Goolwa to Wellington Local Action Planning Board Inc, Coorong & District Local Action Plan Committee & Department for Environment & Heritage

Sustainable Grazing to Promote Ramsar Values around the Lower Murray Lakes

5502031 – R007

December 2002

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REPORT

Job 5502031

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1 Introduction

The Lower Murray Lakes region includes a range of habitats that are very highly valued as waterbird habitat. Although the River Murray is counted as the world's fourth longest river and covers 14% of Australia's landmass it has a low discharge. Rather than entering the sea across a large delta formation, it first spills out into two shallow, terminal lakes, Lake Albert and Lake Alexandrina, where its waters are trapped behind the sea by a barrier formed by sand dunes. The waters of these lakes and that of the adjacent Coorong lagoons, finally find their way to sea through a gap in the dune barrier, between the Younghusband and Sir Richard peninsulas.

The Coorong and Lower Murray Lakes, Albert and Alexandrina, together with the islands in the lakes, were declared a Wetland of International Importance in 1985 under the Ramsar Convention (DEH, 2000). The Ramsar area includes the land adjacent to the Lakes, adjacent saline swamps and floodplains, when they are within the area inundated by the 1956 flood. As party to this convention, a management plan was prepared that promotes the wise use and conservation of their ecological character (DEH, 2000). The concept of wise use, according to the Ramsar definition, is sustainable utilization of the wetland for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem (Ramsar Convention Bureau, 1997).

Grazing is one of the major land uses around the lakes of the lower Murray River. The lake edge is highly valued for its summer feed and availability of permanent fresh water. The perceived impact of livestock grazing around the Lower Lakes, and consequently its sustainability, is not currently uniform within the community. There are strong commercial and social reasons given for continuing this practice by local community members, some of whom also believe, that grazing is not only sustainable, but essential to maintain a range of habitats for some Ramsar bird species. There are also equally strong views held by others, that stock should be excluded from the lake edge on the grounds that the practice of grazing damages habitat, reduces edge stability and threatens water quality.

The aim of this project was to investigate and provide information on grazing management as it relates to the protection and enhancement of Ramsar values, water quality and control of lakeshore erosion and through this investigation meet the following detailed objectives.

- Assess and compare the perceived and actual value of the lake edge for grazing.
- Assess the impact of grazing on lakeshore erosion and water quality.
- Provide detailed information on the impact of grazing on the habitat vale of the lake edge for flora and fauna communities and in particular as it relates to biota covered by the Ramsar Convention.
- Provide an evaluation of the sustainability of existing stock management on the lake edge and identify and investigate possible alternative management methods.
- Use results of the above investigation to provide recommendations for sustainable grazing practices and future sustainable management of Ramsar habitat within the Lower Lakes region.
- Identify knowledge gaps in our understanding of the sustainable use of the Ramsar area.

In order to assess the current impact of grazing on Ramsar habitat and how grazing in this system might be carried out so as to sustain it, it is essential to understand the nature of the habitat covered under the Ramsar Convention. In general the habitat covered by this study is radically altered habitat as a result of the changes in land use since European settlement and the subsequent regulation of the Murray River flows and lake levels. It includes only a few remnants of the largely estuarine adapted, lake swamp vegetation (pre barrage construction) and few intact areas of fringing highland or saline and freshwater floodplain vegetation.

The Ramsar Convention therefore covers an area of very much modified and depleted habitat in the lower lakes area and these changes are discussed in detail in Section 3. Consequently, this study of grazing impacts on Ramsar habitat deals specifically with the formerly estuarine areas of the lakes behind the barrages that are now maintained as a freshwater system by impounding Murray flows. It includes the many islands within the lakes (several of which straddle the divide between Murray Mouth and Lake), the freshwater lake edges, the adjacent inland swamps, sandhills, limestone cliffs, their fringing samphire floodplains and the freshwater, riverine areas at the mouth of Currency Ck, Finniss R., Angas R., and Bremer R.

MAP 1 HERE – showing rivers and entries to the lakes etc, study area, towns etc

2 Methods

2.1 Investigation of Ramsar Habitat & It's Use by Fauna

A number of investigation methods were used to investigate the current status of Ramsar habitat and how fauna uses it. Penny Paton and Nigel Mallen assisted Janet Pedler in gathering relevant information for this investigation, interpreting it and summarising it. P. Paton drew on her extensive knowledge of waterbird feeding behaviour and published material, to produce the summary tables of preferences in habitat, food and foraging behaviour given in section 5.

Various properties and key habitat sites were visited over the course of the study to gain information on particular issues. Key community members were interviewed where it was ascertained that they held key knowledge on many different aspects of the Lower Lakes environment while other specialist researchers were contacted on a *as needs* basis to provide other detailed information.

2.2 Investigation of Grazing Regimes & Impacts Investigation

There were four main activities in investigating the grazing of lake edges:

- Literature review on the effects of grazing – conducted by A Herzberg, Earth Tech
- Producer meetings.
- Visits to key landholders and their properties to
- Inspection and testing of the different species of plants grazed on lake edges.

The latter three activities were carried out by Simon Ellis and Janet Pedler with field assistance given by Tim Murphy.

2.1.1 Producer Meetings

Two producer meetings were held at Meningie and Clayton to determine:

- What are current grazing practices of the lake edges?
- What are community attitudes to grazing the lake edges?

Landholders from the dairy, sheep and cattle industries plus small-area landholders were invited to half-day workshops. Their attitudes to grazing lake edges were determined by:

- A scene-setting field visit to typical grazed, lake edges.

Plate 2.1 Landholder meeting at Meningie inspects lake edge damage

- A pre-workshop personal questionnaire (Appendix 1).
- A brief technical presentation.
- Small group (3-4 people) discussions addressing two issues each. The questions
  discussed are given in Appendix
- Full group discussion of the issues considered in the small groups.

The agenda for the producer meetings (including topics discussed), the pre-discussion survey are attached as appendices 1 and 2 respectively.

2.1.2 Visits to and Interviews with Key Producers

An attempt was made to visit as many major areas of Ramsar habitats on grazing properties as was possible. Although not all major areas were covered a large number were and the range included sites throughout the Lower Lakes area which differed widely on the type of habitat they contained, the grazing regimes being implemented on them and the aims of the producers. In addition during the course of the study other important issues emerged from the landholder workshops or landholder comments that were best investigated by visits to relevant properties.

2.1.3 Investigation of Plant Species Productivity and Quality

The productivity of selected plant species growing on the lake edges were measured by quadrat cuts. One quarter metre square quadrats were harvested to water or ground level with hand shears. Sites were selected to obtain pure stands of a single species to give specific information.

Plate 1. 2 Cutting lake edge plants for quality and quantity estimations.

The quality of plant species was measured by submitting selected samples to the Feedtest Laboratory (Department of Natural Resources and Environment at Hamilton, Victoria). Samples from each species were sorted into qualities where the structure of plants varied significantly. Analyses were for energy, protein, digestibility and dry matter.

3 Literature Review of the Impact of Livestock Grazing on Riparian Areas

Introduction

Riparian is defined here as 'that part of the landscape which exerts a direct influence on stream channels or lake margins and on water and aquatic ecosystems contained within them' (Bunn & Price, 1993).

The literature review undertaken as part of this project has found that there is very little literature relating to the impact of grazing on lake edges, while there is a wide range of studies that deal with grazing impact on the riparian zones of watercourses or stream channels. The impact of grazing on wetlands is generally better covered and, although much of the literature on the topic acknowledges the impact of stock on the wetland systems, there is little primary data on the way stock influence wetland ecology (Robertson, 1997). In summary most of the literature found on the impacts of grazing in riparian zones is related to lotic (flowing) riverine systems where the effects of varying flow velocities and water levels are most influential.

Furthermore, whilst the general literature relating livestock grazing on riparian areas is considerable, experimental studies with statistically valid results are rare. In a review of over 1500 articles relating to grazing impacts on the riparian zone by Larson *et al*, (1998), only 89 of these were found to be experimental.

A large proportion of the literature is concerned with the impact of cattle. Cattle are thought to cause greater damage in riparian areas than other livestock due to their increased habitation of the riparian zone. As most of the livestock grazed around Lakes Alexandrina and Albert are cattle, this literature bias is useful and this review reports on the impacts of cattle unless otherwise stated. The impacts of related management activities on the riparian zone are also examined.

The available literature reviewed in this study showed the impacts of livestock grazing on riparian zones falls into two main categories: direct impacts, such as trampling or feeding damage, or indirect such as impacts on water quality or changes in vegetation diversity. The literature investigating these two damage categories are reviewed below.

3.1 Direct Impacts of Livestock Grazing on Riparian Areas

Several studies have demonstrated that riparian and wetland habitats suffer from grazing more than dryland habitats because stock tend to concentrate around water sources (Bryant, 1982; Gary *et al*, 1983; Trimble and Mendel, 1995; Robertson, 1997; James *et al*, 1999). Clary and Medin (1990 reported in Fitch and Adams, 1998) estimated that the time livestock spend in riparian areas may be 5 to 30 times longer than expected based on the limited extent of the riparian zone alone.

On this basis, riparian zones are particularly prone to direct impacts of grazing pressure during summer when in the riparian zones relative to other grazing areas, there are higher volumes of feed vegetation that is of higher palatability, only short distances to walk to access drinking water and a greater availability of shade (Trimble & Mendel, 1995).

The direct impacts of livestock grazing on riparian areas have been found to include:

- Consumption and trampling of standing riparian vegetation,

- Removal of regenerating riparian vegetation,
- Changes in riparian vegetation composition due to selective feeding,
- Damage to banks from hoof shear and/or 'pugging' of ground in shallow water,
- Change in water quality from cattle manure,
- Physical disturbance to wildlife.

3.1.1 Trampling and Consumption Damage to Riparian Vegetation

Cattle can have direct impacts on riparian vegetation as a result of trampling damage and consumption of vegetation. Trampling impacts include broken branches, ringbarking of trees from rubbing and crushing of seedlings (ID&A, 1999). Platts and Nelson (1985, in Trimble and Mendel, 1995) reported that grazing of riparian areas could remove up to 80% of riparian vegetation. Littoral vegetation (growing along the water's edge) is at particular risk from damage as it is this area that is most often disturbed by cattle tracking.

Livestock with access to riparian zones will not only damage the existing vegetation but also limit the potential regeneration of these areas as they trample and consume seedlings. The majority of experimental literature in this area has focused on the regeneration of riparian vegetation with and without grazing pressure.

The limited regeneration of river red gum (*Eucalyptus camaldulensis*) in South Australia has been attributed to grazing. Venning (1984) and Kiddle (1987) observed that regeneration of this species only occurs in areas such as islands, reedbeds or dense stands of lignum that provide protection from grazing.

In a study to examine the effects of livestock on riparian zone vegetation along the Murrumbidgee River, Robertson and Rowling (2000) noted that seedling and saplings of dominant *Eucalyptus* species in riparian areas were up to 3 times more abundant in areas with no stock access. Jansen and Robertson (2001) developed a rapid assessment index for classifying riparian condition. Many sites classed as poor (which significantly correlated with livestock grazing) had very little or no regeneration of the dominant canopy *Eucalyptus* species.

Webb and Erskine (1999) noted that the lack of regeneration of seedlings in the Hunter Valley was partly attributed to the seedlings being trampled by stock.

3.1.2 Changes in Vegetation Composition

Grazing can alter the species and structural composition of vegetation communities as a result of both trampling and feeding.

Livestock can alter the floristic composition of riparian vegetation by selective feeding (Wilson and Harrington, 1984). Changes in species composition can involve minor changes to the relative abundance of species, but others can cause irreversible change with original species disappearing and new species colonising (Margules and Partners *et al*, 1990).

Robertson and Rowling (2000) showed that grazing has resulted in significant differences in plant community composition between riparian areas along the Murrumbidgee River with and without stock. They found that understorey species richness was controlled most by the density of canopy-forming eucalypt species. Since grazing animals actively removed regenerating canopy species it suggested that grazing impacts did ultimately control the understorey species richness and composition through their negative impacts on regenerating canopy species.

Height of woody vegetation tends to increase once grazing has ceased. Green and Kauffman (1995), documented significant increases in the mean height of woody plant species ten years after grazing ceased. This correlates with the impact that grazing livestock have on regenerating seedlings.

3.1.3 Bank Damage

Often the most visible immediate damage from livestock grazing in riparian zones is damage to banks as stock approaches the water's edge. Severe pugging adjacent to the water's edge is common where stock graze riparian areas, particularly in dispersive soils that loose their structure when wet and are then subject to surface pressure. Hoof forces can result in slices of bank material up to 10cm thick being sheared off (Trimble and Mendel, 1995).

The removal of riparian vegetation as a result of trampling damage and consumption leaves riparian banks with less stabilising root systems in place and therefore more susceptible to damage, particularly in areas where erosive forces from wind and wave action are already high.

3.1.4 Water Quality

As cattle spend a disproportionate amount of time adjacent to or at the water's edge, a disproportionately high amount of animal waste (manure and urine) is deposited directly into waterbodies. These contribute phosphorous, nitrogen, bacteria and viruses to the water, which have subsequent impacts on aquatic ecosystems (Land and Water Resources, 1996). In addition the turbidity of water increases with the addition of animal faeces and suspended solids released by hoof damage to banks.

These impacts and the effect of runoff from grazing areas are discussed further in section 4.3.

3.1.5 Wildlife Disturbance

The tendency of livestock, in particular cattle, to spend large proportions of time adjacent to sources of water means that they cause on-going disturbance to feeding and breeding sites.

It is generally agreed that bird populations respond to changes in vegetation structure as a result of grazing, rather than only as a direct response of the presence of stock (Bock and Webb, 1984 reported in Knopf *et al*, 1998). Trampling damages habitat and potential nesting sites for water birds in the near-shore environment. Damage to vegetation through trampling and feeding reduces plant material for consumption by fauna, limits the invertebrate fauna present as prey items for predatory species, reduces habitat and shelter available to wildlife.

3.1.6 Specific Reported Impacts of Grazing on the Lower Lakes

Substantial trampling impacts from grazing have resulted in severely damaged wetland vegetation around the Lower Lakes (Pillman, 1980). In particular, heavy grazing and trampling on Mundoo, Ewe and Tauwitcherie Islands have impacted plant communities. Greatest impact has been to supratidal plant communities where palatable species such as *Atriplex paludosa* have been significantly reduced. (Edyvane *et al*, 1996). Overgrazing in some areas has resulted in severe pugging (DEH, 2000).

3.2 Indirect or Secondary Impacts of Livestock Grazing on Riparian Areas

Many of the impacts caused directly by grazing in riparian areas have subsequent impacts on riparian areas. These indirect, or secondary impacts, have been classed as indirect impacts, and include changes to:

- Riparian vegetation,
- Soil stability,
- Water Quality;
- Aquatic Ecosystems, and
- Habitat use by fauna,
- Species composition of fauna

3.2.1 Riparian Vegetation

Indirect changes to vegetation condition as a result of grazing include changes in vegetative biomass, plant vigour, vegetation condition, species diversity, regeneration, and weed infestation.

The replacement of perennial species by annuals is a typical change to land subject to grazing (Wilson and Harrington, 1984). Grazing creates disturbance that can lead to condition suitable for weed species to thrive. Trampling and hoof damage can create open areas where weeds can establish.

Overseas studies from New Zealand (Dobson, 1973) and Oregon, USA (Evenden and Kauffmann cited in Kauffman and Kreuger, 1984) have reported increases in weeds in riparian zones as a result of grazing.

The high levels of disturbance present in riparian areas due to stock removing plants, trampling perennial rootstock and creating patches of bare earth through hoof damage, creates an ideal environment for the establishment of weed species (Land and Water resources, 1996). Stock can also be vectors for weed transport and establishment, both internally via seed expelled in faecal material, and externally by seeds carried on the animal’s coat (OCE, 1991).

3.1.2 Soil Stability

Grazing by livestock can impact directly on soil structure and therefore indirectly on soil stability. An increase in compaction of soils may result in increased runoff and a greater potential for soil erosion by water. Such loss of structure also results in decreased infiltration of water and may increase susceptibility to erosion by wind and water. Trampling by livestock has been shown to increase soil compaction, which leads to reduced absorption and increased overland flow (Pettit *et al*, 1998; Trimble and Mendel, 1995). The erosion impacts of trampling have been positively correlated with soil moisture (Marlow and Pogacnik, 1986).

Grazing can also accelerate soil erosion as a result of loosened soil particles making it more susceptible to wind erosion and erosion through wave or current action. Several studies have shown significantly greater sediment losses from grazed stream banks compared with ungrazed banks (Platts, 1991; Myers & Swanson, 1992; Trimble, 1994 cited in Trimble and Mendel, 1995).

3.1.3 Water Quality

Indirect grazing impacts on water quality include increased sediment and turbidity caused by disturbance to soils on banks and bed, deposition of faecal materials that increases nutrients and faecal coliforms in runoff, and increased temperature of shallow water resulting from less shade producing overhanging and emergent vegetation.

As livestock moves across lake edges, bank material is compressed, sheared and pushed towards the water. This material can be transported into deeper water by runoff from adjacent land and by wave action (Trimble and Mendel, 1995). Increased sediments in lake waters increase the turbidity and potential for greater nutrient storage (Bourman, 2000).

Increased turbidity decreases light penetration in lakes, rivers and streams. This in turn reduces growth and productivity of submerged and floating plants, which indirectly affects the populations of invertebrates, fish and birds in the lakes (Paton 2000, Lovett & Price 1999) and directly impacts on invertebrate filter feeders and phytoplankton.

A relationship between algal bloom development and grazing has been established and it has been suggested that cattle activities have the potential to increase the likelihood of algal blooms in Australian rivers (Harris **DATE**, Prosser et al. in Lovett & Price 1999).

3.1.4 Aquatic Ecosystems

Lakes such as those of the lower Murray River support significant populations of invertebrates that are important food for birds and fish. High levels of sedimentation can fill pools and scour holes near the banks, decreasing substrate variation and limiting habitat for aquatic fauna (Koehn & O'Connor 1990).

Increased turbidity decreases the growth and productivity of submerged aquatic plants, which reduces food and habitat sources for aquatic invertebrates and plants This in turn impacts on other invertebrates, fish, frogs and birds by reducing diversity and biological production of whole communities (Lovett & Price 1999, Paton 2000).

3.1.5 Regional Effects on Wildlife

Riparian ecosystems provide food, shelter and habitat for a wide range of wildlife. Decreases in fish, birds, other invertebrate species diversity and population in riparian vegetation have been reported as resulting from disturbances to riparian areas. When riparian vegetation is removed, those species dependant on riparian ecosystems may be greatly reduced or even disappear from those areas.

Henke and Stone (1978, cited in Kauffman and Kreuger 1984) found 93% fewer bird numbers and 72% fewer bird species along 2 sections of the Sacramento River (USA) where riparian vegetation had been removed. In another study in North America, avian species richness and relative abundance was found to increase significantly following the removal of stock from riparian areas (Dobkin *et al* 1998). It concludes that the revival of avian populations was linked to the recovery of riparian vegetation, which was a consequence of livestock removal.

The mobile nature of most wildlife species means that when riparian habitat is removed, manipulated or damaged, the impact on wildlife can extend beyond the riparian zone. Wildlife productivity in adjacent areas can be depressed following changes to riparian vegetation (Kauffman & Kreuger 1984). Where riparian areas are part of wildlife corridors and terrestrial territories, alteration or removal of riparian vegetation increases the predation risk to terrestrial fauna.

3.3 Impacts of Livestock Management Activities on Riparian Areas

There are a number of landuses that contribute to an increase in the supply of nutrients and sediments to watercourses and lakes. While the grazing and removal of riparian vegetation plays a direct role in allowing these nutrients to enter the water uninterrupted during runoff events, the presence of grazing animals on adjacent slopes increases the amount of nutrients in close proximity to streams, rivers and lakes (Lovett & Price 2000). Where fertilisers are applied to adjacent pastures this process is exacerbated further and the volume and velocity of runoff increases where cropping and cultivation to produce feed and hay for livestock removes all vegetative cover adjacent to the riparian zone. Cropping also precludes the growth of perennial plants whose root growth might otherwise succeed in stabilising riparian soils and adjacent slopes. While irrigation of pasture on slopes adjacent to the riparian zone is likely to increase the likelihood of fertilisers and pesticides entering the riparian zone.

3.4 Impacts of Grazing on Lakeshore Erosion

Lakeshore erosion on the Lower Murray Lakes is caused by of a combination of artificially high water levels, wave effects (due to wind and high fetch distance) and highly erodible soils on the lakeshore (ID&A, 2001b). Although grazing is not considered to be a primary cause of lakeshore erosion on the Lower Murray Lakes, grazing has been found to have a significant impact on littoral vegetation and cause a decrease in lake edge stability.

The relationship between lakeshore erosion and littoral vegetation was investigated as part of a study of lakeshore erosion around the Lower Murray Lakes by ID&A (2001a,b). Littoral vegetation plays a very important role in stabilising lakeshores. Reeds, rushes, sedges and other species that grow on the lake edge provide protection for the banks (ID&A, 2001a) by providing the following functions:

- Offshore stands of emergent aquatic vegetation dampen wave energy thereby reducing the force of waves reaching the shore;
- Root masses of vegetation hold together and stabilise eroding soils; and
- Emergent stems and leaves capture sediments in the water and the resultant deposition rebuilds the lake edge.

Where littoral vegetation still exists, a decline in reed populations and an increase in bank erosion are almost inseparable processes. Furthermore, they are often symptomatic of interconnected changes such as lakeshore development, grazing and damage from introduced species, water level changes, wake from boats and altered sedimentation rates (Ostendorp *et al.* 1995).

In many areas, reed decline is the first link in a chain of events that may lead to a deterioration of the lakeshore ecosystem. These processes (Ostendorp *et al.* 1995) often include:

- Lack of bank protection which leads to erosion and drift of sediments,
- Uprooting of near-shore trees and bushes and the extinction of submerged vegetation,
- Reduction in the population size of the phytophyllic fish species, and
- Disappearance of bird species.

The grazing of stock has been shown to make a significant contribution to the removal of littoral vegetation around the lakeshores and, at high stocking rates, effectively preventing regeneration of reeds, rushes and sedges (ID & A 2001a). Both these changes drastically reduce the protective covering of vegetation along the shoreline and therefore its stability, thereby contributing to lakeshore erosion.

4 Description and Condition of Ramsar Habitat Plant Communities

Summary of Change in Lower Lakes Habitat

In order to understand the effects grazing may have on habitat, it is essential to identify the following.

1. What habitat is actually covered under the Ramsar Convention.
2. How it might have changed in recent years.
3. How it was formerly used by fauna.
4. How it is currently being used by fauna.

