The Macquarie Marshes
an ecological history

Gillian Hogendyk

Institute of Public Affairs
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A note on sources

Gillian Hogendyk has accessed publicly available information, interviewed long term local residents of the Macquarie Valley with historical knowledge of the Marsh area, and held discussions with relevant public servants.

The author has taken all photographs unless otherwise acknowledged.

From the Executive Director

It is essential that solutions to environmental problems are based on evidence. The Macquarie Marshes are a case in point.

In 2007 environmental issues do not lack for public attention, but too often these important issues are filtered through a narrow ideological lens. The Institute of Public Affairs has long advocated for and supported science firmly based on the evidence.

The IPA does not necessarily endorse the policies advocated in this occasional paper, but we welcome this valuable contribution by Gill Hogendyk to a better public understanding of the history and ecology of the Macquarie Marshes.

John Roskam
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Institute of Public Affairs

About the author

Gillian Hogendyk lives on a property near Warren in the Macquarie Valley. She is a co-owner of 'Burrima', a property within the Macquarie Marshes bordered on three sides by the North Marsh Nature Reserve.

She visited the Macquarie Marshes regularly during her time as a member of the Northern Plains Regional Advisory Committee to the National Parks and Wildlife Service; from 1996 to 2007.

She is a keen amateur naturalist and has an Honours degree in Veterinary Science. She is a member of Birds Australia, NSW Birds Atlasers, and the NSW Wildlife Information and Rescue Service (WIRES) Raptor Rehabilitation Team. She is also the secretary of the Australian Environment Foundation, a group focussed on practical, achievable solutions for environmental problems.

Gillian Hogendyk is married to Chris Hogendyk who manages Auscott Ltd, an irrigation property on the Macquarie River near Warren. Gillian has not been commissioned or paid by any person or organisation to write this paper.

Foreword

It gives me considerable pleasure to provide this foreword to Gillian Hogendyk's carefully researched ecological history of this iconic Australian wetland system. Since the first few decades of European settlement of Australia, the existence of the "great marshes" in the centre of the Murray-Darling Basin has attracted interest. Early explorers, such as John Oxley, Charles Sturt and Thomas Mitchell marvelled at the size and complexity of the system in both wet and dry conditions, while early settlers were stimulated primarily by the vastness of the wetlands and their potential for exploitation in agricultural production.

Not surprisingly, the size and complexity of the system led the first European visitors and settlers to believe that there was little or no limit to the extent to which the Marshes could be exploited and of its resilience to recover from such treatment. There was little understanding of the Marshes' dependence on the volumes of flows in the Macquarie River and therefore on rainfall and run-off in its catchments and the balance between this water supply and rainfall on the swamp itself. There were no exact maps and no opportunity to view the size and nature of the whole system from the air and relatively few high points to view large areas at one time.

We now know that the Macquarie Marshes are a quintessential example of the capacity for the remarkably flat terrain of the Australian inland landscape to form both ephemeral and enduring wetlands. In this instance, the north flowing Macquarie River flows into just such an area north of Warren. Here, the river, over centuries, has slowed and retained water brought to it by the multiplicity of bifurcating and anastomosing channels originating from the Macquarie River and areas to the east. Since formation, seasonal flooding of this vast inland delta via these channels has sustained a complex of permanent and ephemeral wetlands and floodplains amongst islands of higher ground that supported woodlands of varying complexity. Under natural conditions, in the past, the system operated as a sponge which soaked up and retained the water that flowed into it until the "sponge" was filled and water channels leaving the swamp coalesced to supply the Macquarie River, which continued to flow to the north eventually to join the Barwon and the Culgoa Rivers and form the south-west flowing Darling River.

The water retained in the Marshes provided the basis for the development of swampy grasslands, reed meadows (mostly of Phragmites) and woodlands. These provided a haven for Australian wildlife and an obvious attraction to graziers, whose hard-hoofed stock had an immediate adverse effect on the swampy soils at the cost of the native animals and Aborigines, as noted by Thomas Mitchell.

