscuta epithymum
95	*Vulpia bromoides														+		*Vulpia bromoides
63	*Polycarpon tetraphyllum														+		*Polycarpon tetraphyllum
80	*Sherardia arvensis														+		*Sherardia arvensis
35	*Holcus lanatus														+		*Holcus lanatus
6	*Arctotheca calendula														+		*Arctotheca calendula
37	*Hordeum leporinum														+		*Hordeum leporinum
50	*Marrubium vulgare														+		*Marrubium vulgare
99	*Agropyron junceiforme														1		*Agropyron junceiforme
101	Amphibromus neesii														+		Amphibromus neesii
111	Juncus gregiflorus														+		Juncus gregiflorus

Appendix 2. Checklist of vascular plant species

a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Acacia paradoxa	Hedge Wattle													r		
A. retinodes	Wirilda													c		
A. sophorae	Coast Wattle													r		
Acaena anserinifolia	Bidgee-widgee						r									
Adriana quadripartita	Rare Bitter-bush													r		
**Agropyron junceiforme*	Sea Wheat-grass				r										r	
Agrostis avenacea	Blown Grass									c						
A. billardieri	Blown Grass				r											
**Aira caryophyllea*	Silvery Hair-grass														r	
Alisma plantago-aquatica	Water Plantain												o			
Amphibromus neesii	Swamp Wallaby-grass									r						
Amyema preissii	Wire-leaf Mistletoe													c		
**Anagallis arvensis*	Pimpernel													o	c	
Angianthus preissianus	Salt Angianthus				r											
Apium annuum	Annual Celery				c	r		r								
A. prostratum	Sea Celery							o	c							
**Aponogeton distachyus*	Cape Water-hawthorn															r
**Arctotheca calendula*	Cape Weed														r	
**Asparagus asparagoides*	Smilax Asparagus													c		
**A. officinalis*	Asparagus								r							
Asperula conferta	Common Woodruff							c								
**Aster subulatus*	Aster-weed								r	c	c	c	r		c	
Atriplex australasica	Saltbush						r					r				
**A. hastata*	Hastate Orache				o	o	c	c	c	c	o	o	o		c	
A. paludosa	Marsh Saltbush			c	r	r			c							
Avicennia marina	White Mangrove		a	r	r											
Azolla filiculoides	Pacific Azolla										c	c	a			
Baumea juncea	Bare Twig-rush			r												
**Beta vulgaris*	Wild Beet								r							
Brachycome graminea	Grass Daisy								r							

Appendix 2 (cont.).

a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
**Briza minor*	Lesser Quaking-grass														r	
**Bromus catharticus*	Prairie Grass							o							r	
**B. hordeaceus*	Soft Brome							c							a	
**B. sterilis*	Barren Brome													o	c	
Bulbine bulbosa	Bulbine Lily													r		
**Callitriche hamulata*	Water Starwort									c	o					
**Callitriche sp.*	Water Starwort										r		r			
Calocephalus citreus	Lemon Beauty-heads							r								
Calystegia sepium	Large Bindweed										c		c			
Carex appressa	Tall Sedge									o						
C. tereticaulis	Sedge									r						
Casuarina stricta	Drooping She-oak													o		
**Catapodium rigidum*	Fern Grass													r		
**Cerastium glomeratum*	Mouse-ear Chickweed							o							o	
Chenopodium glaucum	Glaucous Goosefoot					o	o									
C. pumilio	Clammy Goosefoot											r				
**Chysanthemoides monilifera*	Boneseed													c		
**Cirsium vulgare*	Spear Thistle							c		o					o	
Clematis microphylla	Small-leaved Clematis													c		
**Conyza bonariensis*	Tall Fleabane														r	
**Coprosma repens*	Taupata													c		
Cotula coronopifolia	Water Buttons				c	c	c			c		a	a		c	
C. reptans	Creeping Cotula			o					c			c				
C. vulgaris	Slender Cotula				r											
Crassula helmsii	Swamp Crassula										a	a	a			
**C. natans*	Crassula										r					
**Crepis foetida*	Stinking Hawksbeard							r								
**Cuscuta epithymum*	Common Dodder				r											
Cynodon dactylon	Couch													o		
Danthonia setacea	Bristly Wallaby-grass													o		