Before the advent of river regulation, the Murray-Darling River system delivered highly variable flows to the Lower Lakes and to some degree, to the Coorong system. Together the lakes and Coorong acted as a huge estuarine system which would have varied greatly, both seasonally and over long periods of time, in its salinity, standing levels, flow regime and ability to interchange water with the sea (DEH 2000, Paton in Jensen et al. 2000). An example of this variability illustrates the wide range of conditions likely to be present within this natural system over time: seasonally, low flows from the River Murray created a generally estuarine environment in the lake water and when extreme drought conditions prevailed in the upper reaches of the river the result could include incursions of seawater up into the Murray River itself past Wellington. Conversely, sporadic and extremely wet periods in the Murray-Darling catchment combined with local high rainfall that caused the other rivers entering Lake Alexandrina to flow strongly, could result in a freshwater flushing of the system.

In this generally saline environment, it appears unlikely that reed beds were extensive but were restricted to several areas where there were regular, seasonal, freshwater flushes from major watercourses such as the Finniss, Bremer and Angas Rivers, Currency Ck and the Murray River. Much anecdotal evidence exists to support this picture, e.g. John Eckert pers.comm. (2002). The extensive areas of swamp that did exist would have been largely semi-saline in nature, and depending on location, would have been classified mainly as Samphire Swamp or Swamp Paperbark Swamps *Melaleuca halmaturorum.* These swamps would have included a rich diversity of rush, sedge and other plant species and supported a diverse faunal community. Their other most important feature, besides their estuarine nature, was their variable, but largely shallow, water levels.

River Murray water regulation began in the 1880's and has continued to the point where only one third of the original flow reaches the sea, (Edyvanne et al. 1996). With the construction of barrages across the tidal channels of the Lower Lakes that separate the lakes from the Coorong and from the Murray Mouth, salt water no longer enters the lakes and they now hold permanently freshwater at a very much raised lake level. Conversely, the Murray Mouth estuarine area is now restricted to the Coorong and the area immediately below the barrages. Overall, significant estuarine habitat has been lost and has been replaced by freshwater habitat.

Long before the barrages came into operation European settlement had caused drastic modification to the landscape fringing the lakes. Grazing sheep and cattle among native vegetation on pastoral runs, clearing land for grazing and cropping and later irrigation, removed the majority of "highland" vegetation, *Allocasuarina* *verticillata* and Eucalypt woodlands, around the lakes well before the time Pillman (1980) reported on the health of Lake Alexandrina and Lake Albert as the first in a series of surveys of River Murray wetlands. Similarly the Red Gum and Woolly Tea-tree swamps associated with the entry of the Finniss River, Currency Creek, Angas River and Bremer River to Lake Alexandrina were heavily altered by grazing and timber cutting before barrage construction. The introduction of rabbits to the region during the 19th Century and their subsequent population explosion was also a crucial part of the decline of native vegetation coverage and its ability to regenerate. Myxomatosis was introduced to the Lakes and Coorong region in 1950, and there was a fall in rabbit numbers to 20% of their former population by 1953 (Noye 1974), but even after this rabbits have remained a potent inhibitor of regeneration.

With all these changes in native vegetation, the introduction of feral predators like the fox in the 1890's (Eckert in Strathalbyn Naturalist Club Inc, 2000) and wholesale hunting and destruction by European settlers, many species of mammal and bird are known to have been lost from the region, e.g., the *Bettongia penicillata* Brush-tailed Bettong, *Macropus eugenii* Tammar Wallaby and *Lasiorhinus latifrons* Southern Hairy-nosed Wombat, SPECIES NAME Magpie Goose, NAME Brolga and NAME Ground Parrot (Eckert 2000).

The habitat covered by this study is therefore radically altered habitat which may still be undergoing major change as a result of drastic modification to the environment of the Lower Lakes. The following discussion summarises information in the literature on specific habitats and associated issues and includes further information gathered during this investigation.

4.1 Extension of Freshwater Vegetation

4.1.1 Historic distribution of Freshwater Habitat

It is difficult to ascertain the pre-barrage distribution of freshwater vegetation. Many sources refer to there having been limited reed beds around the lakes and they mainly occurred in the vicinity of the outflows from the creeks and rivers which enter the lakes, (Pillman 1980, John Eckert pers. comm. 2002, Terry McAnney pers. comm.2002).

There is further evidence that the freshwater swamps associated with the mouths of the Finniss River (Black Swamp) and Currency Creek have always supported freshwater swamp vegetation including extensive reed beds and riparian shrubs and trees such as *Acacia retinodes* Swamp Wattle, *Leptospermum lanigerum* Woolly Tea-tree, *Eucalyptus calmaldulensis* Red Gum and a large part of Currency Creek is protected as the Currency Creek Game Reserve in the SA NPWS system.

Where the Angas River and Bremer-Barker River reach the lakes the situation is different. The Angas River reaches Lake Alexandrina over a samphire flat 2 km west of Milang, without a substantial estuary area like the Finniss R. and Currency Ck. However Thompson (1986) describes the adjoining edge of Lake Alexandrina as an almost continuous series of temporary and permanent wetlands running from about 6 km ENE of Milang to 5 km south. The waters of another creek (name unknown) also enter Lake Alexandrina through across these wetlands south of Milang. While some of the wetlands have reed and rush vegetation, many of them have saline swamp vegetation only. Presumably this important series of wetlands which link to Kindaruar Corner and Reedy Point, would become a freshwater extension of the Angas River times of extreme flooding from these watercourses and/or R. Murray generated floodwaters.

The Bremer River enters L. Alexandrina in a similar fashion ca. 7 km northwest of Milang. It first passes through a large expanse of floodplain, south of Langhorne Creek township. In times of flood the waters of the Bremer spill out into this Red Gum swamp area and local residents note that during big flood events Mosquito Creek carries water away from the swamp and into L. Alexandrina through the samphire floodplain in and around Boggy Lake, West Creek and Dog Lake area. It has been suggested that in extremely big flood events (T. McAnney *pers. comm.* 2002) that the flood waters extend throughout the samphire areas and meet those at the true Bremer River mouth. Certainly these opinions tally with the other generally acknowledged information that there always has been big reed beds in the vicinity of Boggy Lake, Dog Lake, the Tolderol point area and back towards Milang around Snake Island. Presumably these reed beds were able to survive even quite extended periods of high salinity in the lake because they had seasonal flushes of freshwater from the freshwater swamps.

Similarly, although it has consistently been reported that the River Murray channel, as far up as Wellington, was often saline from the influence of estuarine conditions in the lakes and prolonged droughts that produced low river flows (e.g., Paton in Jensen et al. 2000) the same area often was flushed by freshwater flows from the Murray River. This was presumably enough to ensure the long term survival of *Typha* and *Phragmites* reed beds, although in prolonged saline periods they may have existed only as established, but dormant root masses. This is supported by Ganf's suggestion (in Jensen *et al.* 2000) that the underground rhizomes of *Typha, Phragmites* and *Bulboschoenus* can tolerate salinities between 33-66% of seawater.

There are still significant reed beds in the vicinity of the R. Murray entrance to L. Alexandrina on Nalpa peninsula and fringing the channel closer to Wellington. Here too, *Eucalyptus calmaldulensis* extends down from the river channel and into the entrance.

Plate 4.1 Remnant Red Gums lining the R. Murray channel downstream of Wellington with introduced Willows

All the areas of reed beds that historically have been recorded as waterbird rookeries, still exist and support seasonal breeding colonies. These breeding areas are on Lake Alexandrina: Tolderol Point - Snake Island, Mosquito Point – Boggy Lake area, Sth of Milang, Kindruar Corner – Reedy Point, Opposite Clayton - Goat Island, Goose Island, Finniss River mouth, Currency Ck mouth, Salt Lagoon Islands, Coolindawerh Lagoon, Rat Island, Rushy Island They are on Lake Albert: the Narrung Narrows, Warringee Point complex.

These sites may represent the distribution of pre barrage reed beds. Importantly, however, no new rookeries appear to have been documented in new areas of reed beds that have resulted from post barrage changes. **(G. Carpenter consult)**

Plate 4.2 Snake Island waterbird breeding colony just offshore on L. Alexandrina, J. Eckert's property.

Plate 4.3 Remnant Red Gum swamp in Bremer River overflow area near Langhorne Ck, with Red Gum regeneration and *Carex bichenoviana* and *Juncus* sp. understorey.

4.1.2 Expansion of Freshwater Reed Beds

This distribution of pre barrage freshwater wetlands makes it dramatically obvious that the construction of the barrages has led to a huge increase in freshwater vegetation. Appreciating the nature of these changes is essential to understanding how the Lake system is currently operating as wetland habitat.

Statistics in Pillman (1980) provide insight into what physical parameters have effected change. Barrage construction increased the area of freshwater influence by 8685 ha or 10.6%, but far more important is how water depth was altered. Pillman suggests that the most important zone for productivity is 0-100cm deep with the optimum depth for water fowl feeding being 0-50cm. Barrage construction has increased the area of water formerly within the 0-10cm zone to a depth of 100cm. Furthermore in lake edge waters at the current lake level of .75 ADH, high turbidity due to wave action and therefore lack of visibility and light penetration, completely disrupts this zone. Thus construction of the barrages has increased the amount of permanent, shallow water habitat and permanently flooded many of the former saline wetland areas.

Currently a considerable flood (equal to raising the pool level by 20 cm) will now increase the water area by 4757 ha but would have only increased the area by 2265 ha pre barrage (Pillman 1980). However, flooding and therefore long drying events have been substantially reduced both in frequency and extent by the regulation of River Murray Water, while the area under permanent freshwater inundation now includes all of the previously seasonally inundated areas and a majority of the infrequently inundated highly saline areas around the former fringes of the lake. Only the Murray Mouth area seaward of the barrages and the adjoining Coorong Lagoons,still contains a range of predominantly saline influence habitats and with a reduction in Murray River flows and their impoundment by the barrages, this area now only receives a reduced and distorted pattern of seasonal freshwater flows. This distortion has never been more obvious than during the 2002 spring-summer period when the Murray Mouth has silted over and there has not been a post snow melt, summer flow entering the lakes.

The overiding of natural flooding and drying cycles has had far reaching effects on nutrient cycling within this system and therefore dramatic impacts on the whole ecosystem. Thompson (1986) points out that although it is well known that flooding terrestrial vegetation provides a rich food source for waterfowl, this does not explain the importance of flood waters for many other species of waterbirds and how floods can stimulate waterfowl and fish breeding. The explanation is contained in the detail of where important plant nutrients are held in a temporary wetland system. Essential plant nutrients are dissolved in the presence of flood water and

“become chemically bound to clay particles on the beds of wetlands, and effectively become unavailable to plants. The chemical bonds are broken when the clay dries, and the nutrients dissolve into the water when the wetland next floods.” , (Thompson 1986).

As a result there is a flush of readily available nutrients in newly flooded wetlands that stimulate rapid algal and in turn aquatic invertebrate growth that lead to the production of vital food for fish larvae and a host of waterbirds. The disruption of this vital process and its consequences is discussed in more detail in section 5.

Further to this disruption of natural cycles, the composition and diversity of freshwater vegetation Is likely to have changed. Those species that can cope with permanent freshwater habitat along the lake edges also has to be able to cope with the highly erosive wind and wave action that occur in the shallow and highly turbid lake edges. Under these conditions, only species that are able to tolerate the wave action and /or can manage in low light conditions will thrive along the lake shore. Ganf (in Jensen *et al.* 2000) attributes the poor diversity of herb and submerged plant communities in the lakeshore environment to high turbidity, erosive wave action and domination of this zone by the reed and rush species that can withstand these conditions.

Thus a typical freshwater plant transect moving inland from the deeper lake waters to a shallow, permanent, and well vegetated freshwater edge would be as detailed in Table 4.1 below.

Table 4.1 Freshwater Swamp Transect in Lower Murray Lakes region, from lake edge to dry edge.

Water Regime & Water depth	**Form**	**Native Plant Species** / ***Introduced Plant Species**
Permanent Freshwater 150 - 50 cm	Emergent Tall Rush	*Shoenoplectus validus* River Club-rush
Permanent Freshwater 150 - 0 cm	Emergent Tall Reeds	*Typha domingensis* Narrow-leaf Bulrush *Phragmites australis* Common Reed
Permanent Freshwater 75 – 10 cm	Submerged Aquatics	*Myriophyllum sp*. Milfoil *Vallisneria spiralis* River Eel-grass
Permanent Freshwater 50 – 5 cm	Emergent Small Rush	Eleocharis acuta Common Spike-rush
Seasonally Innundated Semi-perm Freshwater 25 – 0 cm Soil is Permanently Wet & plants tolerate seasonal and storm inundation	Herbs Reed Sedge	*Calystegia sepium Native Bindweed* *Cotula* vulgaris Native Water Buttons *Epilobium pallidiflorum* Showy Willow-herb *Hydrocotyle verticillata* Shield Pennywort *Lycopsus australis* Australian Gipsywort *Lythrum salicaria* Purple Loosestrife *Marsilea drummondii* Common Nardoo *Persicaria decipiens* Slender Knotweed *Ranunculus amphitrichus* Small River Buttercup *Selliera radicans* Shiny Swamp-mat *Samolus repens* Creeping Brookweed *Sonchus hydrophilus* Native Sow Thistle *Triglochin procerum* Water Ribbons *Phragmites australis* Common Reed *Carex appressa* Tallsedge *Cladium mariscus Leafy Rush* *Schoenoplectus pungens* Spiky Club-rush **Aster subulatus* Wild Aster
Occasionally Inundated Freshwater 15 - 0cm Root Zone always stays damp/wet	Woody Shrub Herbs Grasses Sedge Reed	*Muehlenbeckia florulenta* Lignum *Epilobium billardierianum* Robust Willow-herb *Persicaria prostrata* Creeping Knotweed *Rumex bidens* Mud Dock *Samolus repens* Creeping Brookweed *Sonchus oleraceus* Common Sow Thistle **Cotula cornopifolia* Water Buttons **Mentha pepenta x citrata* Lemon Mint *Agrostis avenacea* Common Blown Grass *Pucinella stricta var stricta* Aust. Saltmarsh Grass **Paspalum dilatum* Paspalum **Paspalum distichum* Water Couch **Pennisetum clandestinum* Kikuyu **Polygpogon monspeliensis* Annual Beard Grass *Cyperus gymnocaulos* Spiny Flat-sedge *Phragmites australis* Common Reed **Juncus acutus* Sharp Rush
Terrestrial Permanently Damp, Freshwater Influence Plants not innundated NB. In addition many of the species in the Occasionally Inundated zone also occur in this zone	Herbs Grass Sedge Reed	*Lavatera plebia* Australian holly hock *Lotus australis* Austral trefoil **Medicago sp*. Medic Clover **Melilotus indica* King Island Meliot *Distichlis distichophylla* Emu-grass **Elymus sp*. Tall Wheatgrass **Paspalum dilatum* Paspalum **Pennisetum clandestinum* Kikuyu **Cynadon dactylon* Couch *Baumea juncea* *Phragmites australis* Common Reed

However, not all the species shown in Table 4.1 will occur at every freshwater edge site. This study and Pedler & Mallen (2001) found few freshwater sites exhibit this level of diversity. Those that do, are usually in sites found behind the main lake edge, ranging from very shallow freshwater depressions to extensive freshwater swamps covering many acres, to lake edge sites in the large mouth areas of the Finniss River and Currency Creek. In these areas there is little, if any, wave action, the water is clear and supports a large diversity of aquatic plants, supporting the assertion that the higher lake level with its high level of active erosion and turbidity is limiting floral diversity (Ganf in Jensen *et al*.2000).

Plate 4.4 Freshwater vegetation in good condition supports a diverse range of reeds, rushes, sedges and herbs. Australian Gypsy wort *Lycopus australis*, rated Rare in the Murray Region, is shown here among *Phragmites australis* on seasonally inundated ground.

Around the exposed lake edge there are many areas that do not support more than a few straggly pockets of reeds and rushes and have a actively eroding edge held together only by Kikuyu. As has been well documented by other studies (ID&A 2001a, ID&A 2001b) the shorelines most susceptible to erosion are exposed shores with the sodic Poltalloch soils (black fluvatile clays overlying bleached marine sand) that are highly prone to dispersion and erosion. When the continual process of fretting of these soils is combined with dramatic erosion events associated with high energy, wind produced waves during winter and summer, the rate of erosion of the shoreline per year can be unacceptably high, e.g., 2-5 m per year. In the main, this loss of substrate is permanent, with soil and accompanying nutrients being deposited in deeper areas of the lakes. Holding the lake levels artificially high EL 0.75 m AHD and often surcharging to EL 0.85 m AHD before summer to offset evaporation from the lake (average fall of .25 m each summer) greatly increases the erosive capacity of the wave action.

Along most of the shoreline with greatest erosion potential, vegetation that once existed has been lost through erosion, and freshwater vegetation, as described above, has difficulty in re-establishing. This has been found to be particularly so where there is unfettered access to the shoreline by stock (ID&A 2001a & 2001b). While grazing and therefore removal of vegetation and damage to soil structure is not the primary cause of erosion it is a major contributing factor. However it has also been demonstrated by several landowners, who have undertaken erosion control works on their properties, that where littoral vegetation can be preserved or restored it is possible to halt and/or reverse the removal of the shoreline. Live plant material with perennial root masses has been shown to protect the shoreline, causing sediments to be deposited at their base (ID&A 2001a). The best rehabilitation results have been where stock access to the shoreline has been removed or severely restricted.

However, despite the continual removal and renewal of freshwater vegetation on the shoreline, many substantial areas behind the shoreline now carry beds of freshwater reeds, rushes and sedges. These are most often the salty shallow depressions behind the lake edge that once carried samphire shrubland, but they also include extensive shallow areas that were once large saline swamps. Many of these areas still carry some healthy stands of samphire shrubs indicating where the soils are too salty and, or, too dry to support freshwater reed beds. However, the majority of sites close to the lake edge have significant areas on the lakeward side that are now dominated by freshwater reedbeds rather than saline adapted swamp vegetation.

Plate 4.5 Example of an extensive freshwater swamp behind main lake edge in good condition (C. Mason's property) which may once have been predominantly saline and supported shallow lagoons and samphire swamp vegetation

The pattern of distribution observed in the field during this study and anecdotal evidence (J. Eckert, T. McAnney, M. South, A. Hartnett, J. Yelland, pers. comm. 2001 & 2002, Nigel Mallen 2000) suggest that the invasion of formerly saline swamps has been made possible by freshwater flushing that these areas receive from waves breaking and splashing along the shoreline and from fresh, groundwater seepage from the lake itself back into the depressions behind. Thus both the soils and the standing water in these depressions receive freshwater flushing during winter and in areas of high wind activity, throughout the year and in particular when the lake is surcharged to meet irrigation needs over summer.

This process has presumably continued to be a feature of lake vegetation change since the barrages were constructed. In some areas, shoreline erosion has removed the frontline of reed beds and rushes and gone on to remove samphire shrubland while lake water continues to flush the entire samphire area. In many of these instances substantial freshwater reedbeds have established at the back of depression and later aid in stabilising the new shoreline.

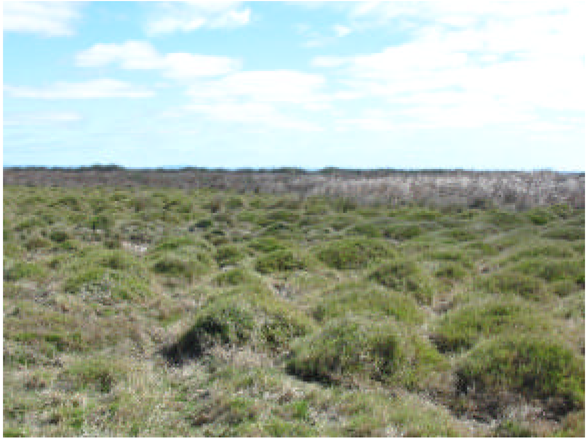
Several freshwater species are particularly favoured by this saline-fresh flushing regime. Both the Bulrush *Typha domingensis* and the Common Reed *Phragmites australis* are able to grown in quite saline waters (N.Mallen & J.Pedler pers.obs. Ganf in Jensen et al. 2000) and *Phragmites australis* is able to grow in very saline soils that receive seasonal freshwater flushes (Mallen 2000). Consequently many samphire sites were observed with heavy Phragmites growth into samphire areas from freshwater areas.

Plate 4.6 In background a formerly samphire area on Lucerne Is. that has been completely overtaken by *Phragmites australis* with freshening of water from Eastick Creek. In foreground active invasion of a Samphire – Swamp Paperbark area is still progressing.

The other plant that has used the freshwater flushing to make major expansions into samphire swamps is the introduced *Paspalum dilatum* Paspalum. While not able to withstand the violent erosive forces on the shoreline or consequent inundation, it is able to grow behind Kikuyu dominated edges and grow into the samphire where there is frequent freshwater flushing. It is further advantaged by uneven soil surfaces such as pugging by cattle produces, where it is able to grow on top of the mounds above the water level, leaving its root zone in aerated soil.

The growth of these freshwater invaders ecosystems is the single most significant aspect of change in plant communities of the Lower Lakes. The impact they have on the Lake ecosystems is profound and their influence and management is discussed in detail throughout this report.

Plate 4.9 Growth of Paspalum species into wet area that would support samphire or freshened herbland. This plant can overcome the permanently waterlogged soil condition via strongholds on the drier, aerated tops of mounds formed previously by cattle pugging up the wet muds.



4.1.3 Degradation of Red Gum Swamps

The other important change to note in freshwater habitat is the decline in diversity and condition of the freshwater Red Gum swamps areas around the lake. There are still extensive remnants of these swamps, particularly in the area south of Langhorne Creek where the waters of the Bremer River spill out towards Lake Alexandrina, However, now most of these remnants, only consist of remnant, mature *Eucalyptus camaldulensis* Red Gum and occasionally *Meuhlenbeckia florulenta* Lignum, (pers. obs. J. Pedler 2002, pers. comm. J Follet 2002). Two areas of remnant Red Gum swamp near Langhorne Ck, (owned by J. Follet) were examined as part of this study. They were in much better condition than most and although there was some areas of thick, dense understorey, there was very little diversity of species. There was however significant regeneration of Red gums with many age classes represented throughout the swamps and several other plant species were found including *Carex bichenoviana* Notched Sedge and *Acacia retenodes* Swamp Wattle (see Plate 4.3).

Three areas that once were reported to support Red Gum - sedge associations were visited in the area between Wellington and the River Murray's entrance to the L. Alexandrina. While remnant Red Gums remained and some natural regeneration was observed near Brinkley on Aboriginal Lands Trust site**,** there were very few other native species, while Willows dominated as tree cover in some areas. (At Jockwar Rd reserve there was a rare occurrence of another *Carex* species, *C. appressa*, under the willows).