Unfortunately, what was notable became "normal" and the way was opened for exploitation of the Marshes' water to continue. Continuous water flows along the main water courses increased the cross section of these channels and increased the volume of water leaving the swamp for downstream users. Eventually, exploitation extended to an increase in the use of water for irrigation in the catchment and to a consequent decrease in water flowing into the swamp. Not surprisingly, the impact of these changes varied with the nature of the rainy season; the impact of dry years being much more serious for the marshes and for the landholders who exploited their resources for financial gain.

The situation is further complicated by the possibility for changes in flow distribution and retention of water to be generated spontaneously in the wetlands themselves. For example, a small breakaway channel from the main supply to an extensive Phragmites marsh which first appeared in the mid 1990s appears to have eventually captured and redirected the flow away from the Phragmites beds leading to their demise. Relatively small earthworks can change long established flow patterns and extend water retention in one area, while depriving it from another. Some of these changes in water distribution appear to have altered localities for waterbird nesting. The impacts of grazing animals on the vegetation and soils of the Marshes also cause profound changes to the ecology of the system. All these changes vary in their intensity and duration with respect to the availability of water in the Marshes and their catchments which is ultimately dependent on a naturally highly variable pattern of rainfall in the region. In the face of all these and other uncertainties, it is germane to question whether local landholders and government authorities have an adequate understanding of the current ecological resilience of the Marshes as a whole and in relation to the areas for which they are responsible.

The future of the Macquarie Marshes is ultimately dependent on those people and institutions who seek to manipulate its water resources in the catchment and in the Marshes themselves. Their decisions must be well-informed, with respect to the impact of their management decisions, and objective in regard to the long term consequences on the ecology of the overall system. Divided ownership of such a complex and variable system provides another complication. Perhaps the community as a whole needs to evaluate the extent to which portions of the Marsh that are privately owned should be set aside as reserves in the interest of conserving the ecology of the whole system.

These are challenging issues and Gillian Hogendyk's paper provides a lot of the information that will be required to determine how to deal with them.

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Executive summary

The evidence is clear that the Macquarie Marshes of central western NSW are suffering from a number of land degradation issues. The causes of these problems and their solutions are a matter for debate.

Currently many conservation groups and the marsh graziers have aligned to declare that there is one simple solution – more water needs to be purchased and sent to the marshes.

Yet this solution ignores the proliferation of banks and diversions that are capturing the water that is sent to the marshes, and diverting it onto private land for grazing. It also ignores other degradation problems such as salinity and erosion that are surfacing after a long and continuing history of destruction of vegetation by overgrazing and clearing.

The Federal and NSW State Governments have jointly funded the $26.8 million 'Wetland Recovery Program' that aims to address problems in the Macquarie Marshes and other inland wetlands. The NSW State Government has also committed $105 million under the 'RiverBank Program' to which the Federal Government has added a further $72 million to purchase water for iconic wetlands in NSW.

Buying water is an expensive option that will not solve the problems of the Macquarie Marshes, and should only be seen as one component of a recovery plan. Other important initiatives should include:

- the purchase of private land with significant wetlands from willing sellers. This land should be managed for conservation outcomes.
- the removal of levee banks and diversions that impact on significant wetlands
- the construction of effective erosion control structures in significant wetlands
- programs to encourage active revegetation on public and private land
- investigation into the salinity problem in the North Marsh and how to address it
- infrastructure to reduce water losses incurred in the delivery of water to users in the Macquarie Valley. This will improve the availability of water to all users, including the environment.
- better management of environmental flows so that water is not diverted away from significant wetlands.