Appendix 2 (cont.).

a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Dianella revoluta	Black-anther Flax-lily													o		
Dichondra repens	Kidney-weed													c		
**Diplotaxis muralis*	Wall Rocket														r	
Disphyma clavellatum	Rounded Noon-flower						c	a	o						r	
Distichlis distichophylla	Australian Salt-grass			a	c	o	a	a	a			r			c	
**Ehrharta erecta*	Panic Veldt Grass													o		
**E. longiflora*	Annual Veldt Grass													o		
Eleocharis acuta	Common Spike-rush									o	a	c	o		r	
E. pusilla	Small Spike-rush				r											
E. sphacelata	Tall Spike-rush												r			
Epilobium billardierianum	Robust Willow-herb									o					r	
Eucalyptus camaldulensis	River Red Gum														r	
**Euphorbia peplus*	Pretty Spurge													c		
**Festuca arundinacea*	Tall Fescue						r									
Frankenia pauciflora	Southern Sea-heath				c	a	o								o	
**Fumaria vaillantii*	Fumitory							r							r	
Gahnia filum	Chaffy Saw-sedge			r	r	r	a	r	r							
**Galenia pubescens*	Galenia														r	
Galium australe	Tangled Bedstraw													r		
Geranium sp.	Crane's-bill							r								
Halosarcia halocnemoides	Grey Glasswort					r										
H. pergranulata	Black-seeded Glasswort					c	o	r								
**Hedypnois cretica*	Cretan Hedypnois													r		
Hemichroa pentandra	Trailing Hemichroa		c	c	c	o	o	r								
**Holcus lanatus*	Yorkshire Fog														r	
**Homeria miniata*	Two-leaf Cape Tulip								r							
**Hordeum geniculatum*	Mediterraneum Barley-grass											r				
**H. leporinum*	Common Barley-grass														r	
**H. marinum*	Sea Barley				o	o	o	o	o							
Hydrocotyle capillaris	Threat Pennywort				r											

APPENDIX 2 (cont.)

a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
**Hymenobolus procumbens*	Oval Purse				r											
**Hypochoeris radicata*	Cat's-ear													o		
Hypoxis glabella	Yellow Star						r									
Isolepis cernua	Nodding Club-rush				r	r										
I. marginata	Club-rush				o	c	o			c					o	
Juncus gregiflorus	Rush									r						
J. krausii	Sea Rush		c	a	o	r	r		c							
J. pallidus	Pale Rush							r								
J. revolutus	Creeping Rush									r						
J. subsecundus	Finger Rush							r								
**Lagurus ovatus*	Hare's-tail													c		
Lawrencia spicata	Salt Lawencia						r									
Lemna minor	Common Duckweed											c	a			
L. trisulca	Ivy-leaf Duckweed												r			
Lepilaena bilocularis	Small-fruited Water-mat										o		o			o
L. cylindrocarpa	Long-fruited Water-mat											c	o			c
L. preissii	Slender Water-mat															o
Leptospermum laevigatum	Coast Tea-tree													c		
L. lanigerum	Woolly Tea-tree									r						
Leucopogon parviflorus	Coast Beard-heath													c		
Lilaeopsis polyantha	Australian Lilaeopsis				r											
Limonium australe	Yellow Sea-lavender				o											
Limosella australis	Austral Mudwort				r											
**Lolium multiflorum*	Italian Rye-grass														r	
**L. perenne* x *rigidum*	Rye-grass							o		c				o	a	
**Lycium ferocissimum*	African Box-thorn													c	o	
Lycopus australis	Australian Gipsywort										o					
Lythrum hyssopifolia	Small Loosestrife									o					o	
**Marrubium vulgare*	Horehound														r	
Marsilea hirsuta	Short-fruit Nardoo									r	r					

Appendix 2 (cont.).