Plate 4.8 *Carex appressa* among Willow trees on R. Murray channel at its entrance to L. Alexandrina.

It is clear that the vegetation of the Red Gum swamp areas have suffered greatly through grazing and with few exceptions, all remain unprotected from grazing and are severely affected by weed species. Coupled with changes in the flooding regimes of the Bremer River and in the Wellington to Nalpa area, the Murray River, there would appear to be very little opportunity for any Red Gum regeneration and establishment to occur, let alone for regeneration and establishment of a suite of other species that once would have occurred in these Red Gum - Sedge swamps.

4.2 Melaleuca halmaturorum Swamp Paperbark Distribution

While it is largely agreed that the Lower Lakes area previously supported large areas of saline swamp vegetation, it appears the former extent of *Melaleuca halmaturorum* Swamp Paperbark, is not definitively known. While exact distributions of this species are absent in the published literature, there are numerous and conflicting personal observations as to its extent prior to European influence and even just prior to barrage construction. There are however still several significant stands which offer some insight as to its probable distribution. They are around the west, north and east coast and inland of Lucerne Island, along the south coast of Hindmarsh Island, on Goose Island opposite Clayton, and an extensive area around Coolindawerh and Salt Lagoon and associated islands. In these areas they fringe samphire swamps, forming dense stands that could be classed as Low Closed Forest to Low Woodland.

Although some observers would disagree, e.g. J. Eckert (pers. comm. 2002), it is likely that *Melaleuca halmaturorum* woodlands were common, if not extensive, around samphire swamps in the region and have been cleared for wood or degraded by grazing to the point where there no young trees have survived to replace senescing individuals. This view is supported by evidence of a widespread distribution which is now only represented by scattered degraded stands in the region: inland on Nalpa Station north of the Wellington to Langhorne Creek Rd, Swamp Paperbark – Samphire Swamp on Lihou property, fringing remnant on Lake Albert adjacent Colleen Bakker property and an extensive remnant on Coolindawerh Lagoon on the Harvey property . In addition, where regeneration areas are protected from grazing as on Nalpa Station, the Harvey and Lihou properties, Lucerne Island and Goose Island, low level, constant regeneration and major regeneration events can be observed.

Plate 4.9 Remnant *Melaleuca halmaturorum* Swamp Paperbark behind Coolindawerh Lagoon

Further observations also support this view. K. Denver (pers.comm.2002) has reported finding *M. halmaturorum* stumps in saline lagoons and channels on the Wyndgate property, Hindmarsh Island, where there has not been any living trees at least since the 1960's. He has also come to recognise the woody roots of this species when he has encountered them while digging postholes in saline muds where there are no longer *M. halmaturorum* trees. Denver also reported evidence of these Melaleucas having been harvested for fuel for paddlesteamers, with several large stacks of cut *Melaleuca halmaturorum* remaining on Lucerne Island, presumably unused by boat traffic. Several anecdotal reports suggest that large amounts of timber was taken from fringing Swamp Paperbark stands where it could be accessed from the water by boats pulling standing timber out from the channel side. In these same stands, harvesting from the landward side would have been impossible with horses and carts quickly becoming bogged in the mud of the Samphire swamps. Denver (pers. comm. 2002) further suggested that in the Murray Mouth area the second onslaught on Melaleuca timber would have been during the construction of the barrages in the 1940's when up to 1,000 men at any one time were accommodated and fed in camps around the construction sites.

Pillman (1980), reports that vegetation reports of the L. Alexandrina – L. Albert district have made little reference to wetland vegetation (Jessup 1946 and Specht 1972 in Pillman 1980). Pillman goes on to suggest that there appears to be two basic types of permanent freshwater wetland around the lakes. One type he calls "sedgeland", is characterised by the presence of *Typha, Phragmites, Schoenoplectus* (formerly *Scirpus*), *Juncus, Ranunculus* and *Hydrocotyl* species as well as various grasses. The other he calls "Open Woodland" with *Melaleuca halmaturorum* as a dominant, and understorey species being similar to those in "Sedgeland".

Pillman divides a typical transect from lake edge to highland into 6 zones which equate well with the classifcation of zones in the revegetation guidelines prepared by Pedler & Mallen (2001), and suggests that *M. halmaturorum* occurs in zone 5 in the southern part of the lakes. Pillman suggests that the Swamp Paperbark swamps found in the southern region of the lakes are probably remnant of the semi-saline pre-barrage period when, like mangroves, they were capable of tolerating a highly saline intertidal zone as suggested by Specht (1972). Pillman also notes that with the freshening of the lakes, this is also the area where dense Typha or Phragmites growth 'would effectively reduce seedling survival should seed germination ever occur'. A reference is also made to the importance of these Melaleuca swamps for cormorant and spoonbill breeding and the presence of drowned trees in known breeding colonies in Pelican Lagoon is noted, (Pillman 1980). The latter was also observed during this study at the above location and on the North side of Lucerne Island.

Unlike Pillman's classification of vegetation zones, the study carried out during the preparation of the Revegetation Guidelines (ID&A 2002), identified the most likely preferred growing zone of *M. halmaturorum* as being influenced most heavily by the soil salinity while soil moisture and therefore inundation pattern defined its regeneration niche and success as a seedling. These conclusions were drawn from field observation of both remnant and planted vegetation, anecdotal and historical evidence. To summarise, this evidence from the ID&A (2002) study and the current study suggests the following:

1. Germination of *M. halmaturorum* seeds is stimulated by substantial freshwater inundation of areas where the seeds already lie dormant and/or are washed in by floods.

2. Seedlings cannot grow well if the substrate remains continually waterlogged and therefore the root zone is not aerated. Denton & Ganf (cited by Ganf in Jensen et al. 2000) demonstrated that M. halmaturorum seedlings that are top-flooded for more than three weeks did not survive.
3. The water regime for successful growth after initial germinations would therefore have to include a drying period, which in this formerly estuarine Lower Lakes area, includes all the low lying, shallow, saline swamp areas.
4. Within this favoured range of saline soils subject to temporary inundation the salinity can be too high for *M. halmaturorum* growth and the zone most suited to its growth can be defined in Samphire Swamps as the *Irregular Inundation* and *Saline Edge* Zones (Pedler & Mallen 2001).
5. Growth and germination can occur on soils with freshwater influence but here waterlogging can be a risk so on the Lake Edge its favoured zone is the *Rising Ground* that has a substantial probability of drying out.
6. Growth of Creeping Brookweed *Samolus repens* marks the conditions favourable to *Melaleuca halmaturorum* growth in saline and semisaline soils and growth of this plant can be used to define where *M. halmaturorum* can grow and may have grown in the past.
7. This range of water regimes and topography includes areas of high soil salinity where the soils are rarely flushed by flood events and local runoff collects and is evaporated off, and, in the case of remnant stands, excludes areas where the soil and standing water were fresh and constant enough to support freshwater dependent, reed bed growth (Bullrush and Common Reed beds) before the installation of the Barrages.

In the light of these conclusions it is likely that fringing *M. halmaturorum* stands would have occurred formerly in areas where the freshwater dependent reedbeds did not, and indeed could not. It therefore would have been found throughout the lower lakes system and accompanying inland saline swamps (where it persists today) as it is throughout the Coorong region. It is likely that it provided shelter and cover for roosting birds, including Black Cormorants, Nankeen Night Herons, other Herons, Egrets and Ibis (as has been reported by Eckert 2000, Thompson 1986) In extreme flood events, inundation of mature stands would have provided an abundance of nesting sites for a wide range of waterbirds and there would have been widespread germination of this species with receding floods.

During less extreme seasonal cycles, fringing Swamp Paperbark stands would have provided shelter to the saline swamps from wind, cutting wave action on the then less extensive shallow water, and therefore allowing waterbirds, and in particular migratory waders, to feed more effectively. Consequently, they also would have aided the establishment and growth of a variety of saline tolerant, rushes, sedges, herbs and samphires which in turn provided shelter and habitat to a diverse range of invertebrate fauna.

In contrast today, there are few sites on the lake edge that now have fringes of *M. halmaturorum.* At the most extensive of these remnant sites around Coolindawerh Lagoon, and around Lucerne Island, and parts of Hindmarsh Island, the height and density of the Paperbark Melaleuca stands provide dense windbreaks that shelter saline swamps behind the lakeshore. In these localities samphire bushes are noticeably taller within the area adjacent to the trees that receives the most wind-break benefit. A greater diversity of herbs, rushes and sedges was also noted in among the areas shaded by the Melaleucas that retain pools of water for longer than in the relatively open samphire shrubland. However, where the remnants had recently been grazed this diverse cover was obviously subject to trampling by cows sheltering under the trees.

Plates 4.10 and 4.11 on Lucerne island showing high diversity of herbs in the zone shaded by Swamp Paperbark on left and on right the windbreak protection provided to the samphire vegetation by the Swamp Paperbark lining the channel.

When viewed In the light of this investigation's predicted past distribution of *M. halmaturorum* Woodlands, Pillman's (1980) comments on the threat posed to Swamp Paperbark remnants by overgrowth with freshwater dependent reed beds, deserve much greater emphasis. Like Pillman, this study also saw many instances of *Phragmites australis* and Typha sp. invasion into the edge of remnant Swamp Paperbark stands. If the previous distribution of Swamp Paperbark stands was as extensive as our study predicts, then the invasion that we are witnessing now is not a new process, but rather the end of a very long process of loss and degradation of Swamp Paperbark which will eventually destroy all remnants that lie in areas directly influenced by the freshwater and raised water levels of the lakes as they have existed since the 1940's.

4.3 Saline Swamps – Samphire Shrubland

A number of changes are evident in the current distribution and condition of the Samphire Swamps that once dominated the lakes area, and that, when inundated provide the basis of migratory wading bird habitat around the lakes. For ease of discussion it will be assumed here that references to samphire swamps refer to saline swamps dominated by samphire vegetation that may or may not have had fringing Swamp Paperbark. All the samphire swamps occur on saline soils (where the majority of other plant species that occur in the region cannot grow) and often on areas that are seasonally or irregularly inundated.

Samphire Swamp vegetation generally occurs as Low Shrubland formations behind the edge of the lakes. In sites visited during this study and in developing the revegetation guidelines (ID&A 2001), the dominant shrub layer was usually comprised of two or three of the following species, Black-seed Samphire *Halosacrcia pergranulata ssp. pergranulata* Shrubby Samphire *Sclerostegia arbuscula*, Austral Seablite *Suaeda australis* and usually *Sarcocornia quinequeflora* although *Sarcocornia blackiana* is found in some areas. In general this study did not attempt to identify samphire species unless readily recognizable and has grouped them as Samphire species. Many other samphire shrub species are listed in the *Biological Survey of the Murray Mouth Reserves* (Brandle 2002). As illustrated by Pedler & Mallen (in *Revegetation Guidelines for the Lower Murray Lakes* 2001) distinct changes in vegetation diversity and relative composition can be seen when moving across saline swamps from the outer, less saline zones to the inner hypersaline muds at their centre. Table 4.2 shows the range of species in their relevant zone.

As already mentioned in discussing the historic distribution of Swamp Paperbark and the extension of freshwater communities, the generally saline conditions around the lower lakes prior to barrage construction, most favoured saline swamp vegetation. Although they have not been seen as valuable habitat these areas still occur in various forms throughout the Lower Murray Lakes area, ranging from tiny samphire clad depressions directly behind the lake edge to large saline swamps that extend many kilometres inland from the shores of Lake Alexandrina and Lake Albert such as those of Blind Creek, Waltowa Swamp. In all these sites the predominant influence in their formation and continuity is high salinity, which in these areas is the result of a build up of salts from saline groundwater, and the whole region's former estuarine nature.

In general the inland samphire swamps are not directly connected to the Lower Lakes except during times of high flooding such as the 1956 flood. In these circumstances, without flushing, their soils become hypersaline as more salt is accumulated. In inland swamps there may be inundation from local rainfall that can result in significantly lower soil salinity while the water sits in the swamp until it evaporates. This allows some plants to grow well or their seeds to germinate during the periods of inundation. Prior to barrage construction samphire swamps behind the lake shoreline would have been inundated at times by tidal flows pushed up by wind, received water from wave splash along the shoreline and at times, depending on their position off the lake, by freshwater inflows from the Murray River, and/or from the smaller watercourses, Bremer, Finniss, and Currency or other local runoff.

With river regulation and the tremendous increase in use of Murray waters, floods that can reach the inland swamps will be less frequent in their occurrence, if they are able to occur at all. However, since barrage construction, samphire swamp areas immediately adjacent to the lakeshore are more regularly flushed by freshwater intrusions from the lakes (wave action and seepage) and therefore cannot remain hypersaline all year around. Both these two changes in water regime have profound affects on the diversity and composition of the samphire swamp vegetation.

Table 4.2 Saline Swamp in Lower Murray Lakes region that receives occasional seasonal inflows from Lake, major watercourse or local stormwater drainage. Transect from Rising Ground to Hypersaline, Seasonal Inundation Zone using revegetation guideline zones (Pedler & Mallen 2001)

Water Regime & Soil Salinity	**Form**	**Native Plant Species *Introduced Plant Species**
Rising Ground Saline Influence	Shrubs & Herbs	Atriplex cinerea Coast Saltbush Atriplex paludosa Marsh Saltbush Atriplex suberecta Lagoon Saltbush Enchylaena tomentosa Rising Ground Maireana brevifolia Short-leaf Bluebush Maireana oppositifolia Salt Bluebush Nitraria billardierei Nitre-bush *Sclerostegia arbuscula Shrubby Samphire* Rhagodia candolleana Sea-berry Bush *Sporobolus virginicus* Salt Couch *Cyperus gymnocaulos* Spiny Flat-sedge - sand Isolepsis nodosa Knobby Clubrush -sand *Muehlenbeckia florulenta* Lignum Melaleuca lanceolata Dryland Teatree Myoporum insulare Common Boobialla **Atriplex prostrata* Hastate Orache **Lycium ferocissium* Boxthorn **Plantain coronopus* Buckshorn Plantain
Saline Edge Saline Soil Local Precipitation, saline Groundwater & Rare Extensive Flood Events	Shrubs & Herbs Grasses Sedge Rush	Disphyma crassifolium ssp. clavellatum Round–leaf Pigface *Frankenia sp.* Sea Heath *Melaleuca halmaturorum* Swamp Paper-bark *Samolus repens* Creeping Brookweed *Sarcocornia sp. Samphire species* *Sclerostegia arbuscula Shrubby Samphire* *Suaeda australis Austral Seablite* *Wilsonia backhousei* Narrow-leaf Wilsonia Wilsonia rotundifolia Round-leaf Wilsonia *Distichlis distichophylla* Emu-grass *Pucinella stricta var stricta* Aust. Saltmarsh Grass *Sporobolus virginicus* Salt Couch *Gahnia filum* Cutting Grass *Juncus krausii* Sea Rush **Elymus elongatus* Tall Wheat Grass **Paspalum vaginatum* Saltwater Couch **Plantain coronopus* Buckshorn Plantain **Critesion marinum* Sea Barley Grass
Irregular Inundation Hypersaline Soil Soil flushed and slightly freshened with less saline water when temporarily inundated	Shrubs & Herbs Grasses Sedge Rush	Disphyma crassifolium ssp. clavellatum Round–leaf Pigface *Frankenia sp.* Sea Heath *Gahnia filum* Cutting Grass *Lawrencia squamata* Thorny Lawrencia *Melaleuca halmatruorum* Swamp Paper-bark *Samolus repens* Creeping Brookweed *Schoenoplectus pungens* Spiky Club-rush *Wilsonia backhousei* Narrow-leaf Wilsonia *Pucinella stricta var stricta* Aust. Saltmarsh Grass **Polypogon monspeliensis* Annual Beard Grass **Plantain coronopus* Buckshorn Plantain **Elymus elongatus* Tall Wheat Grass
Seasonal Inundation Hypersaline Soil	Emergent Sedges	*Bolboschoenus caldwellii* Salt Club-rush (in water) *Schoenoplectus pungens* Spiky Club-rush (in water) NB Water forms shallow saline pools with saline muds. Soil not flushed with inundation as water lies in this zone, accumulates salt from soil until water evaporates leaving salt in soil. While pool remains creates less saline growing conditions.

Formerly depressions behind the lake edge with saline seepage carried only saline tolerant vegetation such as samphire species, a range of saline tolerant herbs like *Frankenia pauciflora* Sea Heath, *Samolus repens* Creeping Brookweed, and where there was permanent saline water, sedges like *Shoenoplectus pungens* Spiky Club-rush and *Bulboshoenus caldwellii* Salt Club-rush would be found. Where these areas now receive freshwater seepage from the lake edge all year round and considerable quantities of freshwater splash from wave action during the winter months, another type of plant association develops, which will be called here "*semisaline herbland*" for want of a better term.

On the side where the soil is most regularly flushed with freshwater, usually adjacent to the lake edge, a number of species native and introduced are found together in a low herbland which is often damp and/or inundated all year around. They include the native species; *Triglochin procerum* Water Ribbons, *Triglochin striatum* Streaked Arrowgrass, *Distichlis distichophylla* Emu-grass, *Mimulus repens* Creeping Monkey Flower, *Persicaria decipiens* Slender Knotweed, *Epilobium billardierianum* Robust Willow Herb, *Sonchus hydrophilus* Native Sow Thistle, *Shoenoplectus pungens* Spiky Club-rush, *Pucinella stricta var stricta* Aust. Saltmarsh Grass. Some native species, like *Hydrocotyle verticillata* Shield Pennywort, are unable to tolerate even low levels of soil salinity and/or being inundated by slightly saline water, and consequently they do not appear in this modified saline zone while they do in this position behind a freshwater edge on non-saline ground. However others, as mentioned in the discussion of the expansion of freshwater communities into samphire zones, are actually able to move between the freshwater habitat and the freshened saline zones. *Typha domingensis* is able to grow into highly saline waters from an original base in freshwater, while *Phragmites australis* is not as tolerant in water. However *Phragmites australis* is able to grow into highly saline, moist soils so long as they are flushed occasionally with freshwater.

This modified zone is also where the most introduced species are able access the freshened samphire edge; *Cotula coronopifolia* Water Buttons, Water Couch *Paspalum distichum*, Sow Thistle, Paspalum *Paspalum dilatatum*, Medic Clover species and King Island Meliot *Melilotus indica*. Where there is sufficient intermittent flushing or long periods of inundation with freshwater, Paspalum (*Paspalum dilatatum*) is able to gain a stronghold in the semisaline herbland and then colonise well into the samphire swamp into the zones that would have formerly been called the Hypersaline Irregular Inundation zone and the Hypersaline Seasonal Inundation Zone (Pedler & Mallen 2001). Paspalum is able to overgrow samphire shrubland completely, sometimes forming an unbroken mat over many acres of former saline swamp.

Table 4.3 Vegetation transect of formerly Saline Swamp modified by freshwater inundation. Transect from Freshwater Lake Edge into highly saline soils & Seasonal Inundation Zone using revegetation guideline zones (Pedler & Mallen 2001)

Water Regime & Water depth	Form	Native Plant Species *Introduced Plant Species
Permanent Freshwater 150 - 50 cm	Emergent Tall Rush	*Shoenoplectus validus* River Club-rush
Permanent Freshwater 150 - 0 cm	Emergent Tall Reeds	*Typha domingensis* Narrow-leaf Bulrush *Phragmites australis* Common Reed
Permanent Freshwater 75 – 10 cm	Submerged Aquatics	*Myriophyllum sp.* Milfoil *Vallisneria spiralis* River Eel-grass
Rising Ground Formerly Saline Swamp, Flushed by Freshwater Seasonally by wave splash. Dries out on surface but root zone remains damp/wet		*Melaleuca halmatruorum* Swamp Paper-bark *Samolus repens* Creeping Brookweed *Frankenia sp.* Sea Heath *Muehlenbeckia florulenta* Lignum *Distichlis distichophylla* Emu-grass *Pucinella stricta var stricta* Aust. Saltmarsh Grass *Sporobolus virginicus* Salt Couch *Schoenoplectus pungens* Spiky Club-rush *Juncus krausii* Sea Rush **Paspalum dilatum* Paspalum **Paspalum distichum* Water Couch **Pennisetum clandestinum* Kikuyu **Cynadon dactylon* Couch
Semi-perm Brackish water in Saline depression Frequently Inundated 25 – 0 cm Root Zone always stays damp/wet	Herbs Reed Sedges	*Cotula vulgaris* Native Water Buttons *Triglochin procerum* Water Ribbons *Triglochin striatum* Streaked Arrowgrass *Phragmites australis* Common Reed *Bolboschoenus caldwellii* Salt Club-rush *Schoenoplectus pungens* Spiky Club-rush **Cotula cornopifolia* Water Buttons **Paspalum dilatum* Paspalum **Paspalum distichum* Water Couch
Seasonally Inundated Freshwater on upper edges of Saline Depression 10 - 0cm Root Zone always stays damp/wet	Woody Shrub Herbs Grasses Reed Sedges Rush	*Melaleuca halmatruorum* Swamp Paper-bark *Cotula vulgaris* Native Water *Samolus repens* Creeping Brookweed *Frankenia sp.* Sea Heath *Mimulus repens* Creeping Monkey Flower, *Pucinella stricta var stricta* Aust. Saltmarsh Grass *Distichlis distichophylla* Emu-grass *Phragmites australis* Common Reed *Cyperus gymnocaulos* Spiny Flat-sedge *Gahnia filum* Cutting Grass *Juncus krausii* Sea Rush **Aster subulatus* Wild Aster **Cotula cornopifolia* Water Buttons *Elymus elongatus* Tall Wheat Grass **Parapholis incurva* Curly Rye Grass **Paspalum dilatum* Paspalum **Paspalum distichum* Water Couch **Paspalum vaginatum* Saltwater Couch **Plantain coronopus* Buckshorn Plantain **Polygpogon monspeliensis* Annual Beard Grass **Juncus acutus* Sharp Rush

In other circumstances, where the shoreline is not protected by littoral vegetation and/or wave action has removed it, active erosion eats removes the shoreline itself and then begins to erode into the samphire swamp behind it. Actively eroding samphire depressions were seen in many sites around the lakes in this study and during the revegetation guideline preparation (ID& A 2002).

To summarise, holding freshwater at permanently high pool levels in the lakes has had the following influence on remnant samphire areas.

- It results in freshwater flushing of saline soils and seasonal inundation of saline, samphire areas with freshwater.
- With the increase in erosive action, many of the samphire swamps behind the shoreline have simply been eroded away leaving the less saline soils exposed and subject to further erosion or colonisation by freshwater species.
- It allows a suite of semisaline native species to colonise the freshened edge and areas permanently inundated with freshwater.
- It produces conditions that allow weed species to invade this freshened zone and then grow into the edge of the remnant saline areas.