Introduction

> Around 6000 to 8000 years ago, the waterway now known as the Macquarie River began to undertake a slow but fundamental change about 250 km north-west of present day Dubbo. Where it reached a vast, semi arid lowland plain, the strong, sand-banked river gradually began to break down into hundreds of tiny channels…. The product of this process is the Macquarie Marshes…
>
> *(Welsh 2002)*

Photo 1: A channel in the North Macquarie Marsh, 2007

The Macquarie Valley

The Macquarie Marshes are supplied by the Macquarie River, which originates in the central highlands of NSW near Bathurst. See Map 1. Burrendong Dam is the major water storage for the Macquarie Valley. It was completed in 1967, and is situated just upstream of Wellington. A much smaller storage, Windamere Dam, has been built on the Cudgegong River. The Cudgegong River flows into Burrendong Dam. The Macquarie River is therefore a regulated river because these storage dams and other structures in the river allow a certain amount of control over its flow.

Downstream of Burrendong Dam, further tributaries (the Bell, Little and Talbragar Rivers) enter the Macquarie as it flows west, then north. Upstream of Dubbo the river channel is deep and steep-sided. Here, when the Macquarie River floods, flooding is confined to a narrow band of river flats.

The Macquarie River enters its floodplain at Narromine, and from here downstream the river channel capacity declines (Sinclair, Knight and Partners 1984). During periods of high flow, a variety of effluent creeks and streams receive the water as well as the main river channel. In major floods, thousands of hectares of this vast flat floodplain can be inundated (Sinclair, Knight and Partners 1984; DWR 1990). Much of this floodwater leaves the Macquarie Valley via effluent creeks and overland flow, flowing into the Bogan River, and then to the Darling River.

When the Macquarie River reaches Marebone Weir, 50 km downstream of Warren, it breaks into a number of creeks and channels and forms a complex of wetlands called the South Marsh. The channels then coalesce for a brief stretch of river, before spreading out again into another vast complex of wetlands called the North Marsh.

This complex of permanent wetlands, ephemeral wetlands, and floodplain is collectively known as the Macquarie Marshes (the Marshes). Under natural conditions the Marshes would on average have received around one third of the total annual average flow in the Macquarie River. This is because a significant amount of water is lost from the main flow as the water travels along 850 kilometres of the Macquarie River, flowing out into associated wetlands and effluent creeks (DLWC and NPWS 1996; DLWC 2004). Therefore, prior to the construction of Burrendong Dam, much of the water that now flows into Burrendong Dam would not have reached the Macquarie Marshes.

Finally, the overflow from the North Marsh flows into the Barwon, then the Darling River. Under natural conditions, this flow was highly variable, and frequently there was no flow past the North Marsh (Warman 1933; Brennan 1975). In 1846, Sir Thomas Mitchell described the Macquarie River channel downstream of the North Marsh as 'a muddy ditch one might step across' (Mitchell 1848). The North Marsh Bypass channel, constructed in 1972, now delivers water requirements to residents downstream of the Marshes in dry times.