a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
**Medicago polymorpha*	Burr Medic						o	c	r					o	c	
Melaleuca lanceolata	Moonah													a		
**Melilotus indica*	Sweet Melilotus							c							c	
Microlaena stipoides	Weeping Grass							r								
Mimulus repens	Creeping Monkey-flower											o	c			
**Minuartia hybrida*	Fine-leaved Sandwort													r		
Montia australasica	White Purslane										r					
Muehlenbeckia cunninghamii	Tangled Lignum								c	a		r			o	
Myoporum insulare	Common Boobialla													r		
Myriophyllum muelleri	Hooded Water-milfoil															o
M. propinquum	Common water-milfoil										o					
M. salsugineum	Water-milfoil											o	c			c
M. verrucosum	Red Water-milfoil										o		c			o
**Oxalis pes-caprae*	Soursob													c		
**Parapholis incurva*	Coast Barb-grass				r											
Paspalum distichum	Water Couch										a	a	c			
**Pennisetum clandestinum*	Kikuyu Grass														r	
**P. villosum*	Feathertop														r	
**Phalaris aquatica*	Towoomba Canary-grass									c						
**P. minor*	Lesser Canary-grass								r	r						
Phragmites australis	Common Reed								o				a			
**Picris echioides*	Ox-tongue														r	
Pimelea serpyllifolia	Thyme Rice-flower													c		
**Plantago coronopus*	Buck's-horn Plantain														r	
**P. lanceolata*	Ribwort Plantain													o		
Poa labillardieri	Tussock Grass									o						
P. poiformis	Blue Tussock Grass						r	a								
**Polycarpon tetraphyllum*	Four-leaved Allseed														r	
Polygonum lapathifolium	Pale Knotweed										o	o	c			
**Polypogon monspeliensis*	Annual Beard-grass				c	o			r	c		r			c	

Appendix 2 (cont.).

a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Potamogeton crispus	Curly Pondweed															o
P. ochreatus	Blunt Pondweed												o			o
P. pectinatus	Fennel Pondweed				r											
Pratia concolor	Poison Pratia											r				
P. platycalyx	Salt Pratia				r											
Puccinellia stricta	Australian Saltmarsh-grass				c	c									r	
Ranunculus rivularis	Small River Buttercup										o	c	c			
R. trichophyllus	Water Buttercup				r											r
**Raphanus raphanistrum*	Wild Radish														r	
**Rapistrum rugosum*	Giant Mustard														r	
Rhagodia baccata	Seaberry Saltbush													a		
**Rhamnus alaternus*	Italian Buckthorn													r		
Rumex bidens	Mud Dock										c	c	o			
**R. conglomeratus*	Clustered Dock									o	o					
**R. crispus*	Curled Dock						o	o	c	a		o			c	
Ruppia maritima	Sea Tassel															c
Samolus repens	Creeping Brookweed		c	c	c	c	o		o						r	
Sarcocornia blackiana	Thick-head Glasswort				r											
S. quinqueflora	Beaded Glasswort	o	c	a	a	a	a	o	c	r		r			c	
Schoenoplectus pungens	Club-rush				r				r	o	o	a	r		r	
S. validus	River Club-rush												o			
Schoenus nitens	Shiny Bog-rush													o		
Sclerostegia arbuscula	Shrubby Glasswort			r	o	a									r	
Sebaea albidiflora	White Sebaea				r											
Selliera radicans	Selliera			c	o		c	o	o							
Senecio biserratus	Jagged Fireweed	r														
S. glomeratus	Annual Fireweed						r									
S. lautus	Variable Groundsel								r	c	o	o	r		o	
**Sherardia arvensis*	Field Madder														r	
**Silene gallica*	French Catchfly														r	

Appendix 2 (cont.).