These influences have all combined to reduce the areas of samphire swamp via complete removal due to erosion of the lakeshore or via the process of being overgrown with weed species.

The other way that Samphire Swamps can be threatened is through land management regimes that have allowed continual or prolonged grazing to take place without reference to maintaining the health of the shrubland at a specific level. In many sites that were visited during this study and others (ID&A 2002, Pedler 2002) signs of grazing that had become detrimental to the survival of that plant community were noted. They were in order of temporal change and intensity:

1. A decrease in biodiversity in herb species within the samphire, e.g. *Samolus repens* Creeping Brookweed, *Frankenia pauciflora* Sea Heath, *Mimulus repens* Creeping Monkey Flower, *Pucinella stricta var stricta* Aust. Saltmarsh Grass, and a corresponding change in diversity of shrubs and herbs on the rising ground adjacent to the swamp.
2. Obvious signs of hoof damage to samphire shrubs and to shrubs, sedges and rushes on the rising ground, accompanied by hoof damage to soil structure with an accompanying decrease in biomass of the shrubs due to grazing and very few herbaceous species present and few young individuals.
3. An increase in the number of areas of bare, hypersaline soil where no weeds could grow with a further decrease in biomass.
4. A dramatic increase in space between bushes and a corresponding increase in weed invasion into the edge e.g., Sea Barley Grass *Critesion marinum,* Hastate orache *Atriplex prostrata* and Buckshorn Plantain *Plantago coronopus.*
5. Complete removal of the majority of samphire bushes leaving predominantly bare areas fringed only by pasture weeds like Sea Barley Grass.

These five stages of decline roughly equate to the condition score method used by DEH on native vegetation under Heritage Agreement (Croft 2001), which could be readily adapted for use in samphire communities.

During the course of this study and preparation of the Revegetation Guidelines (ID&A 2002) it became obvious that there are very few areas that still carry good saline swamp vegetation, including healthy *Rising Ground* zone vegetation. Only a few sites still carried any at all. The best inland site was on the Lihou property (ID&A 2002) while on the lake edge at the best Swamp Paperbark site on the Harvey property the vegetation in this zone was greatly limited in diversity and extent. Two sites were visited in this study behind the lake edge that had highly diverse *Rising Ground* zone vegetation in excellent condition: the Tarni Warra Sanctuary, Hindmarsh Island and adjacent Lucerne Island, part of the Wyndgate Reserve. On both these properties the excellent condition and diversity of the vegetation could be directly attributed to either no grazing or extremely light grazing regimes.

Plate 4.12 Area of samphire vegetation in excellent condition on Lucerne Island, with *Atriplex paludosa* on the Rising Ground in foreground, and Swamp Paperbark lining the channel in background.

It was also noted in the field, and anecdotal evidence was also gathered that suggests where sheep instead of cattle had been grazed, samphire shrubland generally was maintained in better condition, (Pedler 2002, pers. comm. J. Yelland 2001 & J. Eckert 2002). On other properties that grazed cattle on samphire areas there were dramatic differences in condition depending on the grazing regime that was implemented and many properties had samphire in highly degraded condition. These differences are identified and discussed further in Sections 5 and 6.

5 Current Use of Ramsar Habitat by Fauna in the Lower Murray Lakes Region

5.1 Introduction

The Ramsar Convention defines the wise use of wetland is,

> *"…their sustainable utilisation for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem."* (DEH 2000),

where natural properties of a wetland are defined as,

> "..*those physical, biological or chemical components, such as soil, water, plants, animals and nutrients and the interaction between them.."* ,

and ecological character is defined by the Ramsar Convention as being,

> "*the structure and interrelationships between the biological, chemical, and physical components of the wetland. These derive from the interactions of individual processes, functions, attributes and values of the ecosystem(s)."* (DEH 2000).

The Ramsar Management Plan (DEH 2000) notes that the ecosystems protected under the plan are open systems where they influence, or in turn, are influenced by, other ecosystems outside the management area. It includes ecosystems as far removed as in the breeding ground of migratory wader bird species in Siberia and Alaska and the entire Murray-Darling Catchment.

Thus management of this Ramsar habitat must ensure that the natural properties of the Lower Lakes and Coorong area are protected and the structure and interrelationships between the wetland components are intact. When management is effective in achieving this goal it then follows that the natural fauna and flora of the region will be protected and buffered from decline.

At the time of nomination 85 species of waterbird had been recorded in the region. Several species of native mammals were thought to still inhabit the region, the Water Rat *Hydromys chrogaster*, the Eastern Swamp Rat *Rattus lutreolus* and the Grey Kangaroo *Macropus fuliginosus*, Echidna *Tachyglossus aculeatus* and as many as 9 bat species. However they represent only a small number of the species that once inhabitated the area. Eckert (in the Strath. Naturalists Club 2002) suggest the probable number of species that once were present as around 36.

Many reptiles (up to 44 species for the Strathalbyn area Eckert 2000) utilize the habitats of this region and several including the Long-necked Turtle *Chelodina longicollis* and the Murray Turtle *Emydura macquari*i and the Water Skink *Eulampaus heatwoldi*i are particularly dependent on the water habitat of the lakes. Similarly 10 species of frogs are dependent on the habitat in the lake environs.

There is a rich fish fauna dependent on the lakes and Coorong with the communities loosely grouped into freshwater, marine and estuarine species. There is at least 66 species known form the region (DEH 2000). The lakes are dominated by freshwater species which cover all types of feeders including the predatory Murray Cod *Maccullochella peeli* and Callop *Macquaria ambigua*, the detritivore Bony Bream *Nematalosa erebi* and a good range of small, mid-water and benthic predatory fish (DEH 2000). However several species of fish have been introduced which have had a widespread impact on the lake system. They include European Carp *Cyprinus carpio*, Redfin Perch *Perca fluviatilis* and Mosquito Fish *Gambusia holbrooki*.

The generally depauperate nature of the aquatic invertebrate fauna of the lakes has been observed in several studies (e.g. Edyvanne *et al.*1996, Geddes in Jensen et al. 2000, Seaman in Brandle 2002) all of whom, to some degree, attribute this to the altered nature of the lake system and the reduction in estuarine area. Since the aquatic invertebrates and phytoplankton form the base of many of the food chains operational within the lakes the abundance and composition of this fauna is critical to the use of the Ramsar habitat by all fauna and it will be discussed in further detail later in this section.

The preceeding summary of fauna present in the Lower Lakes habitat indicates the importance of it but only hints at how the habitat is used by fauna. The following discussion on one of the major faunal groups, birds, serves to illustrate the vital features of the habitat that must be protected.

5.2 Use of Ramsar habitat by birds

Of the 29 wader bird species listed for the region by Carpenter (in Edyvane & Carvalo 1995) approximately 20 species are migratory waders and 19 were listed by JAMBA and/or CAMBA agreements. Many species breed in Alaska, northern China and Siberia and have to make a journey of 12,000 km to and from their breeding grounds. This necessitates protection of their habitat in both summer and winter areas but also the protection of their staging areas on the way where they rest and replenish body fat (DEH 2000). With the Coorong, the Lower Lakes is part of the East Asian-Australasian Shorebird Reserve Network. Many bird species are protected under the terms of the Japan-Australia Migratory Birds Agreement (JAMBA) and the China-Australia Migratory Birds Agreement (CAMBA).

Bird species classed as *Waders* include Oystercatchers, Lapwings, Plovers and Dotterels, Stilts, Stilts, Avocets, Sandpipers, Stints, Snipe, Godwits and Knots. Table 5.1 compiled by P.A. Paton for this study, summarises the current status and listings for each species.

Carpenter (in Edyvane & Carvalo 1995) listed 39 *other waterbird* species which include the Grebes, Pelican,Darte, Comorants, Herons, Egrets Bittern, Ibis, Spoonbills Rails and Crakes, Moorhens, Swamphens and Coots, Gulls and Terns. There is a further 14 species of *Waterfowl* which include Swans, Geese and Ducks and several other species of bird closely allied to, and dependent on, the wetland habitats in this region including Eagles, Falcons, Kites and Harriers and Reed Warblers, Grassbirds and Cisticolas.

That the Ramsar habitat of the lower lakes is of utmost importance to bird fauna, there can be no doubt. In one small area of the habitat covered by the Ramsar convention, the Hindmarsh Island area, Paton, Pedler & Pedler (1989) documented, using a grid system for recording, the occurrence of 114 bird species during the period from late December 1988 to February 1989. The areas of greatest concentrations of waterbirds occurred on the eastern and southeastern parts of the island where most of the freshwater wetlands were relatively undisturbed.

Brandle (2002) states 4 of the 21 bird species with a SA conservation rating of ‘Rare’ use habitat in the Murray Mouth area for breeding; the Musk duck, Baillon’s Crake, Southern Emu-wren and Golden-headed Cisticola. Two other species rated ‘Rare’ are provided with important non-breeding habitat in this area; Cape Barren Goose and Great Crested Grebe.

Carpenter (1995 in Brandle 2002) summarised the estimated abundances of birds in the Lower Lakes and upper Coorong as:

- 60,000 waders (40,000 migratory) of 30 species (20 migratory),
- 110,000 waterfowl of 14 species, and
- 70,000 waterbirds of 38 species.

The Lower Murray Lakes area is also the largest freshwater drought refuge in South Australia (Brandle 2002, Paton in Jensen *et al*. 2000) and supports breeding colonies of Australian Pelican, ibis, egrets, spoonbills and cormorants. If current drought conditions persist, in the summer of 2002-03, it is expected to contain a large proportion of the waterfowl remaining in South-eastern Australia (pers. comm. J. Pedler information from Waterfowl Advisory Committee SA December meeting 2002).

Table 5.1 List of Waterbird species (Waders, Waterfowl and others) that use habitat in the Lower Murray Lakes region and details of the agreements under which they are protected with their current conservation ratings under Australian legislation (compiled by P.A. Paton)

Bird Species Common Name	Species Name TO be inserted	Protected under CAMBA and/ or JAMBA	EPBC Act 1999	NPWAct 1972
Musk Duck				Rare
Freckled Duck				Vulnerable
Black Swan				
Australian Shelduck				
Australian Wood Duck				
Pacific Black Duck				
Australasian Shoveler				Rare
Grey Teal				
Chestnut Teal				
Pink-eared Duck				
Hardhead				
Australasian Grebe				
Hoary-headed Grebe				
Great Crested Grebe				Rare
Darter				
Little Pied Cormorant				
Pied Cormorant				
Little Black Cormorant				
Great Cormorant				
Australian Pelican				
White-faced Heron				
Little Egret				
Great Egret		JC		
Australian White Ibis				
Straw-necked Ibis				
Royal Spoonbill				
Yellow-billed Spoonbill				
White-bellied Sea-Eagle		JC		Vulnerable
Swamp Harrier				
Buff-banded Rail				
Lewin's Rail				Vulnerable
Baillon's Crake				Rare
Australian Spotted Crake				
Spotless Crake				
Purple Swamphen				
Dusky Moorhen				
Black-tailed Native-hen				
Eurasian Coot				

Marsh Sandpiper		JC		
Common Greenshank		JC		
Wood Sandpiper		JC		
Red-necked Stint		JC		
Long-toed Stint		JC		
Sharp-tailed Sandpiper		JC		
Curlew Sandpiper		JC		
Painted Snipe		C		Rare
Black-winged Stilt				
Banded Stilt				
Red-necked Avocet				
Pacific Golden Plover				
Red-capped Plover				
Black-fronted Dotterel				
Red-kneed Dotterel				
Silver Gull				
Whiskered Tern				
White-winged Black Tern		JC		
Clamorous Reed-Warbler				
Little Grassbird				
Golden-headed Cisticola				Rare

However, no understanding of how to manage this important habitat can be gained by merely viewing the statistics of occurrence of these species. In order to protect the natural processes essential to the existence of these species, it is necessary to understand how these species use the habitat.

5.1.1 Differential use of Ramsar habitat by Bird Species

There is very little published literature on the detail of habitat use by waterbird species in Australia and even less published work specific to these bird species in this region. Only a handful of studies relate to the latter; Jaensch 1982, Paton (1986), Paton et al. 1989, Paton 2002 and Brandle 2002 and the excellent compilation of bird occurrence and use of habitat in the Strathalbyn and Goolwa districts by Eckert (in Strathalbyn Naturalist Club Inc. 2000). Accordingly, to document the differential use of habitat, this study has relied on these sources, and the personal observations of Penny Paton, Janet Pedler, local ornithologist John Eckert and several landholders visited during this study and in 2001, during the preparation of the Revegtation Guidelines.

In Table 5.2, P. Paton has summarised the habitat preferences and type of use known for many of the waterbird species that occur in the Lower Lakes and in Table 5.3 the habitat preferences of waders are summarised. A comparison of these two tables shows a number of crucial differences in habitat use. Firstly the two groups of birds could not be directly compared using the same habitat definitions. To show wetland habitat preference for waterfowl, other waterbirds and associated raptors and passerines, it is necessary to differentiate habitat in terms of adjoining terrestrial vegetation, fringing vegetation, aquatic vegetation and open water, while and the terrestrial vegetation and fringing vegetation is further divided according to subtle differences in species composition, e.g., reed beds comprised of *Phragmites australis* and/or *Typha species* vs. beds of rushes and sedges.

The types of wader habitat presented actually occupy a very narrow range of habitat within the broad range above. The five types listed are all variations on shallow water habitats with a variety of fringing vegetation. They are differentiated in terms of their saline or freshwater regime, whether they are temporary or permanent and whether they have open or vegetated edges. Tables 5.4, 5.5 and 5.6 show feeding styles and food items and further illustrate the major divisions between the two groups in the manner they obtain food within the general lakes habitat and the composition of their diet.

The major and almost exclusive method wading species use to obtain their food is to wade through shallow water and take animal and plant food from the substrate, off the water surface or from the water column. The major variation to this method used by many waders is to probe or glean food items from wet muds or dry substrates, while only two species, the Red-necked Avocet and Banded Stilt actually swim in order to obtain a large percentage of their food (mainly zooplankton). Consequently the defining features of wader habitat are the depth of water, and the type of edge present in the habitat. Heavily vegetated littoral areas such as the edges of Reed beds are seldom used by waders and water over a few centimeters in depth excludes all the small species of waders. Water over 10-15 cm in depth excludes the larger species like Curlews and Sharp-tailed Sandpipers. In addition few of the wader species present in this region actually breed within the region and therefore for migratory species, their needs for approximately 5 months of the year dictate their habitat preferences (during the southern hemisphere summer and autumn). The waders that do breed in the region are:

Black-winged Stilt
Red-necked Avocet
Red-capped Plover
Black-fronted Dotterel
Red-kneed Dotterel
Painted Snipe (1 breeding record only, Eckert in Strathalbyn Naturalist Club Inc. 2000).

Wader species also do not vary greatly in their habitat use during periods of roosting or resting. Birds that feed in large flocks often roost and loaf on sheltered mud flats close to their feeding grounds while waders that feed in smaller groups or singly will generally roost on mud flats in among low shrubby vegetation like samphire to gain protection from the elements and avoid predation.

Table 5.2 Compilation of habitat preferences and use of habitat for 44 bird species that use the Lower Murray Lakes (11 waterfowl, 28 waterbird, 3 passerine and 2 raptor species). Prepared by P.A. Paton using Jaensch (1982) and personal observations.

Bird Species	**Shrub-land**	**Reed-beds**	**Rushes**	**Tussocks Dry?**	**Floating Veg.**	**Grass & Weeds**	**Bare Margins**	**Open Water**
Waterfowl								
Musk Duck	B	B (L)	(F)	B	(L)(F)			LF
Freckled Duck	B(L)	(B) L		B	L		LF	LF
Black Swan		B	B		BF	(B)F	(B)F	BLF
Australian Shelduck	B					BF	L(F)	L(F)
Australian Wood Duck	R					F	L(F)	L
Pacific Black Duck	B(L)	B(L)(F)		B(L)	(L)(F)	BF	LF	LF
Australasian Shoveler	(B)	(B)		(B)	L(F)	BF	LF	LF
Grey Teal	B(L)	(B)		B(L)	(L)(F)	(B)(F)	LF	LF
Chestnut Teal							LF	LF
Pink-eared Duck	B(L)	(B)		(B)		(B)	LF	LF
Hardhead	B(L)	B(L)(F)		B	L(F)	(B)	LF	LF
Other Waterbirds								
Australasian Grebe		(L)			(B)(L)(F)			BLF
Hoary-headed Grebe		(L)			BLF			BLF
Great Crested Grebe		B(L)(F)			(B)(L)(F)			BLF
Darter	L						L	F
Little Pied Cormorant	BL						L	F
Pied Cormorant	L						L	F
Little Black Cormorant	BL						L	F
Great Cormorant	BL						L	F
Australian Pelican							L	LF
White-faced Heron	BL		(F)		F	F	LF	
Little Egret	L				(F)	F	LF	
Great Egret	BL		F		F	F	LF	
Australian White Ibis	BL	B				F		
Straw-necked Ibis	BL	B				F	L(F)	
Royal Spoonbill	BL	(B)					L(F)	F
Yellow-billed Spoonbill	BL						L(F)	F
Buff-banded Rail	BLF	BLF	(F)	BLF		(B)LF	(F)	
Lewin's Rail	LF	BLF		BLF		(F)		
Baillon's Crake	B(L)	(B)LF	B(F)	(B)(L)	(B)FL	(F)		
Australian Spotted Crake	BLF	BLF	F	BLF	F	F	(F)	
Spotless Crake	LF	LF		LF				
Purple Swamphen	L(F)	BLF	B(L)F	(B)(L)	(B)(L)F	F	LF	(L)F
Dusky Moorhen		BL(F)	(B)(F)	(B)(L)	(B)(L)(F)	F	F	(L)F
Black-tailed Native-hen	BL(F)	(B)LF		(B)LF		LF	LF	
Eurasian Coot	BL	BL	(B)	(B)	BLF		(L)F	LF
Silver Gull	(L)					(B)LF	(B)LF	L(F)
Whiskered Tern	(B)			(B)	BL(F)	F	L	F
White-winged Black Tern							L	F
Raptors								
White-bellied Sea-Eagle	(L)					(F)	(L)(F)	(F)
Swamp Harrier	(F)	B(F)	(B)(L)(F)	(F)	(F)	BF	LF	(F)
Passerines								
Clamorous Reed-Warbler			BLF					
Little Grassbird	(B)(L)(F)	BLF		BLF				
Golden-headed Cisticola		BLF		(L)(F)		BLF		

Key to Habitat
Shrubland = Melaleuca halmaturorum
Reedbeds = Stands of Typha spp. & Phragmites australis
Rushes = Diverse beds = Machaerina= Baumea spp
Tussock land = mainly Gahnia filum
Floating vegetation = Triglochin procerum in freshwater Grass & weeds = Dry or subject to inundation Bare or sparsely veg. margins = subject to inundation or dry
Open water = area of water with no emergent or overhanging vegetation

Key to Use
B = uses for breeding purposes
L = uses for loafing or roosting purposes
F - uses for feeding purposes
( ) brackets indicate occasional or probable use of a habitat only

Table 5.3 Use of various types of habitat by Waders. Prepared by P.A. Paton.

Bird Species	Samphire swamps	Shallow swamps with lignum	Brackish/tidal wetlands	Fresh-water wetlands	Ephemeral pools	SHALLOW Saline lakes
Marsh Sandpiper			X	XX		
Common Greenshank			XX	XX		
Wood Sandpiper				X		
Red-necked Stint	X		X	X	X	
Long-toed Stint						
Sharp-tailed Sandpiper	X		XX	X	X	
Curlew Sandpiper	X		XX	X		
Painted Snipe	X	X		X		
Black-winged Stilt	X	X	X	X	X	
Banded Stilt			X			X
Red-necked Avocet	X	X	X	X	X	X
Pacific Golden Plover	X		X			
Red-capped Plover		X	X	X	X	X
Black-fronted Dotterel				X	X	
Red-kneed Dotterel		X			X	

Table 5.4 Food items and Feeding Behaviour for 44 bird species that occur in the Lower Murray Lakes region. Prepared by P.A. Paton using HANZAB (DATE) and personal observations.

Bird Species	Aquatic Inverte-brates	Aqatic Verte-brates	Fish	Aquatic plants	Pasture Plants	Feeding Behaviour
Musk Duck	X		X	X		diving in deep water
Freckled Duck	X			X		filter feeder
Black Swan				X	XX	surface or upending
Australian Shelduck	X			X		grazing, dabbling, upending, paddling, sifting
Australian Wood Duck					X	grazing on land
Pacific Black Duck	X			XX		dabbling, up-ending, grazing
Australasian Shoveler	XX					dabbling in mud or at surface (filter feeder)
Grey Teal	X			X		up-ending, dabbling, dredging mud, stripping seeds
Chestnut Teal	X			X		dabbling, up-ending, pecking at surface
Pink-eared Duck	XX			X		filtering
Hardhead	X			X		diving, sieving mud, up-ending, stripping seeds
Australasian Grebe	X		X			diving, picking from surface, snatching from emergent plants
Hoary-headed Grebe	XX					deep diving
Great Crested Grebe			XX			diving in clear water
Darter	X		XX			diving
Little Pied Cormorant	XX		X			diving
Pied Cormorant			XX			pursuit diving
Little Black Cormorant	X		XX			pursuit diving
Great Cormorant			XX			pursuit diving
Australian Pelican	X		XX			stabbing, driving, scooping, surface-plunging
White-faced Heron		X	XX			stand & wait, gleaning ,peering, foot-stirring
Little Egret	X	X	XX			stand & wait, crouch & wait, slow & quick walking, running, foot stirring, wing-flicking
Great Egret	X	X	XX			Stand & wait, slow walking
Australian White Ibis	X	X	X			walk slowly on land & shallow water- shallow & deep probing, pecking
Straw-necked Ibis	X	X	X			walk slowly on land & shallow water
Royal Spoonbill	X		X			slow sweeping, intensive search, dragging, probing, grabbing
Yellow-billed Spoonbill	XX		X			slow sweeping, intensive search, dragging, probing, grabbing
White-bellied Sea-Eagle			X			also birds, reptiles, mammals, crustaceans & carrion
Swamp Harrier			X			also birds, eggs, reptiles, mammals, frogs, large insects; quartering
Buff-banded Rail	X					also terrestrial Invertebrates, young plants, seeds. fruits, frogs, eggs, carrion
Lewin's Rail	X					also earthworms, arthropods (especially insects & crustaceans),occasionally frogs, eggs. feed on dry ground, soft soil, mud, reed beds, shallow water -peck, probe & drill holes
Baillon's Crake	X					also seeds, snails, small vertebrates glean among floating vegetation saltmarsh, freshwater reeds, mudflats & shallow water
Australian Spotted Crake	X					also seeds, molluscs, insects, crustaceans & spiders glean & probe on mudflats & in reed beds; wade in shallow water & swim, probing

Bird Species	Aquatic Inverte-brates	Aqatic Verte-brates	Fish	Aquatic plants	Pasture Plants	Feeding Behaviour
Spotless Crake	X			X		also seeds, fruits, grass shoots, adult & larval insects, molluscs, crustaceans ,spiders, glean on mud flats, reed beds, shallow water, short grass; swim; scratch in litter
Purple Swamphen				XX	X	also seeds, fruits, insects, frogs, lizards, fish, birds, eggs, small mammals feeds in swamps, damp pasture, grasslands; glean, dig, immerse head in water
Dusky Moorhen	X			X		also seeds, fruit, molluscs, insects,, spiders, carrion glean on water & land; up-ends; glean & peck low vegetation: prefer shallow water with much vegetation
Black-tailed Native-hen				X		also seeds, plant material, insects feed in water & on ground; glean from ground & water surface, submerge head & shoulders
Eurasian Coot	X			X		also seeds, grass, molluscs, crustaceans, eggs feeds in water & on land; scrape algae, pick off water surface, break off shoots, dive, up-end
Silver Gull						Omnivorous! Scavenges for most of food but will take ducklings, mice, large insects etc.
Whiskered Tern			X			carnivorous; insects, crustaceans, small vertebrates like frogs, seeds, centipedes, spiders feed over water & land; plunging, dipping & hawking
White-winged Black Tern			X			carnivorous; insects, spiders forage mainly over estuaries & freshwater wetlands: plunging, dipping & hawking
Clamorous Reed-Warbler	X					
Little Grassbird	X					
Golden-headed Cisticola	X					

Table 5.5 Feeding habitat preferences and behaviour for Waders occurring in the Lower Lakes region - prepared by P.A. Paton using Lane (1987) & personal observations.