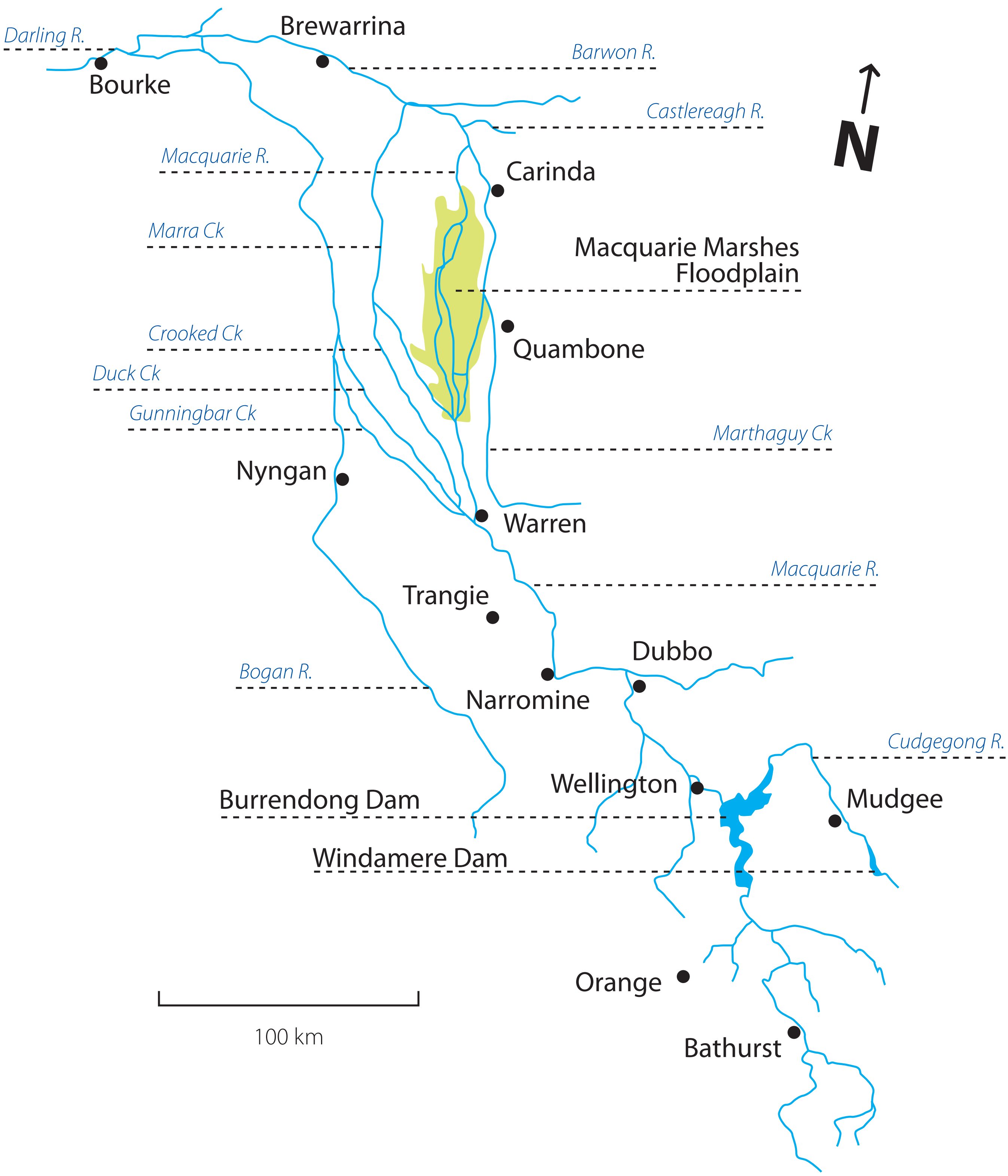
On average, the combined contribution of the Macquarie, Bogan and Castlereagh Rivers accounts for 5 per cent of the total annual average flow in the Darling River at Menindee (Thoms *et al.* 2004).

Definition of the Macquarie Marshes

Discussions about the Macquarie Marshes frequently become confused by a variety of definitions. They basically consist of 40,000ha of permanent and ephemeral wetlands, set in a vast flat 300,000ha floodplain that can be inundated by large floods.

> The Macquarie Marshes are a network of interconnecting channels, lagoons, effluents and associated overflow areas. They occupy an area of some 40,000 hectares, although very large floods inundate nearly 300,000 hectares of land in and around the Marshes. The area broadly consists of

Map 1: The Macquarie River Valley



> two distinct wetland areas referred to as the Southern and Northern Marshes which are separated by a region of higher ground where the Macquarie River is confined to a single channel, except during periods of high flow.
>
> *(McGrath 1991)*

Prior to the 1980s the Macquarie Marshes were defined as the 40,000 hectares of wetlands associated with the Macquarie River (Rankine and Hill 1979; Paijmans 1981). The definition has since been broadened to include the extensive floodplains to the east (DLWC and NPWS 1996; MMCC 1997; DLWC 2004).