a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
**Solanum nigrum*	Black Nightshade														r	
**Sonchus asper*	Rough Sow Thistle														o	
**S. oleraceus*	Sow Thistle				r	r	c	c	c	c			r	c	c	
**Spergularia marina*	Salt Sand-spurrey											r				
S. media	Coast Sand-spurrey				r											
**Sporobolus africanus*	Rat-tail Grass													c		
Stellaria palustris	Swamp Starwort							o			o	c				
**Stenotaphrum secundatum*	Buffalo Grass													o	o	
Stipa flavescens	Coast Spear-grass													c		
S. stipoides	Prickly Spear-grass						o									
Suaeda australis	Austral Seablite		c	c	c	c	c									
**S. baccifera*	Seablite					r										
Tetragonia implexicoma	Bower Spinach													a	r	
Themeda australis	Kangaroo Grass							r								
Threlkeldia diffusa	Coast Bonefruit													c		
**Tragopogon porrifolius*	Salsify														r	
**Trifolium cernuum*	Drooping-flower Clover									r					r	
**T. scabrum*	Rough Clover													r		
Triglochin minutissima	Tiny Arrowgrass				r											
T. mucronata	Prickly Arrowgrass				r	r										
T. procera	Water-ribbons									c	c		c			
T. striata	Streaked Arrowgrass	r	c	c	c	c	c		c		o	c			o	
Typha orientalis	Bulrush (Cumbungi)												a			
Urtica urens	Small nettle									c						
Vallisneria gigantea	Eel-weed															o
Veronica gracilis	Slender Speedwell							o								
**Vicia sativa*	Common Vetch							c							c	
Villarsia reniformis	Running Marsh-flower											o	c			
**Vulpia bromoides*	Squirrel-tail Fescue													c		
Wilsonia backhousei	Narrow-leaf Wilsonia	o														

Appendix 2 (cont.).

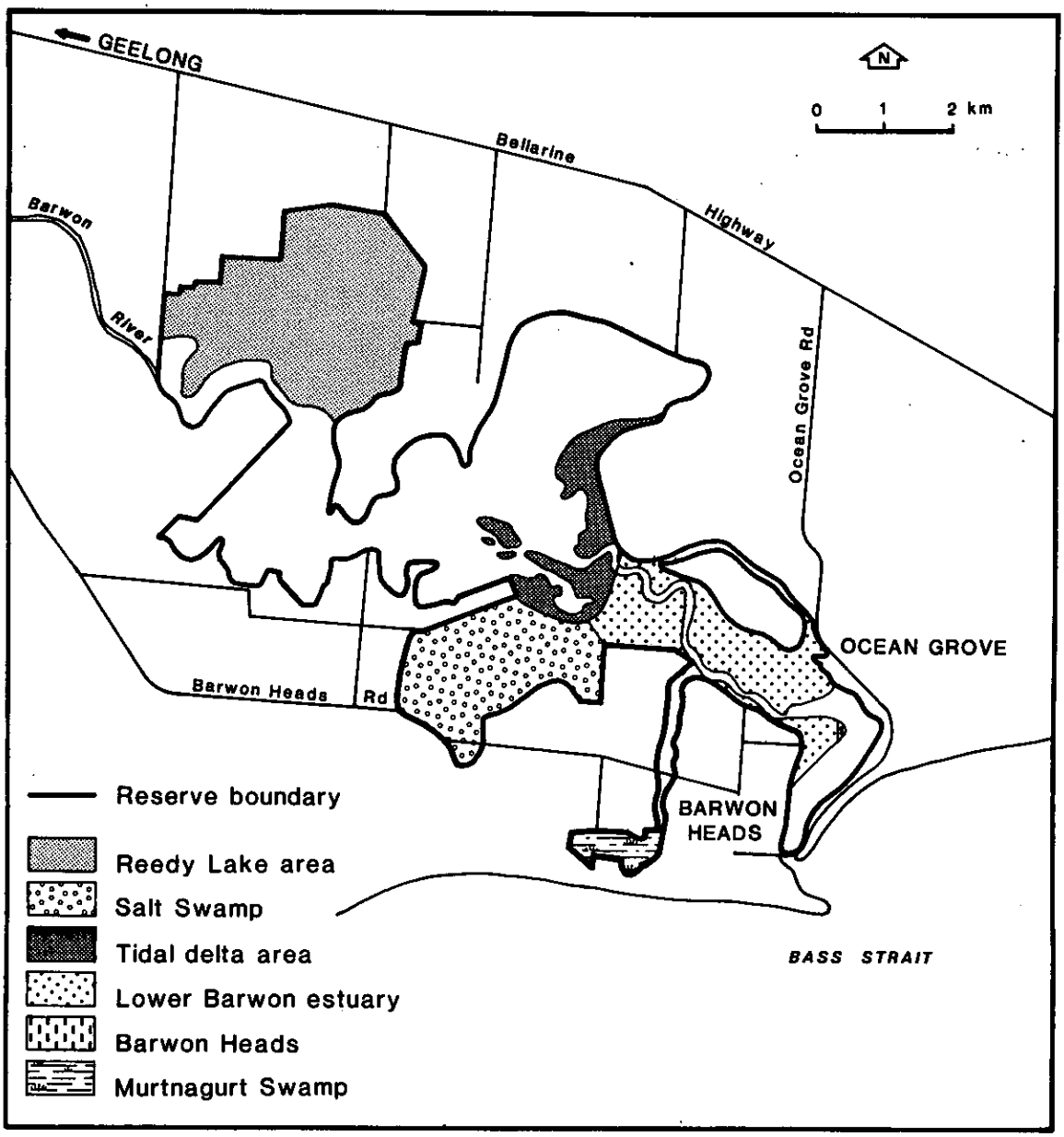
a = abundant, c = common, o = occasional, r = rare, * = exotic