Bird Species	Zone A	Zone B	Zone C	Zone D	Zone E	Feeding Behaviour To be filled in
	dry mud	wet mud	water's edge	shallow water	deeper water	
Marsh Sandpiper		X	XX	XX		
Common Greenshank				XXX		
Wood Sandpiper		XX	XX	XX		
Red-necked Stint		XXXX	XX	X		
Long-toed Stint						
Sharp-tailed Sandpiper		XX	XXX	XX		
Curlew Sandpiper		X	XX	XXXX	X	
Painted Snipe				XXX		
Black-winged Stilt	XX	XX	X	XX		
Banded Stilt		X	X	XX	XXX	
Red-necked Avocet				XX	XXX	
Pacific Golden Plover						
Red-capped Plover	XXXX	XX				
Black-fronted Dotterel	XX	XX	XX			
Red-kneed Dotterel			XX	XX		

Table 5.6 Food items taken by wader bird species that are found in the Lower Lakes Region - compiled by P.A. Paton from Paton 1982 and HANZAB **Date)**

Bird Species	**Food items**
Marsh Sandpiper	insects, molluscs
Common Greenshank	molluscs, crustaceans, insects, occasionally fish& frogs
Wood Sandpiper	insects, molluscs
Red-necked Stint	omnivorous, including seeds
Long-toed Stint	seeds, molluscs, crustaceans, insects
Sharp-tailed Sandpiper	aquatic & terrestrial insects, small shellfish, seeds, polychaete worms
Curlew Sandpiper	At non-tidal sites: oligochaete worms, amphipods, gastropods, insect larvae & pupae
Painted Snipe	vegetation, seeds, insects, worms, molluscs, crustaceans & other invertebrates
Black-winged Stilt	Aquatic & terrestrial invertebrates: molluscs, crustaceans, insects; seeds
Banded Stilt	Mainly crustaceans, including branchipods & ostracods, molluscs, insects, vegetation, seeds, roots, Ruppia turions, small fish
Red-necked Avocet	insects, crustaceans, seeds, vegetation, fish
Pacific Golden Plover	molluscs, worms insects, crustaceans, spiders, occasional seeds, leaves, lizards, eggs, fish
Red-capped Plover	amphipod crustacea, gastropod molluscs, annelids, insect larvae, adult beetles, seeds
Black-fronted Dotterel	molluscs, crustaceans, insects, occasional. seeds
Red-kneed Dotterel	seeds, molluscs, annelids, spiders, insects

In direct contrast, feeding habitat preferences emerge among other waterbird groups according to their feeding behaviour as well as the physical and chemical features of the habitat. Many sub-groups of waterbirds emerge along these lines.

The waterfowl, ducks, swans and geese, show a clear preference for feeding at the margins of wetlands. Ducks and swans also use the stretches of open water within the swamps, using diving, dabbling and upending, feeding behaviours to obtain plant stems, roots and leaves and harvest the blankets of algae and their accompanying rich invertebrate haul, from shallow waters. However they use a variety of heavily vegetated areas for breeding and roosting sites. Similarly, the three grebe species feed almost exclusively by diving in open water and use floating vegetation and to a lesser extent reedbeds for breeding and resting sites.

The crakes, swamphens, moorhens and rails clearly concentrate their feeding, resting and breeding behaviour in among the beds of reed, sedges and rushes and along their edges. A large part of their diet also comes from ingesting these plants and their seeds.

Herons, Egrets, Ibis and Spoonbills show many similarities in the habitat types and depths of water in which they feed, i.e., open water and bare water margins but differ widely in their feeding style and consequently their range of food items. All of these large species, do however, require substantial inundated beds of reeds or rushes or taller vegetation like the tops of Swamp Paperbark trees in which to build their nests. They nest within large breeding colonies that offer them good protection from predation.

Destruction & Protection of the Range of Habitat Types

Once it is clear that there are strong divisions between the habitats required by various groups of waterbirds, i.e. differential use of the region by various bird groups and individual species, it is then clear that to protect Ramsar habitat means to protect
several distinct habitat types. This must also be accomplished for multiple uses and users, in a variety of circumstances i.e., protect habitat spatially and temporally for a variety of needs such as shelter, breeding and feeding. For example wetland habitats must be available to wildlife during flooding events so that species that breed opportunistically with flooding can achieve reproduction.

One strategy used so far by relevant management authorities for accomplishing this protection, is to manage so as to maximise protection of the whole region. If all the natural systems in the region were intact this strategy would seem more than adequate. However the reality is actually very different.

As discussed in section 4, the environment of the Lower Murray Lakes is a drastically altered system with huge changes having occurred since European settlement. It is well documented that with the building of the barrages and subsequent freshening and changes to the water regime, some types of habitat have been expanding dramatically while others have drastically declined. In addition this study has gathered evidence that suggests that these changes are still continuing at an alarming rate with some habitat becoming increasingly rare while others types expand. Put simply, preferred wader habitats, the shallow tidal flats and shallow estuarine or saline swamps with samphire vegetation, are most at risk of destruction from a variety of causes while the habitats favoured by waterfowl and other waterbirds in general have expanded. As discussed in section 4., a third habitat type, Red Gum Swamps, has probably neither decreased or declined in the area that it covers but has become severely degraded within this area. The current status of these three broad habitat groups are discussed below with reference to ongoing threatening processes and other fauna that depend on these habitats.

5.1.2 Current Status of Saline Swamp Habitat & Summary of Threatening Processes

The protection and maintenance of wader habitat presents a major problem everywhere it occurs around Lake Albert and Lake Alexandrina. This study has observed the destruction of saline swamp habitat is occurring by variety of means:

1. Removal of the whole formation by erosion on the lakeshore,
2. Removal of the vegetative cover of the swamp by grazing animals either as wholesale removal of the vegetation by eating or through damage done to the soils and plant-forms by hoofs, which in turn, further destabilises the soils.
3. Freshening of the saline habitat by altering the water regime so that a permanent change in salinity of the water and soils/muds is effected.
4. Overgrowing of the habitat by weed species or native species that are able to utilise the permanently freshened environment, thereby effecting permanent changes in the physical and biotic parameters of the habitat.

The role of that grazing has in the destruction of saline swamps will be further explored in section 6. Loss of shallow saline habitat through changes in water regime has already been highlighted as a major destructive force in this region by many other studies (Paton 1982, Carpenter in Edyvane & Carvalho1995, Paton in Jensen et al. 2000, Paton 2001, Brandle 2002, Cooling & Rudd 2000). Unfortunately there has been even less attention paid to the current and ongoing loss of habitat through overgrowing with other species which has been made possible by the freshening of the water and soils.

An outstanding exception to this is John Eckert's tireless work on the Tolderol Game Reserve (in conjunction with SA NPWS) and work on his adjoining property that has been aimed at addressing this problem for many years. He has used a wide variety of measures to prevent the overgrowth of valuable wader habitat, in the form of samphire swamps, by Paspalum species and *Phragmites australi*s.

Eckert has developed detailed methods to prevent the spread of Paspalum species and *Phragmites australis* into samphire in good condition and over exposed mudflats and to provide what he considers to be rejuvenated habitat for waders and waterfowl, providing both the right physical structure for feeding waders, and the right biotic conditions to ensure the specialised faunal assemblages are present to feed upon. They involve the use of selective grazing, flooding areas and selective spraying and ripping.

His detailed, local knowledge of what structure and conditions are needed to support migratory waders and other waterbirds in the lower lakes cannot be valued highly enough, and his experience in managing field conditions to provide appropriate habitat is extensive and unique. John is now in farming retirement but continues to work to manage these sites. It is vital that his knowledge and methods in this area be documented and investigated further. At present the only formal evidence that Eckert's methods are succeeding is the continuing presence of these bird species on site. Understanding precisely what is being manipulated on site, e.g. salinity of water, presence or absence of particular invertebrates, height of water, shelter from wind and/or predation, etc, will ensure that these methods can be used and refined elsewhere to the benefit of fauna.

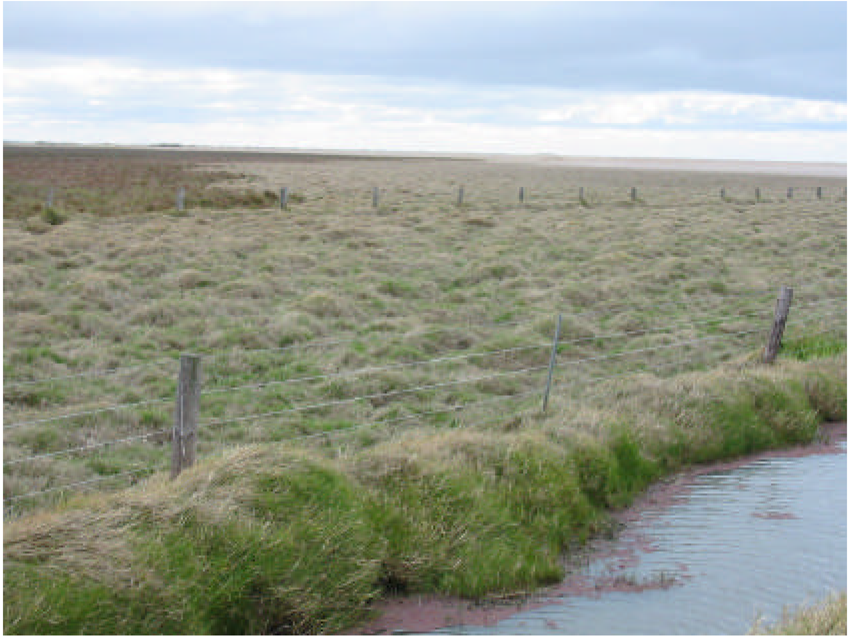


Plate 5.1 Section of Samphire Swamp that has been completely overgrown by *Paspalumvaginatum Salt-water Couc*h, adjacent Tolderol Game Reserve. The red patch to the left in the background, denotes surviving samphire, while the rest of the area which was once an important samphire swamp feeding area for waders has been covered by the invader.

Full documentation of Eckert's methods was not possible during this study but a brief summary of them will serve to highlight the relevant processes. The method assumes that in the current environment of the lakes, the protection of the lake edge by reeds, rushes and sedges is an essential component in the protection and/or production and use of shallow feeding habitat for waders and waterfowl. It recognises that the salinity and water regimes within the habitat control the availability of appropriate food and therefore the value of the site as wader habitat. It also recognises that subtle changes in water and salinity regimes control the growth of several plant species so that manipulation of these variables can prevent loss of habitat by overgrowing. Paspalum spp. and *Phragmites* are both favoured by the conditions in a lake-edge freshwater reedbed and are well placed to grow out from there as winter storm splash and seepage freshen the samphire areas behind the edge.

To counter this inevitable invasion Eckert first ploughs in all standing vegetation and floods the swamp behind the edge with freshwater using water pumped from the lake and channelled into the wetland. Paspalum is unable to withstand flooding, but may take 1-2 years to die completely under floodwater so the water is left to evaporate over a long time rather than being pumped out. The standing and evaporation of the 'flood' waters also serves to gradually increase the salinity of the water over time as it leaches from the hypersaline soils. Eventually the salinity is so high that it is outside the tolerances of both Paspalum spp. and *Phragmites* *australis.* Meanwhile the destruction of standing vegetation has meant that the nutrients they carried have been released quickly into the waters on flooding of the area, mimicking the affect of natural floods on ephemeral wetlands. The flush of nutrients stimulates algal growth and a corresponding growth of aquatic invertebrates. This initial mixture of algae and invertebrates in shallow water that Eckert calls 'teal soup' provides a wonderful food resource for waterfowl. As the water sits and increases in salinity the aquatic plant and invertebrate fauna changes, samphire germinates and begins to regrow. By the time the Paspalum has been killed completely, the water in the lagoon is saline, supports invertebrates that are preferred wader food, and makes this food accessible to them in shallow water while the structure of the re-newed samphire growth offers protection from wind and predators. Control of regrowth of *Phragmites* and Paspalum from the lake edge is actively managed by Eckert by using sheep to graze off the regrowth, rather than cattle, to minimise soil damage and gross destruction of vegetation. This calculated grazing to prevent regrowth is an important factor in retaining the saline swamp habitat.

Within the shallow and exposed saline swamps that do still exist within the much altered environment of the Lower Lakes, many interactions are taking place at a very local level that threaten their integrity as habitat for fauna. Paton (2001) conducted a study of the parameters important to migratory waders feeding in the Murray Mouth during January and February 2001. Paton identified a number of factors that appeared to have affected feeding behaviour. During mid-December to early January the Mundoo barrage was open in a bid to flush out the Murray Mouth. Low wader counts during this period were probably caused by the raised water levels on the tidal mudflats during this period. (Water depths of greater than 5 cm are enough to preclude feeding of the smallest waders).

By late January to mid February the water level had dropped and there were low tides and high temperatures that left the mud flats exposed for most of the day. The number of chironomid larvae found in the muds (saline adapted species that are an important source of food for small waders), declined dramatically between January and February. It is likely that this decline was caused by the exposure of the mudflats as chironomid larvae are unable to escape from their sheltering tube in the mud surface in the absence of water. Another food source, Polychaete worms, are however, able to escape exposure by burrowing deeper into the sediments and numbers of these did not decline dramatically over this period. This study powerfully illustrates how slight changes in water levels have huge potential to alter the suitability of an area as habitat.

The salinity tolerances of many important submerged food plants for waders and waterfowl are another parameter that affects the potential of an area of wetland to provide feeding habitat. The seeds, tubers, turions and leafy parts of *Myriophyllum* species, *Valisneria* species., *Lepilaena* species, *Lamprothamnium* and *Ruppia* species, have all been variously recorded being eaten by waders and waterfowl in the Coorong (Paton 1982). In addition the biofilm and shelter they provide offer rich habitats for a myriad of aquatic insects, crustaceans, molluscs and small fish which are in turn eaten by waders and waterfowl. (Wader diets in the Coorong included small individuals of fish species, the mollusc *Coxiella striata*, cockles, and beetles, Paton, 1982).

With the freshening of lake water, growth of many species has been curtailed seasonally or permanently while others have expanded their range and/or growth period. *Ruppia* species for instance thrive in saline waters of 36.9 -56.5 ppm still a dominant submerged plant within the Coorong system, while the range for

Myriophyllum spp. which are now most common in the Lower Lakes is around 0.38 - 0.50 ppm (Ganf in Jensen et al. 2000). Paton (1982) quotes several studies which have shown that healthy growth of several of these submerged species is dependent on salinity regime and the germination and/or production of turions, tubers, rhizomes and seeds is dependent on temperature and salinity e.g. Lamprothamnium sp. an important duck food.

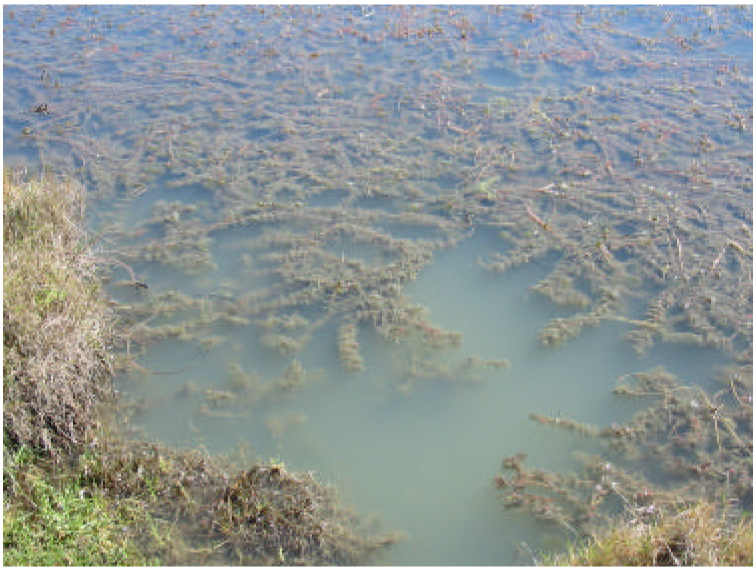


Plate 5.2 Myriophyllum sp. Provides rich habitat for aquatic invertebrates. Submerged plants like this in shallow waters provide ideal feeding habitat for a variety of waterfowl.

Similar tolerances affect the aquatic fauna that accompany these plant associations, e.g. Polychaetes are more tolerant to fresh water than the chironomid species that waders are feeding on in estuarine conditions (Kokkinn pers. comm. 2002, Paton 1982). Turbidity within these waters also greatly affect the range of invertebrate fauna present or absent. These chironomid larvae again serve to illustrate the incredible range of interactions that prevail and affect the presence or absence of invertebrate fauna. They are filter feeders that capture sand particles and scrape the biofilm from their surfaces so low levels of turbidity necessary but on the lake edges where turbidity is high due to suspended clay particles their feeding is interrupted. They are able to escape predation by small fish like Hardyheads picking them off in the mud, by retreating to the bottom of their tubes but if the tubes are severely disturbed such as in erosive events, the larvae go to the surface of the water and hide in the film to resettle later (Kokkinn pers. comm. 2002).

Geddes (in Jensen et al. 2000) highlights two key issues in the changed environment of the Lower Lakes and Coorong: the reduction in estuarine area and changes in water regimes. Geddes summarises the affects of these changing parameters on the invertebrates and fish species, suggesting that the reduction in estuarine area by the separation of the lakes from the Murray Mouth and a restricted range of salinities in the northern and southern lagoons has reduced the productivity of the habitat, affecting commercial and non-commercial fish species. Changes to flow regimes, and in particular the capturing of Murray floodwaters, have been shown to restrict recruitment of many estuarine fish species by removing the cues for spawning of fish like greenback flounder and bream. Geddes further reports that changed flow regimes through the barrages, implemented in 1994, have been shown to be successful in increasing the attraction, feeding and maintenance of mulloway stocks, a large predatory fish species. Several species of fish may be able tolerate the range of saline and brackish waters in the lakes and Coorong (Paton 1982) and could be taken by waders when they are small i.e. Hardyhead, Yellow-eyed Mullet, Black Bream.

Formerly, when fresh floodwaters have spreadout and covered the sheltered saline swamp lands behind the lake, they have become incredibly productive areas for a wide range of flora and fauna and may offer the circumstances for opportunistic breeding of species ranging from birds, mammals, tortoises and fish to invertebrates like crustaceans, insects, molluscs etc. Michael Thompson (pers. comm. 2003) has recorded densities of the Long-necked Tortoise *Chelidona longicollis* of *ca* 50/ha feeding in the flooded saline swamps south of Milang. It is likely that this species was nestng in the paddocks surrounding the swamps during this flood event. He has recorded individuals of this carnivorous species feeding on aquatic crustaceans as small as *Daphnia sp.* Water Fleas.

5.1.3 Current Status of Freshwater Swamp Habitat & Summary of Threatening Processes

As discussed, this habitat type, characterised by beds of reeds, rushes, and sedges appears to have benefited the most from the retention of high levels of freshwater and most likely has expanded dramatically across the Lower Lakes. However within this predominantly freshwater, permanent habitat some aspects of the habitat or particular localities are still threatened and/or actively degrading,

Plate 5.3 Actively eroding shoreline typical of lakeshore erosion throughout the Lower Lakes region, with only Kikuyu able to grow in the unstable conditions but not able to stabilize the shoreline.

As discussed above, the regulated and constantly high pool level results in a moderation of flooding and inundation events that may lessen productivity. However, the biggest challenge to the maintenance of diverse freshwater swamps takes place on the lake edge itself, where the high pool level, shallow water and long fetch lengths combine to produce zones of extremely high erosive activity. In many areas no emergent native vegetation has been able to survive, and only weed/pasture species like Kikuyu are able to partially stabilise the edge.

This limiting factor also precludes submerged plant growth by those species capable of tolerating the freshwater regimes. As a consequence of the erosion, the turbidity in the littoral zone is extremely high and turbidity remains high throughout even the deeper areas of the lakes. Ganf (in Jensen et al. 2000) links the increase in turbidity of lake water with the increase in proportion of flows from the Darling catchment. If not precluded by wave action alone, high turbidity severely reduces the ability of submerged plants to grow in the littoral zone and has been shown to restrict their growth at greater depths (Ganf in Jensen et al. 2000). Many freshwater plants also experience difficulties in maintaining growth under conditions water levels can change dramatically. Most of the aquatic and riparian species can cope with rising flood waters, but many cannot tolerate long periods under water, nor cope with sudden drops in water levels. As winter winds and wave action can cause huge fluctuations in the water level of the lakes, up to1m in some localities, (J. Eckert, T. McAnney pers. comm. 2002), some plant species are unable to survive the fluctuations.

The suite of plant species adapted to freshwater conditions that provide shelter and food resources for waterfowl and other fauna are therefore absent from a large proportion of the lake edge. The shallow depressions behind the actual lake edge are now often the only places that freshwater swamps can develop and persist. Not withstanding that a high proportion of these areas probably were once saline swamps, these areas behind the main lake edge are now the main strongholds of biodiversity and natural productivity in the lower lakes area.

The nearly continual high wave action around much of the lakes edges ensure that the swamps behind the edge continually receive wave splash as well as local precipitation and seepage from groundwater. Consequently many of these swamps behind the lake edges remain under shallow water or are continually damp for most of the year with the muds drying out during summer.

As has already been described above, submerged and emergent plant growth provides the basis for highly productive faunal assemblages. When these backwater swamps are protected from the wind and therefore also wave action across the shallow waters, by bands of reeds, rushes, sedges and Lignum *Meulenbeckia florulenta* they become essential feeding habitat for many Ramsar protected fauna (Roger Jaensch, Snr Program Officer, Wetland Inventory & Waterbird Surveys Wetlands International, pers. comm. 2002). In terms of bird species they provide feeding, resting and breeding resources for swans, ducks, coots, moorhens, ibis, herons, egrets, plovers, Golden-headed Cisticola, Grassbird, Reed Warbler, grebes, crakes and rails. Other waterbirds like Pelicans, cormorants and the Great Crested Grebe need deeper water to catch their food but may use the reedbeds for breeding or shelter. While most of the waders cannot use this habitat for feeding some species are probably dependent on it around the Lower Lakes, e.g. the Sharp-tailed Sandpiper (Jaensch, pers.comm. 2002)

Some of the fauna that currently depends on the freshwater habitats has probably been advantaged by the freshening of the lakes. Thompson (pers. comm. 2003) suggests that the Short-necked Turtle *Emydura macquarii* was still not found all the way down the R. Murray in the 1950's and must have reached and colonised the lakes after this time. Thompson believes the permanent freshwater conditions in the lake would favour this omnivorous species that he has recorded eating freshwater plants like Ribbonweed and predicts that the Broad-shelled River Turtle *Chelodina expansa* will make a similar transition down the Murray and into the lakes in time.

The recent Murray Mouth Biological Srurvey (Brandle 2002) revealed a surprising diversity of fish (16 species) and invertebrate species. Two of the species of fish are listed as nationally as Vulnerable and two have state conservation ratings. Brandle. (2002) suggests this demonstrates that many of the altered freshwater habitats such as the narrow channels with good macrophyte growth on Wyndgate Reserve, may be critical for the survival of several small fish species.

Plate 5.3 Waterbirds leaving major roost on tip of Mosquito Point

Despite its expansion, there is still degradation of this habitat taking place. The destruction of lake edge by erosion, the replacement of the bio-diverse areas with monocultures of *Phragmites australis* and Paspalum *spp*., have already been discussed. The role of grazing in the reduction of biodiversity will be further discussed in section 6. However, it is important to mention two specific effects it has on freshwater vegetation. While many reeds, rushes and sedge plants can be repeated grazed and continue to shoot back from rhizomes, woody plants like Lignum eventually are eaten back or pushed over until they are dead and any benefit they offered in shelter or windbreak for fauna is lost. Similarly in areas where Red Gum or Swamp Paperbarks still exist and/or still germinate the regrowth is continually eaten off and eventually the plants are eliminated completely.

In the shallow areas behind the edge, sheltered from the wind, hoof damage in the freshwater herb zone acts to reduce the diversity of the plant community by damaging, uprooting and killing plants that do not have root mats and leaving the surface deeply pugged. In the resultant landscape introduced species like Strawberry Clover and Paspalum weed species are advantaged. They are able to maintain matts of growth in the well drained tops of hummocks and grow down the mounds when the muds dry. A wide range of native species completely disappear in these circumstances and with them the invertebrate fauna also changes.

Effectively pugging creates isolated pools that are turbid, high in nutrients and often invertebrate predator-free. These conditions are ideal for algal growth and mosquito breeding (Michael Kokkinn, pers. comm. 2002) but not conducive to diverse aquatic faunas. It is possible that the main cool weather, Ross River virus carrier, the mosquito *Ochlerotatas camptorhynchus* could utilise these conditions.

Plate 5.4 Myriophyllum sp growth confined to the edges of Boggy Lake. Before the invasion of European Carp this submerged plant grew across the entire lake (T. McAnney pers. comm.)

Another feral species, the European Carp *Cyprinus carpi*o, is also responsible for reducing the biodiversity and productivity of the freshwater swamps. It plays a significant role in increasing turbidity and destroying the growth of submerged plants such as *Myriophyllum* that are basis of many aquatic communities. Much anecdotal evidence exists that documents a dramatic increase in the turbidity of swamp waters and destruction of major areas of submerged plants in shallow waters, utilised by waterfowl, after the European Carp reached the lake swamps (e.g., J. Eckert, T. McAnney, K. Strother, pers. comm. 2002). Some landholders witnessed large numbers of swans dying from starvation after the removal of literally tons of *Myriophyllum* mats during the first few years that carp reached the wetlands in the 1970's. T. McAnney links the presence of the carp and destruction of submerged plants to a noticeable decline and/or absence on Boggy Lake of Freckled Duck, Blue-bill Duck and Pink-eared Duck (pers. comm. 2002). Paton (in Jensen et al. 2000) also cites the loss of submerged plants as a major factor in the decline of Musk and Blue-billed Ducks. The European Carp has also been identified as destroying the eggs of many bottom laying fish and frog species.

Predation of nesting birds and tortoises and their eggs and hatchlings by feral species such as foxes also threatens wildlife. Finding suitable nesting sites in areas of high erosive activities is also difficult for both tortoise species, although sometimes the deposition of sediments can provide new nesting sites as shown on Mosquito Point in the photograph below.

As mentioned, the breeding colonies of mainly ibis, spoonbills, and other waterfowl, have remained the same throughout European history in South Australia. However Paton (in Jensen et al. 2000) and Pillman (1980) both note that Swamp Paperbarks on the islands have progressively died and disappeared and this continuing decline of *Melaleuca halmaturorum* was noted during this study.

Most disturbing however, are reports by landholders, SA NPWS staff and Ramsar representatives, that increasing disturbance of nesting birds on breeding islands is coinciding with a dramatic increase in recreational boating, sailboarding and jet skiing activity in the region. Unabated disturbance of breeding colonies could result in catastrophic declines in the populations of some species. Another trend that needs investigation is the changing breeding patterns of some species, for instance large numbers of Little Black Cormorants now breed on Snake Island off Tolderol and shelter and feed around Mosquito Point. Disturbance of feeding birds by recreational users of the Lower Lakes is also likely to present an increasing threat to the ecosystem.

Plate 5.5 Sandbank deposited on eroding shore of Mosquito Point where Short-necked Turtles *Emydura macquarii* nested recently

Plate 5.6 Drowned *Melaleucca halmaturorum* trees among *Phragmites australis* on Lucerne Island.

5.1.4 Current Status of other Associated Habitat

As described in Section 4, the habitat formed by rivers and creeks spilling floodwaters into the Lower Lakes is essential. While the swamps of Currency Creek and Black Swamp are protected by NPWS reserves, the Red Gum swamps of the Bremer are not. There is little natural vegetation left and many of the areas that would flood in a major event and allow regeneration of Red Gum are now not only farmed but support vineyards.

There are a number of other uses of habitat associated with the lake shore which are not as dependent on specific swamp habitats. This study has not been able to address this use in full but bird examples will suffice to illustrate these points. For example the lake environs are important habitat for the recovering Cape Barren Goose population centred on the area. They breed on offshore islands of the Sir Joseph Banks group near Tumby Bay, Eyre Peninsula but need the lake margins to feed. These birds do not specifically require saline or freshwater swamp but graze on the margins of both as well as utilizing pasture and crops grown by graziers.

The *Neophema* parrots also use a variety of lake margin and coastal habitats. This group includes Rock Parrots, Blue-wing Parrots, Elegant Parrots, and the rare Orange-bellied Parrot whose population may be on the way to recovery with extensive habitat protection in Victoria and Tasmania. These species all feed on a large variety of plant material, a good proportion of which is found in Samphire Shrubland and associated habitats. Their requirement for terrestrial habitat in good condition further reinforces the need to protect all zones of all habitats around the lakes from degradation whether they are swamps that are dry or wet, freshwater or saline.

6 Study of Grazing Practices and Impacts on the Lower Murray Lakes

Background

Historically, the lake edges have been seen as a valuable grazing area by graziers. At the same time, there has been an acknowledgment by graziers that this grazing causes damage to the lake edges. There has also been significant voluntary input into managing lake edges by some graziers (see Plate 1).

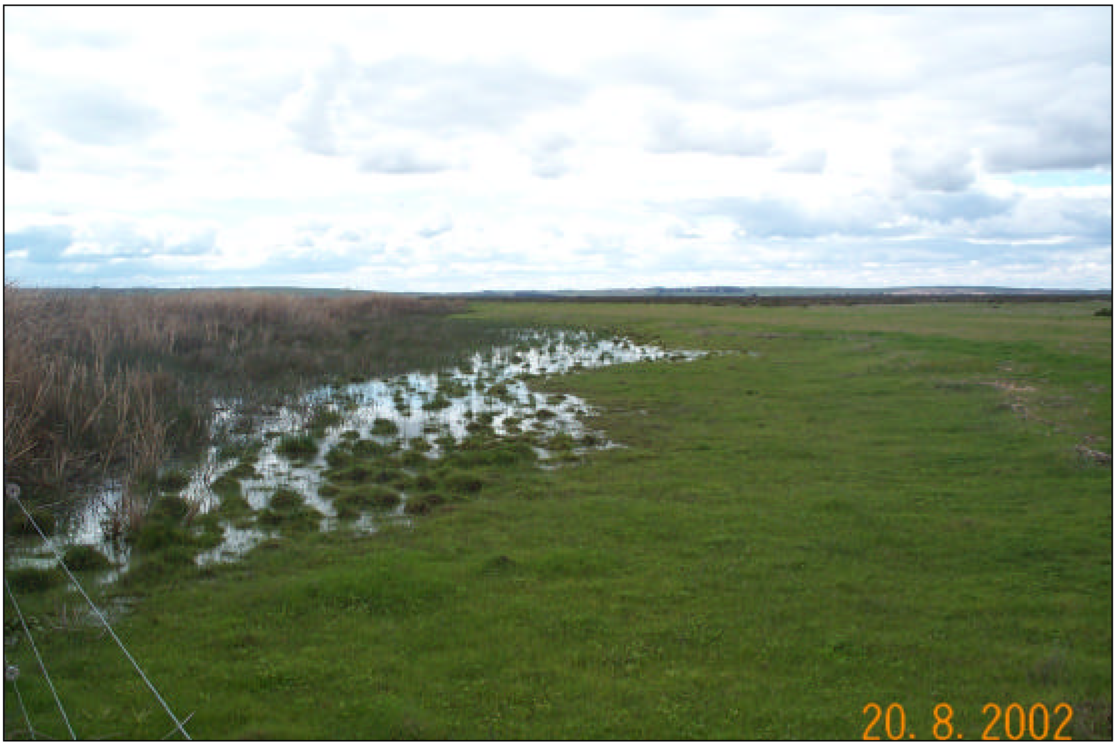


Plate 6.1 Reed re-establishment at Lake Albert Station

Nevertheless, there continues to be serious, widespread damage caused to lake edges as result of past and present grazing practices. Further, there is little information on the productivity and feed quality of plants growing on the lake edges.

This study set out to determine:

- Current grazing practices
- Community attitudes to grazing lake edges
- The productivity and quality of lake edge plants.

Producer Meetings

Discussion at the landholder meetings revealed some general agreement among graziers:

- Landholders generally, but not all individuals, ***acknowledge*** that grazing seriously damages lake edges, causing a ***loss of biodiversity and erosion***.

- There are ***many different*** types of and many different causes of damage to the lake edges. Uncontrolled grazing is ***one of a number*** of causes. Other causes include poor water quality from upstream, changing lake levels and algal blooms.

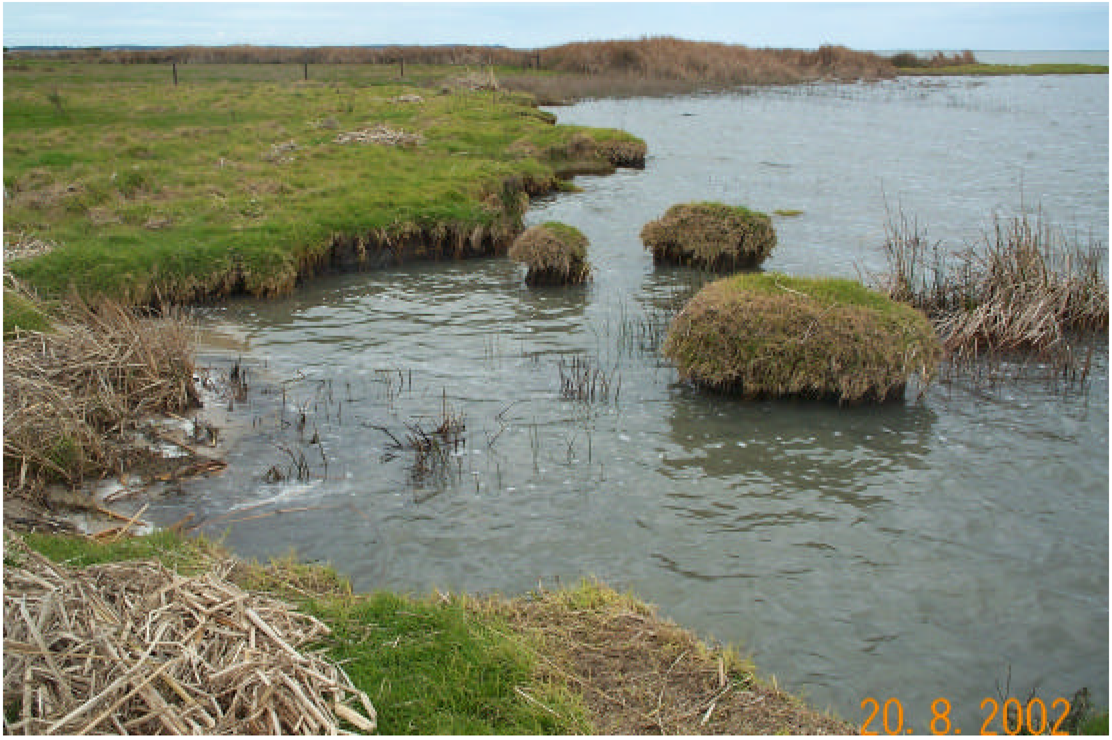


Plate 6.2. Erosion on Lake Edges

- Different parts of the lake edges have different problems and causes. ***There is no one solution to all problems.***
- Lake edges provide a significant amount of ***good quality grazing*** for livestock. They also provide free, reliable stock water. Landholders do not want to lose what they see as a very valuable summer/autumn resource for their livestock.
- Lake edges are often associated with a number of ***animal health problems*** – in particular liver fluke, trace element deficiency and intestinal worms.
- There needs to be ***control*** of livestock grazing on the lake edges. This involves:
  1. Summer grazing (with stock removed before plants are damaged).
  2. Minimal (or no) winter grazing when most plants are dormant.
  3. Total exclusion of livestock can allow weeds to dominate lake edges.
  4. Control of siting and set-up of water points.

  In spite of these general principles, many landholders felt that there was a lack of knowledge about the best way to manage stock on lake edges.

Plate 6.3. Grazing livestock Excluded from Lake Edges

- Any plans to change current management must actually improve the condition of lake edges. This means well-researched proposals trialed over a number of seasons.
- ***A lot of time and money*** will be required to repair the existing damage and to prevent future damage. Landholders feel that significant financial assistance is vital to the success of any plan to change lake edge management.
- Once new fencing is erected, there is an increase in the amount of time required to ***manage*** livestock and ***maintain*** water points.
- Landholders are faced with a ***daunting task*** to repair and prevent damage to lake edges.
- There needs to be reliable ***methods to re-establish*** native vegetation on lake edges.
- ***Demonstration areas*** would be valuable to convince landholders to change practices.

The full details of discussions at the producer meetings are given in Appendices 3 and 4.

6.3 Results of Producer Survey

The results of the producer surveys filled in at the workshop have been entered onto an Excel spreadsheet to be made available with this report to the LAP committees. The small number of producer responses (due to low numbers at the workshops) would not represent a valid statistical sample of all graziers so the results have not been analyzed statistically but the general trend in responses and any variance is reported in this chapter.

6.4 Interviews of Key Producers & Issues Identified on Property visits

The visits to individual properties and interviews of landholders served to clarify several issues. A range of properties were visited, chosen in order to view particular management or rehabilitation strategies and gain a better understanding of the issues facing landholders. These visits to properties were also chosen to expand upon the range of properties seen during the preparation of the Revegetation Guidelines. The issues discussed on these visits were similar to those dealt with at the grazier workshops but other aspects often arose during the visits. A summary of the information gathered follows.

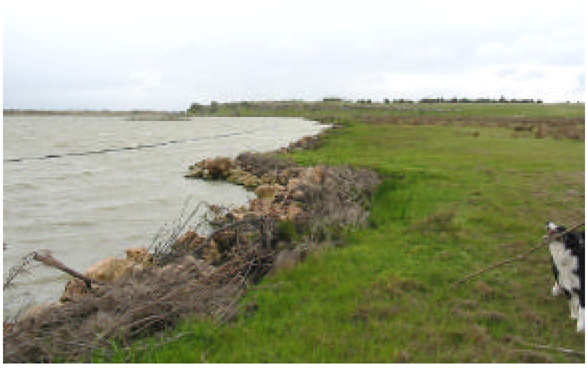
6.4.1 Lake Shore Erosion & Habitat Destruction

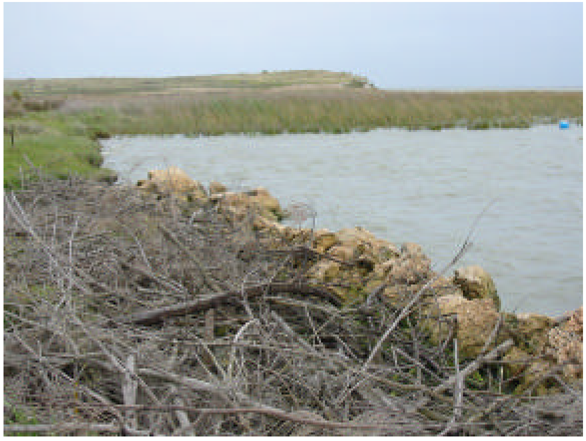
Significant erosion of the lakeshore was occurring on many of the properties visited and many different strategies to arrest the erosion were being made or had been made in the past. There were many obvious consequences to Ramsar habitat noted:

- While the shoreline was actively eroding very few plant species could maintain any growth on them and few were native species.
- Shorelines that had no sheltering emergent reeds or rushes on the lake side usually had active erosion of the shoreline occurring.
- Shorelines with large, dense beds of emergent reeds, rushes and sedges did not show any signs of active erosion from waves but did have an inundated area from seepage and wave splash on the shore side of the reed beds.
- On properties where there was still shoreline vegetation there was obvious damage to regenerating reed beds both offshore and on the adjacent rising ground that had been caused by cattle.
- Where attempts had been made arrest lake shore erosion, the use of rocks to make a protective barrier along the shoreline had been most successful in stabilising the shoreline and establishing reed beds.

Plate 6.4 Active erosion on shoreline where only Kikuyu can grow that is continuing into samphire area behind.

Shoreline erosion could be seen as the single biggest threat to protecting Ramsar habitat on grazing properties. On many properties large expanses of shoreline were actively eroding and no reed beds could establish on the lake side, no native vegetation could maintain populations on the rising ground of the shore and usually was not present behind the shoreline where water accumulated during the winter. In these areas the only vegetation present was usually mats of Kikuyu and Paspalum species that could grow without shelter from the wind and tolerate some degree of inundation but were not able to withstand the erosive forces on the shore itself. On some properties remnants of vegetation or the range of introduced plants present behind the shoreline allowed identification of former saline swamp areas, e.g. samphire remnants were present or Emu Grass *Distichlis distichophylla* with Spiky Club-rush *Schoenoplectus pungens*. Therefore, it is clear that both freshwater swamp and saline swamp areas are being lost, along with whatever grazing resources the areas provided, wherever shoreline erosion is proceeding.





Plates 6.5 & 6.6 Installation of protective barriers on shoreline on South property, Point Sturt. Left shows floating boom and protective rock wall, on right plant debris piled in gap between wall and remaining shoreline to catch silt shown.

The lack of any substantial vegetation, native or introduced, behind an eroding shoreline demonstrates two further important considerations.

1. Along eroding shorelines the area affected by the process is much larger than the shoreline itself. The harsh conditions on an eroding shoreline extend many metres behind the active area with lack of wind protection, inundation and the force of waves breaking making conditions impossible for establishment and growth of all but a few plant species.
2. This effectively leaves many metres of ground behind the actively eroding zone exposed and ready for erosion as the active area proceeds back away from the former lake edge.

Several properties had been highly successful in retaining vegetation in the nearshore area and grazed the shoreline area very selectively so as to retain this protective barrier. On these properties the integrity of the nearshore and rising ground vegetation was maintained by keeping good cover on the ground behind the shore line through fencing off a large area behind the shore and/or using very selective grazing management to avoid damage behind the shoreline. On the majority of properties visited during this study and preparation of the revegetation guidelines (ID&A & 2001) protection of this zone was not recognised as important in retaining the shoreline. All landholders, with the exception of J. Eckert, were completely unaware of its importance as a protected and productive feeding zone for fauna.

On several other properties where shoreline erosion was active, landholders had also gone to great lengths to establish protective structures in the nearshore area with various measures of success. The most successful of these structures appeared to be rock barriers. One property had combined several protection methods, (South property on Point Sturt Peninsula). They have fenced stock out of the shoreline zone, constructed vertical barriers of rock up to .5 m in front of the remaining edge, and have filled the space with branch debris from weed species like Boxthorn to hold any silt in the gap deposited by wave action and to encourage colonisation with reeds and rushes. In addition they have constructed and successfully used and adapted floating boom structures to dissipate the wave energy many metres off shore.

6.4.2 Grazing & Ramsar Habitat Issues

During property visits a number of issues relating to protection and damage to Ramsar habitat emerged other than the wholesale loss of lake edge habitats through shoreline erosion.

Some habitats are being removed/damaged more easily than others due to particular behaviour exhibited by stock. Well established reed beds offer great resistance to the passage of cattle and even more so to sheep. Cattle on well vegetated shorelines therefore tended to do most damage to the wet area just behind the dense reeds (Seasonally Inundated zone Table 4.1) where there is often a variety of herbs and sedges. Given the tendency of Phragmites australis to be able to tolerate and grow in fairly saline damp ground it is possible that this zone only exists where stock graze and arrest the reed growth or the adjoining soils are too saline for dense reed and rush growth. Certainly where grazing is light, or by sheep this zone was more heavily vegetated, was more diverse in nature and supported healthy growth of larger freshwater and semisaline plants like Lignum *Muehlenbeckia florulenta* and Cutting Grass *Gahnia filum* that were usually in poor condition or absent when grazing was heavy. In heavily grazed areas the long term result of impact on this area was usually loss of native cover, deep pugging and colonisation by paspalum species and sometimes Strawberry Clover when it could deal with the conditions.