Species	Common name	Vegetation unit														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
W. humilis	Silky Wilsonia	a														
W. rotundifolia	Round-leaf Wilsonia	o														
Wolffia australiana	Tiny Duckweed												c			
Zostera muelleri	Dwarf Grass-wrack															r
Zygophyllum billardieri	Coast Twin-leaf													c		

Appendix 3. Areas of importance for flora conservation

No.	Site	Feature
1	Reedy Lake area	Reedy Lake is the largest freshwater marsh in central Victoria. It supports exceptionally diverse wetland vegetation. Grassy climax vegetation along the levee of the Barwon River is of particular interest.
2	Salt Swamp	Extensive area of unusual salt marsh and subsaline marsh vegetation. Contains examples of several communities that are uncommon in Victoria. The large area of *Wilsonia humilis* herbland at the southern end of the swamp is of outstanding significance.
3	Tidal delta area	Contains one of the largest active tidal deltas supporting terrestial vegetation in Victoria. Of outstanding significance.
4	Lower Barwon estuary	Extensive area of undisturbed mangrove, wet salt marsh and subsaline marsh vegetation. The occurrence of *Distichlis distichophylla* grassland along the levees of the Barwon River is of particular importance.
5	Barwon Heads	Unusual occurrence of *Sarcocornia* salt marsh seaward of mangrove belt. Possibly unique.
6	Murtnagurt Swamp	The reserve's centre of salt marsh floristic richness. The annual flora is particularly species-rich.

Appendix 3 (cont.).