Apart from actual grazing within a well vegetated freshwater wetland some areas will be used and therefore trampled more than in other areas. As cattle take the path of least resistance they will tend to go out into the water along the shoreline to avoid thick reeds on the rising ground and near shore zone, thus impacting greatly on some of the most fragile vegetated areas which in turn leads to a weakening of the dense reed line. They also take any opportunities they can to shelter behind larger denser areas of vegetation and rub against hard surfaces. Lignum bushes, in particular, seemed to bear the brunt of leaning on and rubbing by cattle and were often pushed over and gradually trampled.

Areas that are clear of reeds on the shoreline are clearly favoured for drinking from by cattle which were often observed going as a mob to drink and favouring particular places even when there was several alternative sites. This leads to particular sites suffering more than others from pugging and instability and these areas often showed severe erosive processes had begun when only a few metres away the shore was vegetated and stable. Drinking sites were often where cattle had wandered further into the water and started walking along the front of the reed line.

Samphire habitat, where it still existed, was routinely grazed by graziers. Inundated samphire swamps only tended to still exist behind a well vegetated shoreline. In other areas where the shoreline vegetation was poor the samphire vegetation tended to be very poor in condition and often overgrown by Paspalum species and Kikuyu. There was a huge range of condition of dry samphire. Dry samphire swamps, back from the lake edge, did not tend to be invaded by Paspalum species and *Phragmites australis*, presumably because without regular flushing of the soils by local flooding or wave splash, the soils were too saline to allow growth of any but the most saline tolerant range of native plants. Buckshorn Plantain was the only weed species that seemed to be able to colonise the most saline dry areas.

Various degrees of grazing pressure were noted in these areas as discussed in section 4. With increasing pressure samphire vegetation became less diverse with few herb or ground cover species, and bushes became increasingly smaller, with less fresh growth, more dead woody material, while the spaces between them became increasingly larger and had no vegetative cover. In extremely damaged areas from overgrazing few plants of any sort were present and there was obvious topsoil erosion and loss.

The loss of diversity was particularly noticeable on the fringes of dry samphire swamps where the lower salinity enables great diversity of palatable plants in areas in good condition, e.g. Aust. Saltmarsh Grass *Pucinella stricta var stricta,* Sea Rush *Juncus kraussii*, Cutting Grass *Gahnia filum*, Marsh Saltbush *Atriplex paludosa*, Sea-berry Bush *Rhagodia candolleana,* Short-leaf Bluebush *Maireana brevifolia*, still fewer had any large bushes Common Boobialla *Myoporum insulare*. However, on most of the properties visited Sea Barley Grass *Critesion marinum*, provided the only vegetative cover in this zone. As already mentioned there was only a few properties that still had a fringe of Swamp Paper-bark *Melaleuca halmaturorum*, and on those that had only a few remnant individuals, the trees were in very poor health and the ground was severely impacted below them from where stock camped.

Samphire areas also suffered selective damage from stock traffic with those that were between the lake edge where stock watered and more lush areas of grazing incurring the most damage. Landholders in general did not seem to be aware of the signs of degradation of samphire areas and did not see their preservation as healthy shrubland as a priority.

Two other major issues emerged during property visits: grazing by sheep appears to have less impact on Ramsar habitat areas and well directed grazing can be beneficial in slowing the down the overgrowing of inundated samphire swamp areas by Paspalum species and/or *Phragmites australis*.

Several landholders pointed out evidence of the beneficial affects of grazing sheep rather than cattle on lakeshore areas. These benefits accrue from the lighter body weights of animals that reduces hoof impact, the sheep's wise unwillingness to enter water to forage and the smaller nature of sheep means they are less able to push through and therefore gradually destroy established vegetation. However it is also obvious that most landholders are not prepared and/or financially able to run sheep rather than cattle on their lakeshore holdings as sheep have no place in their overall farming business activities.

Many landholders were very much aware of the balance between grazing the lake edge and the extent to which Phragmites australis overgrew pasture land or samphire shrubland behind the edge. Only John Eckert mentioned the similar relationship between grazing and Paspalum species, but most landholders were aware of the need for grass and clover species to remain out of the waterlogged zone and their ability to persist on heavily pugged ground on the tops of mounds.

In general landholders' motivation for preventing the overgrowth of samphire with Phragmites australis was to ensure that open areas remained for grazing rather than land being closed up and impenetrable to stock. In the main they were aware and/or indifferent to the accompanying loss of plant diversity.

6.5 Investigation of Plant Species Productivity and Quality

Table 6.1 gives the feed quality and the amount of dry matter per hectare for selected plant species growing on lake edges. Some key points to note:

- The feed quality of lake edge plant species ranges from poor to excellent. The quality difference between the leaves and the stems of most species is dramatic.
- The amount of feed on offer is huge on a per hectare basis when total biomass is considered. When the high quality leaf is considered alone, however, the amount is far more limited.

Plate 2.7 Samphire – the fleshy leaves are highly nutritious, the woody stems are the opposite.

Simon Ellis to Insert Summary Table and discussion of poor-good to interpret these results as outlined below with accompanying ifs and buts about accuracy given no. of samples etc.

Notes: Some Strawberry Clover Good, Kikuyu Mod, Couch Mod, Green growth samphire good but woody poor,

Pucinella Mod CotulaMod Buckshorn good Best Leaf (Cape Barren Geese eat it preferentially)

Phrag & typha might make mod

Juncus, Gahnia, Lignum, Bulboshoenus, Eleocharis, River Club-rush all poor

6.6 Discussion & Summary

6.6.1 Lake shore erosion

There is no argument from any segment of the community that the lake edges are degrading at an alarming rate. lakeshore erosion not only removes valuable grazing land and freshwater Ramsar habitat but it also threatens the integrity of Ramsar habitat remaining behind the lake edge.

There is uncertainty among landholders as to the area behind the water line that lake edges need special management. There are two land classes that constitute lake edges:

1. The immediate area abutting the water. This is where the most visible damage is being done – native vegetation loss and soil erosion.

2. The area behind, which inundates occasionally and suffers from pugging, overgrazing and erosion. The damage to this area is less obvious, but just as serious in terms of damage to native flora and fauna habitat and, to a lesser extent, erosion.

Both areas should be included in any plan to protect lake edges. To counter these problems, attempts to halt lakeshore erosion must simultaneously protect the area just in front of the active zone on the lake side and protect the area behind the zone from forces that would destabilise the soil structure and/or prevent re-establishment of stabilising vegetation. On properties visited during this study, during the preparation of the Revegetation Guidelines (ID&A 2001) and the erosion control study (ID&A 2001a), there was ample evidence that grazing cattle could cause substantial damage to established and re-establishing vegetation in the nearshore zone and behind the shoreline. Growth of stabilising vegetation, native and non-native can be retarded by the physical removal of parts of the plants during grazing, damage to rootstock and remaining parts of the plant is incurred with hoof action and regrowth of plants can be completely eliminated by hoof damage, especially in boggy ground.

Therefore an essential step in protecting re-establishing or existing vegetation is to remove grazing pressure. This study (as did the others), visited several properties where landholders have recognised this principle over many years and have excluded stock completely from fragile areas or altered their grazing regimes to ensure cattle are not able damage standing vegetation or impact on vegetation which is re-establishing.

Table 6.1 Shows Results of Feedtest Analyses of Lake Edge plants commonly grazed.

Date test	Species	Common Name	Part of plant	ME	Digest-ability	CP%	DM	kg DM/ha
Indicative Ranges of Figures								
	Poor feed		Stems, woody parts, straw	<7.7	<55%	<8.0%	Scarce	<800
	Average feed		Moderate height, not woody	7.7 - 10.0	55-70%	8.0-15%	OK	800-1200
	Good feed		Short, green, fresh, vegetative	>10.0	>70%	>15%	Plentiful	>1200
Site 1. J. Eckert's Property, West of Tolderol - Very lightly grazed by sheep								
31/10/2002	Eleocharis acuta	Common Spikerush	Dead	6.1	44.4%	2.1%	45.0%	6,336
	Eleocharis acuta	Common Spikerush	Green	7.1	52.8%	5.5%	28.7%	2,032
	Eleocharis acuta	Common Spikerush	Whole plant (by calculation)	6.3	46.4%	46.4%	2.9%	8,368
	Paspalum distichium*	Water Couch*	Visually a good quality sample	7.4	52.9%	8.5%	15.6%	3,494
	Phragmites australis	Common Reed	Stalks	4.6	35.1%	4.3%	32.5%	5,486
	Phragmites australis	Common Reed	Best leaf	9.3	64.4%	21.8%	33.0%	2,270
	Phragmites australis	Common Reed	Whole plant (by calculation)	6.0	43.7%	43.7%	9.4%	7,756
	Phragmites australis	Common Reed	Average leaf	9.0	62.7%	20.6%	36.0%	2,160
	Sarcocornia sp.	Samphire species	Woody parts	6.1	44.5%	6.3%	58.6%	12,423
	Sarcocornia sp.	Samphire species	Green growth	12.0	81.7%	8.1%	23.2%	5,884
	Sarcocornia sp.	Samphire species	Whole sample					18,307
Site 2. J. Eckert's Property, West of Tolderol - Very lightly grazed by sheep								
31/10/2002	Muehlenbeckia florulenta	Lignum	Woody	7.2	51.6%	3.7%	33.4%	12,618
	Muehlenbeckia florulenta	Lignum	Soft stems and leaf	7.4	52.5%	17.7%	29.8%	3,332
	Muehlenbeckia florulenta	Lignum	Whole sample	7.2	51.8%	51.8%	6.6%	15,950
	Typha domingensis	Narrow-leaf Bulrush	Older plants green leaf	7.4	52.7%	11.0%	16.4%	6,586
	Typha domingensis	Narrow-leaf Bulrush	Younger plants green leaf	8.4	59.1%	11.8%	19.0%	9,333
Site 3. T. McAnaney Property, Mosquito Point/Boggy Lake - Moderately grazed by cattle								
31/10/2002	Trifolium fragiferum	Strawberry clover	Lush	8.9	61.9%	20.2%	15.1%	1,601
	Cynodon dactylon*	Couch*	Short	8.1	57.0%	13.2%	26.8%	611
Site 4. Wyndgate Reserve, Hindmarsh Island - Ungrazed areas								
6/11/2002	Bulboschoenus caldwellii	Salt Club-rush		7.2	51.7%	9.7%	20.8%	4,543
	Cotula coronopifolia*	Water Buttons*		9.4	65.3%	13.5%	10.2%	2,591
	Distichis distichophylla	Emu Grass		5.9	43.0%	7.1%	51.9%	NM ***
	Juncus kraussii	Sea Rush/Spiny rush		4.8	36.3%	5.8%	46.0%	10,378
	Plantago coronopus*	Buckshorn Plantain *		10.4	71.4%	9.0%	15.0%	2,154
	Puccinellia sp. Native	Native Puccinellia		9.4	65.0%	7.2%	38.3%	NM
Site 5. Goolwa Township - Ungrazed area								
6/11/2002	Pennisetum clandestinum*	Kikuyu*	Long	9.0	62.6%	12.9%	21.5%	1,720
	Schoenoplectis validus	River Club-rush		7.3	52.1%	8.4%	23.9%	NM
Site 6. Clayton, Reserve in Township – Ungrazed area								

6/11/2002	Gahnia filum	Cutting Grass		5.3	39.5%	5.1%	62.8%	NM
Date test	**Species**	**Common Name**	**Part of plant**	**ME**	**Digest-ability**	**CP%**	**DM**	**kg DM/ha**
Site 7. Milang – Ungrazed area								
5/12/2002	Sarcocornia sp.	Samphire species	Woody parts	6.0	44.1%	7.8%	50.0%	10,000
	Sarcocornia sp.	Samphire species	Green growth	10.9	74.4%	8.3%	21.0%	9,845
	Sarcocornia sp.	Samphire species	Whole plant	8.4	59.1%	59.1%	8.0%	19,845
	Sarcocornia sp.	Samphire species	Woody parts	6.3	45.8%	4.9%	37.7%	26,420
	Sarcocornia sp.	Samphire species	Green growth	11.6	78.7%	10.7%	13.3%	1,968
	Sarcocornia sp.	Samphire species	Whole plant	6.7	48.1%	48.1%	5.3%	28,389
	Typha domingensis	Narrow-leaf Bulrush	Stalks	3.8	30.4%	2.2%	69.1%	8,347
	Typha domingensis	Narrow-leaf Bulrush	Best leaf	3.6	45.5%	8.5%	19.2%	7,526
	Typha domingensis	Narrow-leaf Bulrush	Whole plant	3.7	37.6%	37.6%	5.2%	15,874
	Phragmites australis	Common Reed	Stalks	3.5	28.3%	3.0%	57.9%	6,531
	Phragmites australis	Common Reed	Best leaf	7.2	51.4%	17.4%	36.8%	1,501
	Phragmites australis	Common Reed	Whole plant	4.2	32.6%	32.6%	5.7%	8,033

Key
ME = Metabolisable energy in Megajoules per kg of dry matter
DM = Percentage of dry matter in sample
CP% = Crude protein as a percentage of dry matter
kg DM/ha = Kilograms of dry matter per hectare
* denotes introduced species ** IS denotes insufficient sample to test *** NM denotes no measurement

6.6.2 Grazing Management & Feed Quality

The feed resource provided by the lake edges is significant. Landholders fully appreciate the value of the resource. The measurements taken in the project have confirmed a number of things observed by many landholders.

The quality of feed on lake edges is very variable. The young, growing parts of most plants are highly nutritious, while the older, woodier parts are of very low quality. On average, the quality of plants is lower than that of conventional, green pastures.

The optimum method for livestock to utilise these high-quality parts of the plants is to “flash” graze areas, removing stock before all the plant growing tips have been removed. Coincidentally, this practice will also favour the survival and flourishing of most plant species on the lake edges.

As most lake edge species are summer active, this principle will mean very little grazing during the winter and early spring months. At this time there is high quality green feed on areas away from the lake. Again, this practice will see a mutual benefit for livestock and lake edge plant communities and therefore Ramsar habitat. In most of the grazing scenarios on the lake edge, not grazing lake edges at all will generally not favour the survival of a diverse range of indigenous species.

There are several native species present that have greatly benefited from the change in water levels and the freshening of the lake water that will over grow other native plant communities less able to deal with the current conditions, e.g. *Phragmites australis* and to a lesser extent *Typha domingensis.* In addition there are several species of exotic plants, some of good feed value and some not, that left ungrazed will form monocultures in the changed lake environment to the exclusion of most native species e.g., *Paspalum dichatum* Paspalum, *Pennisetum clandestinum* Kikuyu. These interactions are discussed in detail in Sections 4, 5 and

7. While this parameter has been recognised by some landholders, few landholders or natural resource managers have been aware of the impact it is having on one particular type of Ramsar habitat and the local and international consequences for nature conservation.

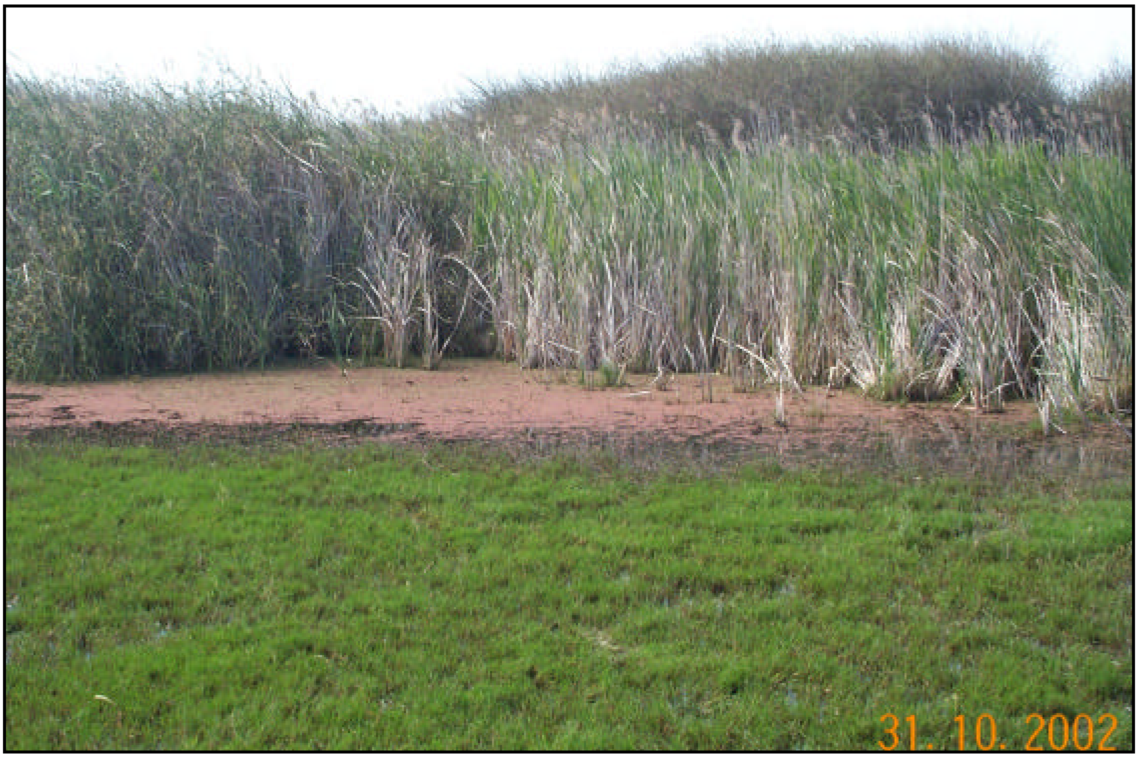


Plate 6.8. Feed on Offer is huge, but high quality is not so plentiful

6.6.3 Feed Quantity

The quantity of feed grown on the lake edges is substantial. The high quality feed amount is, however, far less. Nevertheless, it provides a significant resource for landholders – especially if it is used judiciously. It allows stock green feed over the normally dry summer months.

Table 6.2 gives a rough estimate of the number of young sheep or cattle that a kilometre of lake edge can fatten over summer. It assumes (conservatively) that the high quality portion of the feed grows at 50 kg of dry matter/day/hectare and that young sheep require 2 kg dry matter/day and young cattle 12 kg dry matter/day (allowing a 20% wastage factor).

Table 6.2 Number of Young Stock Fattened over Summer on 1 km of Lake Edge x Width of Edge Available

	100 metres wide	**50 metres wide**	**25 metres wide**
Young sheep	250	125	60
Young cattle	40	20	10

Based on the landholder survey, the average landholder accesses about 5 km of lake edge. On these figures the value of the lake edges as a summer feed resource is significant. Further, it is available at a time when only irrigated pastures can do the same job. So, stock fattened on lake edges during the summer are ready for marketing at a time of higher prices.

Grazing of lake edges in summer also has the advantage for producers of giving stock direct and reliable access to the lake for watering. On the majority of properties visited or surveyed during the workshop period, stock drink directly from the lakes when pastured in lake edge paddocks. Therefore changes to stock access to the shoreline and area immediately behind it must take into account the work and resources needed to provide alternative watering arrangements.

6.6.4 Changes to the Management of Lake Edges

It is important to recognise that there needs to be a multi-pronged plan toaddress all issues causing damage to lake edges, not just livestock grazing.The majority of landholders are aware of the issues and problems facing the lake edges. Encouraging them to adopt new management practices will hinge on the following:

1. The cost must be realistic in dollar and time terms. Preventing these costs from deterring landholder adoption will be a major challenge of any plan.
2. Increasing community awareness of all the issues involved in the promotion of new measures. Many landholders, like the wider Lower Lakes community, are unaware of what constitutes Ramsar habitat, how fauna must use it and how they can assist in protecting it and its corresponding fauna.

The management changes recommended to protect the lake edges from grazing-induced degradation and to protect Ramsar habitat are:

- ***Fence off the different land classes to enable grazing to be managed.***

It is recommended that no grazing be allowed inside the regenerating lake shore zone until it can be demonstrated that the shoreline and adjacent areas are no longer eroding and have substantial vegetative cover. The area protected from grazing should be the equivalent of at least 5 years of shore loss due to erosion.

The fencing must therefore include the installation of new systems to provide water for stock when stable lake edges are not available. It may also include short term methods of stabilisation of lake edges (eg with rubble) until planned new water systems are developed and installed.

This process is a normal part of the farm planning process promoted under NHT and other government-backed programs. Government funding is currently available to cover a significant proportion of the cost of the fencing and new water points. Given the importance of the lake edges, it may be worth considering an option where the full cost of fence erection is borne by government funding.

- ***Construct Permanent Protective Barriers along Eroding Edges***

Where removing grazing alone will not allow successful establishment of protective vegetation, consideration should be given to funding the construction of protective rock barriers and/or off shore booms to dissipate wave energy. Exclusion of stock should be one of the conditions of funding.

- ***Adopt Controlled Grazing Management Systems.***

It is vital that set or continuous grazing is not permitted on lake edges. Pulse or flash grazing of lake edges should be promoted to protect edges and plant species.

- ***Provide Training in Grazing Management.***

Courses that explain and promote more sustainable grazing systems should be offered free of charge to landholders with lake edge property. One such course that could be readily adapted to specifically include management of lake edges is Prograze. Related issues such as management of liver fluke and internal parasites could be also covered as and added incentive for landholders to attend the course.

There would probably need to be separate courses for beef/sheep properties and dairy properties. In addition some one-to-one consultancy could be provided to landholders having difficulty with implementing a new grazing management system.

➢ ***Revegetate lake edges.***

The revegetation of lake edges should be handled in a similar way to other broad-acre agriculture areas. Funding should continue to be provided for landholders to fence, prepare and resow native species. Provision of personnel to handle enquiries and help modify programs are an ongoing and essential part of supporting such programs. Monitoring, research and demonstration of reliable revegetation techniques must be a priority.

➢ ***Remove or Control Introduced Plant Species and the spread of Phragmites australis into Saline Swamps.***

The removal of introduced species such as kikuyu, marine barley grass, paspalum etc is the most difficult step in the handling of lake edges. On some sites it will be wise not to try to control these species but increase the stability of the site so that other vegetation will develop. On other sites it may be important to prevent the spread of these species into valuable Ramsar habitat such as saline swamps and controlled grazing or selective spraying may be necessary under these circumstances. It is essential to provide support personnel who can recognise what action is needed on particular properties and help landholders develop grazing plans. Research and demonstration will be required.

➢ ***Not One Size to Fit All.***

It will be important not to promote one technique or system as the way to address all areas of the lake edges. Different areas have different causes and sensitivities. An appropriate program will need to be devised for each type of lake edges.

➢ ***Identify Ramsar Habitat areas of High Conservation Significance***

Identify areas on grazing properties that require special or immediate protection and provide agency support to prepare specific management plans and/or provide funding to support landholders in protecting these areas. Important feeding sites for migratory waders or breeding sites for waterfowl are two examples of sites that need specific attention. Re-evaluate previous inventories of potential Wetland Rehabilitation sites and the grazing and water management regimes proposed.

Monitoring of effects of Changes to Grazing Management.

Where government monies are invested to enable changes of grazing management it is vital to monitor the outcomes of the work. Simple monitoring systems must be devised that enable basic data on the success of stabilising shorelines and the establishment of vegetation to be collected. A management and review process of this data should be set in place before funding proceeds. Data can be used to modify methods within the program, report on regional affects of the program, support the need for further funding and most importantly presented back to the Lower Lakes community to give positive feedback on the work performed by landholders and therefore act to increase motivation of other members of the community.

- ***Enforcement of Change***

As with any new program, there will be a percentage of landholders that do not readily adopt change. Consideration should be given to how management change could be enforced after a voluntary adoption period.

7 Lower Murray Lakes Ramsar Habitat & its Relationship to Grazing Management: Summary & Recommendations

7.1 Summary of Current Status and Use of Ramsar Habitat

The Lower Lakes region provides a range of habitats that support a wide range of biota including a diverse range of riparian and aquatic plant species, aquatic invertebrates, fish, reptiles, migratory wading birds, waterfowl, and waterbirds. This habitat is protected under the Ramsar agreement. The Management Plan (DEH 2000) notes that the ecosystems protected under the plan are open systems where they influence, or in turn, are influenced by, other ecosytems outside the area. This study has shown that the habitat protected under Ramsar in the Lower Lakes is diverse and produced and maintained through a complex set of biotic and physical parameters and the use by Ramsar protected fauna is also selective and complex. The following points summarise this complexity.

Use of Habitat

- There is differential habitat use by a range of birds and animals, and therefore to protect Ramsar values means to protect several habitat types for use under multiple circumstances i.e., feeding, shelter, breeding, by a huge variety of biota.
- The habitats generated by the ecosystems of the Lower Lakes Region have undergone major changes since the introduction of the barrages and European settlement.
- The habitats generated by those ecosystems appear to still be undergoing major changes and certainly have changed since the region was designated a *Wetland of International Importance* under the Ramsar Convention in 1985.
- Waterbirds and Waterfowl, e.g., Egrets, Herons, Bitterns, Ibis, Spoonbills, Swamp Hens, Moorhens, Coots, Crakes, Rails, Snipe, Pelicans, Grebes, Swans, and the whole range of native ducks use beds of Reeds, Rushes and Sedges to hunt in from, roost, provide shelter and to breed in. These species also use the sheltered, open shallow, water bodies behind them to forage and shelter. Many of these species e.g., Grebes, many ducks, Crakes, Rails, Snipe, Coots will also forage in sheltered, inundated samphire areas behind the reed beds and similar samphire swamps completely removed from the Lake Edge.
- Migratory Waders and some Non-migratory Waders have completely different pattern of use to the birds above, i.e., they use areas of shallow water and mostly inundated shallow samphire areas, for most of their feeding activities while using the protection offered by samphire bushes, reeds, rush and sedge banks, and other vegetation for shelter and roosting. The most productive wetlands for the migratory wader feeding are the saline swamps.
- Another set of birds including Cape Barren Geese, Black-tailed Native Hens, *Neophema* Parrots, are using more terrestrial but associated habitats.
- Other biota also show similar differential use of the habitats of the Lower Lakes Ramsar area and changes which threaten their use of habitats should also be considered, including, tortoise, fish, aquatic invertebrates, aquatic plants, etc.

Threats to Current Habitat

- Lakeshore Erosion and therefore edge instability or loss of land is still the single most threatening process to Ramsar habitat around lakes.
- Grazing contributes to this degradation of habitat through its contribution to shoreline erosion, pugging of fragile wetland habitat and removal of plant biomass through grazing and poses threats to all vegetation where grazing prevents regeneration of native plants.
- A second less obvious but probably the second biggest threat to habitat is continuing to occur throughout the Lower Lakes as a result of the freshening of lake water by barrage construction and regulation of water levels. As a result saline swamps are being replaced by freshwater swamp habitat on a large scale. These changes can be seen on a property scale by the overgrowing of samphire habitat by Phragmites australis and introduced Paspalum species.
- The natural system the Ramsar agreement is charged with protecting has undergone major reorganization with the construction of barrages and agriculture activities in the region and processes leading to degradation of its habitat are still occurring.

7.2 Summary of grazing effects on Ramsar habitat in the Lower Lakes

Grazing is one of the major land uses around the lakes and the lake edge is highly valued for its summer feed and availability of permanent fresh water. This unfortunately brings grazing activities directly into contact with the majority of the wetland habitat protected under the Ramsar Convention. This overlap of management needs occurs in a zone that is most susceptible to destruction due both to its inherent nature and the changes brought about by water regulation and management in the Lower Lakes and in the Murray Darling Basin generally.

The following effects of grazing have been observed and documented during this study:

- Grazing contributes to instability and therefore loss of habitat in all the Ramsar habitats but especially so on fragile areas such as the lakeshore and adjoining swamps.

- Grazing is not the only factor contributing to loss of Ramsar habitat but it has a most significant impact on Ramsar habitat through its contribution to lakeshore erosion processes and degradation of soil structure in swamp areas.

- In Freshwater Swamp areas, grazing can remove protective reeds, rushes and sedges and reduce diversity of these and other freshwater herbs etc.

- On Saline Swamps, grazing can cause removal of samphire bushes, prevent regeneration and reduce diversity of all species, including perennial herbs andgroundcovers.

- In Red Gum Swamps grazing reduces diversity and prevents regeneration of native species during inundation events.

- In all habitats, the impact of hoof damage, and other physical impacts, rather than just consumption effects, (e.g., livestock stripping bark from woody natives and smashing reedbeds and bushes) is severe and one of the major contributors to vegetation removal and prevention of regeneration.

- Grazing contributes to health issues, animal and human, contributing to problems of water quality through the addition of nutrients, an increase in turbidity through erosion, providing hosts for parasites like liver flukes and altering habitat to favour mosquito breeding and therefore increase the possibility spreading mosquito borne diseases.

This study also found that carefully managed grazing can also be used as a positive habitat management tool in the much altered Lower Lakes environment.

• Carefully manage grazing can be used to repress *Phragmites australis* growth and Paspaulum growth.

• Sheep are much better to use as management tool to protect habitat through selective grazing than cattle.

7.3 Recommendations

It is difficult to devise a simple list of recommendations to tackle the huge range of sustainable management issues reported on by this study. Some clear recommendations for promoting more sustainable management of grazing have emerged from this study and they have been documented in detail in section 6. They can be further summarized as follows:

- protect stability of the lake edge wherever possible
- re-establish vegetation wherever possible (particularly reed beds), to promote stability of the lake edge
- promote grazing regimes that lessen the impact of grazing stock on all Ramsar habitat
- demonstrate and promote the best grazing use of lake edge for sustainable production

However, this study has also shown that promoting sustainable grazing will not by itself protect important Ramsar habitat and therefore all the faunal assemblages that depend on it. There are many issues of habitat decline that must first be recognized by the South Australian community and then receive attention and funding they deserve in order to put in place active management strategies to address the habitat decline. As for most projects involving community based action the process must begin with awareness raising of the issues involved and gathering of further evidence as to the nature and rate of degradation and its consequences.

Develop Information Resources for distribution to community and agencies to:

- ensure land-managers are aware of issues,
- stimulate gathering of more information on how habitat is currently used,
- stimulate projects that will work towards habitat protection from community base
- stimulate projects that will coordinate needs of primary industry and Ramsar values
- elicit and direct funding for on-ground work from stakeholders
- avoid further degradation of habitat through ignorance.

This study has shown that around the lakes there are some areas of key habitat that have been key areas since European settlement and are still extremely important areas within the Lower Lakes region. Some of these areas are undergoing major change to the expansion of freshwater ecosystems and may need immediate review to determine their status. It is worth noting here that one such study has already been carried out for the LAP committees (Cooling & Rudd 2000) but this study did not recognize the differential use of habitat by Ramsar fauna and therefore did not map or distinguish between different types of habitat nor design rehabilitation strategies to prevent loss of saline swamps habitat. It is vital therefore to review key habitat in light of this report and develop appropriate protection and management strategies.

Management of key habitat areas to:

- protect vital breeding areas
- prevent destruction of habitat structure by weed species
- prevent destruction of habitat by erosion and wave action
- re-establish or protect salinity-freshwater regimes to ensure protection of vital feeding areas for migratory waders and some waterfowl species

Management of water regimes in lower lakes to:

- ensure regimes needed to protect current Ramsar values are in operation
- ensure that vital habitat is maintained successfully over time

There is an obvious need for the development of management systems to prevent or reverse the loss of saline swamp areas by replacement with freshwater systems. John Eckert has demonstrated that with a good understanding of the processes at work it is possible to use a variety of means to prevent loss of saline swamp habitat. His methods should be documented and supporting data collected to show the biotic changes that take place over time during this management regime. Similarly there is a pressing need to set up and maintain simple monitoring programs in many wetland sites that will show how habitat is being affected over time by changes in water and salinity regimes and what effects this has on the biota using that site. It is only through the collection of such data that good quality management strategies can be devised and trialled.

An even greater task is to use the information thus gained to understand the overall management framework that must be in place for the region if Ramsar habitat is to be protected over the long term. It is vital that the findings of this study are used to stimulate further investigations as to how Ramsar habitat can be best protected through regional planning initiatives in many areas such as determining environmental flow requirements, planning recreational use of the area, managing agricultural industry.

As difficult as some of these tasks may be this study has shown that if the need to take action is ignored, the risk of losing the Ramsar habitat that we seek to protect is extremely high.

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Appendix 1.

Sustainable Grazing Of Lake Edges Community Meeting Program

Time	Topic	Organiser/ presenter
11.30 am	Field inspection of differently managed water-edge sites (45 mins)	Janet Pedler
12.15 pm	Lunch and explanation of format for the day (30 mins) Circulate and fill in pre-discussion survey	Simon Ellis
12.45 pm	**First discussion session (in small groups)** • How does the community view grazing on the lake edges? • What effects are being noticed as a result of the grazing? • What benefits does grazing lake edges provide? • What are the concerns about restrictions on grazing them? • What are the main impediments to changing grazing management on lake edges? (20 mins in small groups + 25 mins presentation of findings and discussion of results)	Janet Pedler to lead and Simon Ellis to record
1.45 pm	Coffee break	
2.00 pm	**Second discussion session (in full group)** • What have been the most successful grazing systems in stabilising lake edges? • What have been the most damaging grazing systems destabilising lake edges? • What assistance is needed for the adoption of changed management practices?	Simon Ellis to lead and Janet Pedler to record

	• (45 mins discussion)	
2.45 pm	Summary and future activities (including a list of what will be done and when)	Simon Ellis
3.00 pm	Close	

Appendix 2. Landholder Survey

Grazing Lake Edges - Pre-Discussion Survey   Survey no. .....

1. Background

How old are 20-35 ☐ 36-50 ☐ > 50 ☐

What is the length of your lake frontage? ☐ kilometres

What percentage of your frontage do you graze? ☐ %

How long have you been farming? ☐ years

What are your current farm enterprises?

How do you graze your lake frontage? Tick one

- Continuously ☐
- Every month or so ☐
- Short bursts ☐

	<50	50-100	>100
How many animals do you graze on your lake fronts?			

What class(es) of livestock do you graze on the lake frontage?

2. Your Views

How do you view the grazing of lake edges? Tick one box on each line

	1	2	3	4	5
1. From a farming point of view					
2. From a land management view					

1 = a very bad thing. 5 = a very good thing

How important is grazing lake edges to your grazing enterprises?

	1	2	3	4	5
Tick one box					

1 = not at all important. 5 = very important

Is grazing lake edges impacting on the natural environment of the lake?

	1	2	3	4	5
Tick one box					

1 = not at all. 5 = greatly

Other comments you would like to make?

Appendix 3 Summary of Group Discussions at Meningie Meeting

1st Discussion Period

Qu 1. Group 1. How does the community view grazing on the lake edges?

- Producer "reality"
    - -not grazing can make worse.
    - -needs lots of money (40 yrs to fix) (reveg behind big rocks only thing that works on the east side).
- Broader community may view it as polluting, eg Jervois & contamination (health risks) – stress this is perception not reality.
- Accepted by other landholders.
- Contributes to lakeshore erosion
    - -but not only cause.
- Has value to landholders
    - -Best source of summer feed
    - -self-service summer watering (no money spent on infrastructure or actual water costs).
- Only lightly stock in winter.
- No negative feedback from community.
- Less of an "icon" than the Coorong, so less concern.

Qu 2. Group 2. What effects are being noticed as a result of the grazing?

- Causes of erosion?
    - -Pugging
    - -Edge collapsing
    - -Reeds being eaten/ killed (Black Angus are more aggressive grazers)
    - -Wind and wave action more of a problem
- Effects of grazing are mostly to do with management of grazing not just grazing itself.
- Kikuyu is not a weed (eg Skel. Weed, Bathurst burn, Scotch thistle, Wild antich).
- Good summer feed.
- Grazing keeps weeds down.
- Crash graze – spread of reeds. Take off before reeds stop growing.

Qu 3. Group 3. What benefits does grazing lake edges provide?

- Free water ($ & time- peace of mind).
- No labour / time associated with broken troughs / checking water levels.
- Treat all as one paddock – no opening & closing gates.
- No decisions to be made.

- Green pick in the summer (strong agreement) – bulk not high quality (dry stock) only good maintenance feed.
- Cattle prefer to cool themselves in water – Health risk (fluke) young stock esp. at risk.

Qu 4. Group 4. What are the concerns about restrictions on grazing lake edges?

- Cost of fencing them off (who pays?)
- Cost of water supply systems.
- Cost of loss of grazing.
- Just fencing areas does not necessarily stop problem – TARGET PROBLEM AREAS.
- Not all areas require restrictions (require flexible approach) eg if already have healthy reeds ought not to have to exclude grazing.
- Pollution aspect as well as erosion – This is the biggest perception of threat.

Qu 5. What are the main impediments to changing grazing management on lake edges? (Summary – All)

- Grazing value, costs of providing other water, on-going pumping and labour costs (checking pumps, troughs).
- Fencing costs.
- If only fenced off, little positive impact on erosion and a waste of time and money- would lose fence.
- Would need to be very good fence (and well maintained) to keep stock out from reeds and lake edge veg (reeds, kikuyu).
- Such a big job in some areas – daunting (finding time money etc to do it- hard enough to reveg dryland – time etc).
- Loss of asset- spend $ to lose $.
- Partially fencing- need well managed / rubbled watering points.
- Est reeds – finding successful and reliable methods for all areas.

Qu 5. What are the main impediments to changing grazing management on lake edges? (Group 2).

- Losing good grazing land (summer).
- Costs (fencing and water) and labour.
- Weed control may become and issue.
- Timing of grazing – management.
- Changing of attitudes.
- Diff areas need radically diff treatments / solutions.
- Ungrazed area –v attractive to stock – better fences.
- Job so big – daunting.
- Not enough proven ways to successfully establish reeds.

Qu 5. What are the main impediments to changing grazing management on lake edges? (Group 3).

- Cost of fencing / watering points / header tank/ pump/ windmill/ power/ irrigation piping/ labour.
- Increased management input through controlled grazing
- Different management systems for different regions.
- Difficulty in re-establishing vegetation and associated costs.
- NB varying management practices- flexible programs required.
- Narrung – rocks effective but foot damage when cattle access – troughs needed

-In few areas trial rocks and trough and see if stops stock going to take. Do they need fence as well?

- Restriction concerns

-lose cheap source of water ie currently no pump charges, no broken troughs, no measurement of water consumed.

Qu 5. What are the main impediments to changing grazing management on lake edges? (Group 4).

- Extra labour costs for checking mechanical watering systems.
- Lower stocking rate on property.
- Complex and variable issues and different at different parts around lake.
- Don't want to lose any grazing – provided the system is sustainable and stable.

2nd Discussion Period

Qu 6. What have been the most successful grazing systems in stabilising lake edges?

- Establish needs.
- Intensive Summer graze.
- Winter rest (exclusion).

(Above points also apply in inland wet areas (Nov-Mar)

- Must fit in with rest of property management.
- Samphire Areas.
- Erosion, grazing and reveg control are the 3 reasons for fencing.

Qu 7. What have been the most damaging grazing systems in destabilising lake edges?

- Contin, uncont. Heavy grazing.
- Winter grazing of any sort.

Qu 8. What assistance is needed for the adoption of changed management practices?

- Costs
- Wildlife management (eg swans)
- Checking water, fences takes more time and stress. How to assist? Uncertain.
- Demo of benefits vital to adoption .. define benefits.
- Allow "rubbled" access points and fence rest.
- Cattle do go around fences into lake.

Appendix 4 Summary of Group Discussions at Clayton Meeting

1st Discussion Period

Qu 1. Group 1. How does the community view grazing on the lake edges?

- Moderate- concern re cows grazing in Finniss

  -defecation – water quality. Similar to Jervois

  -nutrients- algal blooms

  -not much of lake front is fertilised so P input not.
- Water Quality-overall not strong community view, but can be a localised issue (eg in Milang township).
- Reading

  -erosion

  -picturesque
- Ramsar- idea that grazing is beneficial.
- Community don't realise how much system changes – huge changes over time.
- Criticism of overgrazing – bad land management – certain examples give others a bad name.
- Community sees lake as static and needing no maintenance.
- Delicate area- requires careful management.
- Positive and negative views re lake edge grazing.
- There is a "general" view that producers are degrading the lake edge.
- Impact of change of lake level.
- Grazing contribution to lakeshore erosion – study
- Some landholders (% not agreed) would agree that very edge should be fenced off – further back not so sure.
- General public don't care / consider.

Qu 2. Group 2. What effects are being noticed as a result of the grazing?

- Pugging
- Loss of biodiversity – birds, reeds, smaller mammals etc.

- Less (eg strategic grazing controls Kikuyu and allows other plants to grow) / more (maintaining biod = fewer weeds) weeds – dissenting
- Less / more lakeshore erosion / dissenting
- Different sites have different problems and solutions. Enormous variety. No one solution.
- Rapid rate of erosion adds complexity to system.
- Decline in water quality (manure, nutrients, turbidity and sedimentation – dissent)
- Can't have one management rule to "fix" all.
- Animal health eg Liver Fluke – requires active management.
- Tourism/ boating – loss of amenity – birdwatching etc.

Qu 3. Group 3. What benefits does grazing lake edges provide?

- Good summer / Autumn feed (all classes of stock).
- Pasture (highland) growing season only 4 months per year. Green feed fills in gaps.
- Lake edge grows good clover
- Kikuyu when well managed provides good feed (some edges are good qual, some poor – prob swamps are good)
- Access to lake edge for stock water

    -no pumps to break down

    -maintenance free

    -no cost-no licence

- Bushfire protection – stock have somewhere to go.
- Feed always available – low maintenance herd
- Drought proofing.

Qu 4. Group 4. What are the concerns about restrictions on grazing lake edges?

- Access to water for stock
- Loss of control over land-property rights and possible access by others
- Bigger weed problem
- Loss of emergency grazing
- Inflexible –rules won't fit all of lake edge

-may result in greater lakeshore erosion, reduction in biodiversity etc.

- Increased costs

    -watering points

    -fencing

-loss of grazing area

-inspection/policing

-maintaining the area

-Note: If not on lake edge would need fence there anyway.

- Restrictions could cause habitat decline in specific situations – invasion by freshwater reeds etc
- Lack of detailed knowledge / classification of systems of lake edge – variation in soil types, ecosystems, grazing management.

Qu 5. What are the main impediments to changing grazing management on lake edges?

- Most landholders have the desire to do it better
- Economics

  -$ & management skill and time

  -loss of land use
- Watering points
- Maintaining electric fence- reeds grow up and short out fence.
- Some landholders gaining land.

?rotational grazing

Mgt issues- stock numbers- the key

Mgt issues – behind lakeshore – bank builds up (Paspalum, Kikuyu) – keeps

water then need to be opened up.

- Knowledge- do we have the skills and knowledge to devise the best management practice? Not readily available at present. Prob no one knows all bits.
- Key info on grazing LE is lacking.
- Cost of water system and deciding b/w alternatives
- Maintenance of fences, watering system
- Time requirements to ensure everything is working.
- Major planning needed to make these major changes.
- Lack of knowledge about "How to graze" to provide for the environment and grazing value, when will they do the minimum damage?
- Economics

  -cost of buying feed, loss of finishing pasture
- Lack of understanding about what the lake edge should look like for Ramsar species. Which birds do we want and what do they need?
- Uncertainty

  -also of future lake level management by govt

-of best course of action

-causes a reluctance to change and take risks

- Limited options for lakeshore management –flexible range of options
- Property rights – people already feel pressured to make up their own mind / own decisions
- Short term funding doesn't allow enough seasons to be covered – skewed results
- Not enough incentives – what / how much does the community pay?

2nd Discussion Period

Qu 6. What have been the most successful grazing systems in stabilising lake edges?

- Goal- to stop wave action on LE. So, grazing must not bare LE + must stable edge.
- Water points well located.
- Fence off some sensitive areas.
- Reduce stock numbers overall.
- Where reeds remove stock before they start to eat reeds in the water, young stock esp aggressive.
- Two

  -1 Sand bar- uncertain best management

  -2 Natural reed area (Poltalach) – fenced out.
- Intermittent /strategic /controlled grazing – best times etc not yet certain.
- Note high lakes – erosion damage. While low lakes – most reed damage from high level stock access.
- Fencing for control of all LE.

Qu 7. What have been the most damaging grazing systems in destabilising lake edges?

- Overstocking (total over year as opposed to high density short time) – too much grazing pressure over period of time.
- Grazing reeds immediately after burning.
- Burning reeds where affects ability to recover. If Paspalum present burning can open up and help start of regrowth
- Grazing when soil is wet.

Qu 8. What assistance is needed for the adoption of changed management practices?

- High level of community involvement
- Community funding (tax?)
- Local and accessible community support
- Effective enforcement of rules and regulation in place. No point having regs if not enforced. (also requires admin and planning support).
- Funding for education
- Multiple sources of info.
- Local demo projects to show how to do.
- Include all watercourses not just the LE (in eastern MtL) – incl groundwater. Proclaim.