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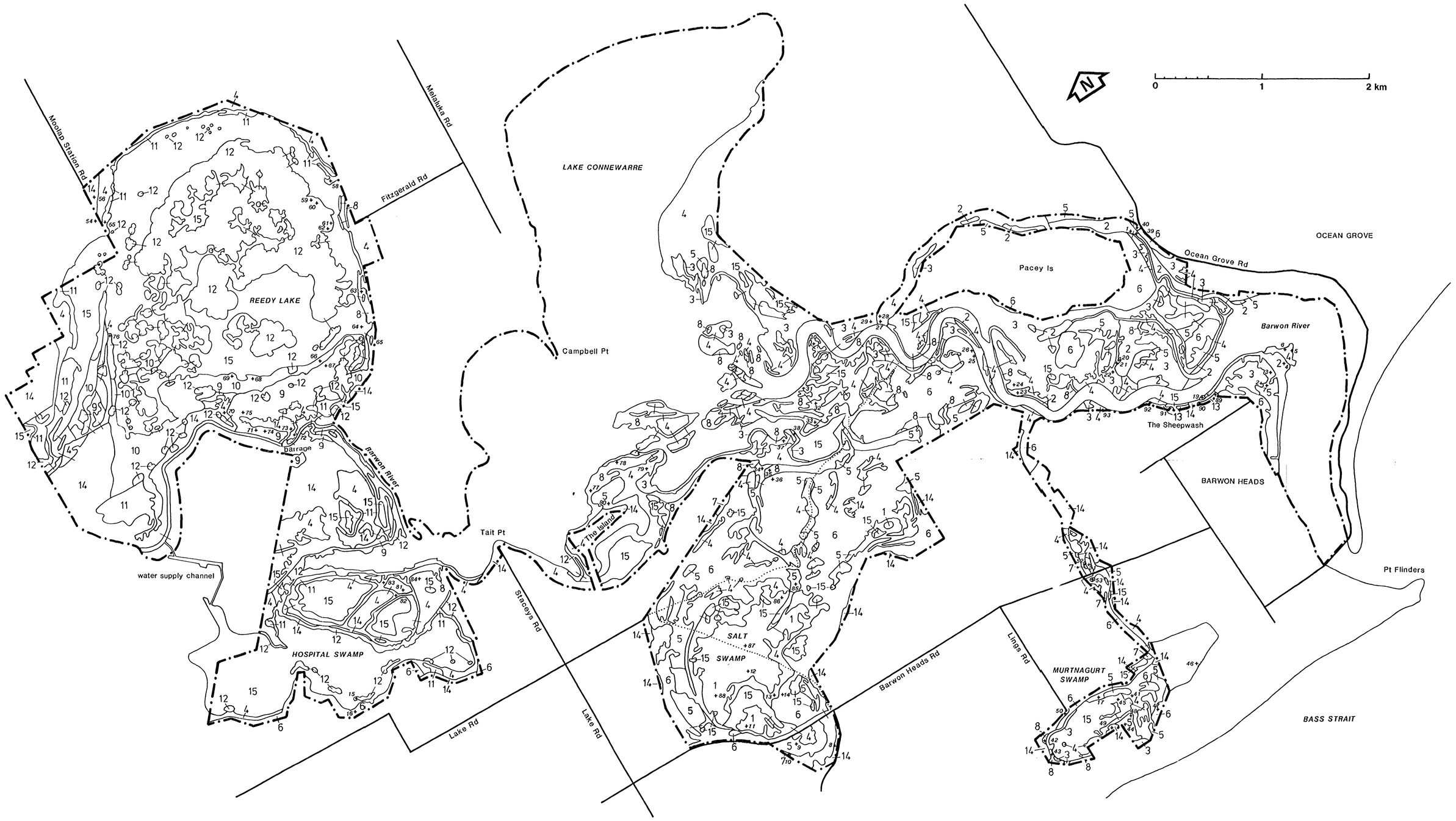
LAKE CONNEWARRE STATE GAME RESERVE - FLORISTIC VEGETATION



LEGEND

1 *WILSONIA HUMILIS* HERBLAND
2 *AVICENNIA MARINA* SHRUBLAND
3 *JUNCUS KRAUSSII* RUSHLAND
4 SAMPHIRE HERBLAND
5 SAMPHIRE SHRUBLAND
6 *GAHNIA FILUM* SEDGELAND
7 *POA POIFORMIS* GRASSLAND
8 *DISTICHLIS DISTICHOPHYLLA* GRASSLAND
9 *MUEHLENBECKIA CUNNINGHAMII* SHRUBLAND
10 *ELEOCHARIS ACUTA* SEDGELAND
11 *SHOENOPLECTUS PUNGENS* SEDGELAND
12 *PHRAGMITES AUSTRALIS* REEDSWAMP
13 *MELALEUCA LANCEOLATA* SCRUB
14 EXOTIC VEGETATION
15 BARE AREAS

QUADRAT LOCATIONS: +

RESERVE BOUNDARY (approx.): —·—·—·—

Map compiled by J.Z. Yugovic, May 1984,
from 1: 18 500 colour aerial photography
Scale: 1: 18 500, not planimetrically corrected

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