The 1996 Macquarie Marshes Water Management Plan chose to adopt the outline of the maximum area inundated by the 1990 flood event as the Marshes boundary to the north, east and west (DLWC and NPWS 1996). See Map 2. This boundary encloses an area of 228,235 hectares (Button 2004). There are some islands of higher ground within this boundary that do not become inundated, and the majority of this area is only inundated in major floods. The southern border of this area was drawn at Marebone Weir, as this represents the start of the extensive River Red Gum *Eucalyptus camaldulensis* woodlands, and the beginning of the breakdown of the main river channel into numerous creeks (D. Shelly pers. comm.).

The Macquarie Marshes Land and Water Management Plan excludes the southern section of the floodplain (MMCC 1997). Most publications now suggest that the Macquarie Marshes cover an area of 200,000ha (DLWC 2004; MMMC 2006) or 220,000ha (Brereton 1994a).

The Macquarie Marshes Nature Reserve, which is managed for conservation by the NSW Department of Environment and Climate Change (DECC), covers an area of almost 20,000 hectares (NPWS 2004). It consists of two main reserves, the North and South Marsh, and a third small reserve, 'Ninia' (see Map 2). The Nature Reserve, therefore, contains 50 per cent of the wetlands associated with the Macquarie River, and approximately 10 per cent of the Macquarie Marshes floodplain.

Surrounding land is privately owned and utilised for the grazing of cattle and sheep, and cropping. Cattle are grazed in privately owned wetlands (MMMC 2006).

Conservation Listings

The North and South Marsh Nature Reserves were listed as a wetland of international importance in 1986 under the *Ramsar Convention of 1971*. A 583ha portion of the private property 'Wilgara' was listed under the *Ramsar Convention* in 2000. 'Wilgara' is located on the Terrigal Creek near Quambone (see Map 2).

The Macquarie Marshes are also listed on the Register of the National Estate, the Register of the National Trust, and the Directory of Important Wetlands in Australia (DLWC and NPWS 1996).

Climatic History of the Macquarie Marshes

The local climate of the Macquarie Marshes is semi-arid, with an annual average rainfall of only 432mm. Local rainfall is fairly evenly spread throughout the year, with a slightly higher summer rainfall. Evaporation is significant over the long hot summer. While local runoff can be important, the wetland is basically fed from the highly variable flow in the Macquarie River. Therefore climate has played the dominant role in shaping these wetlands throughout their history.

In order to reconstruct how the Macquarie Marshes were watered prior to river regulation, it is necessary to use the rainfall records and some river flow records that date back to 1890 in the Macquarie Valley. Early records have been combined with later, much more detailed information on river flows, to develop an approximation of historic inflows to the Macquarie Marshes using computer modelling[1] (Love *et al.* 2005). By removing the effect of water extractions, natural inflows can be modelled. This is called the 'baseline undeveloped modelled scenario' (see Figure 1).

Figure 1 shows the modelled historic inflows to the Marshes due to climate alone, and indicates that there have been three distinct climatic phases between 1890 and 2003. These broad climatic phases are reflected elsewhere in western NSW. There was an early prolonged 'dry phase' from 1895 to 1946, a 'wet phase' from 1947 to 1978, and a second 'dry phase' from 1979 to 2003 (Love *et al.* 2005). Conditions since 2003 have continued dry.

Natural Vegetation Resilience in Flood and Drought

Figure 1 suggests that the natural vegetation of the Marshes would sometimes be subjected to prolonged periods of both flood and drought, and would need to be highly resilient to such extremes. Paijmans conducted the first systematic examination of the vegetation of the Macquarie Marshes in 1980 (Paijmans 1981) and verified this assumption.

The following is a list of the dominant wetland plants he found in the Marshes, and their adaptations to these extremes:

River Red Gums *Eucalyptus camaldulensis* require a flood for seed to germinate. However once established they can tolerate both prolonged drought and inundation for up to 18 months, but will die if inundation continues after this time. They can utilise groundwater provided it is

1 This paper uses the widely recognised Integrated Quantity and Quality hydrological Model (IQQM).

Map 2: The Macquarie Marshes

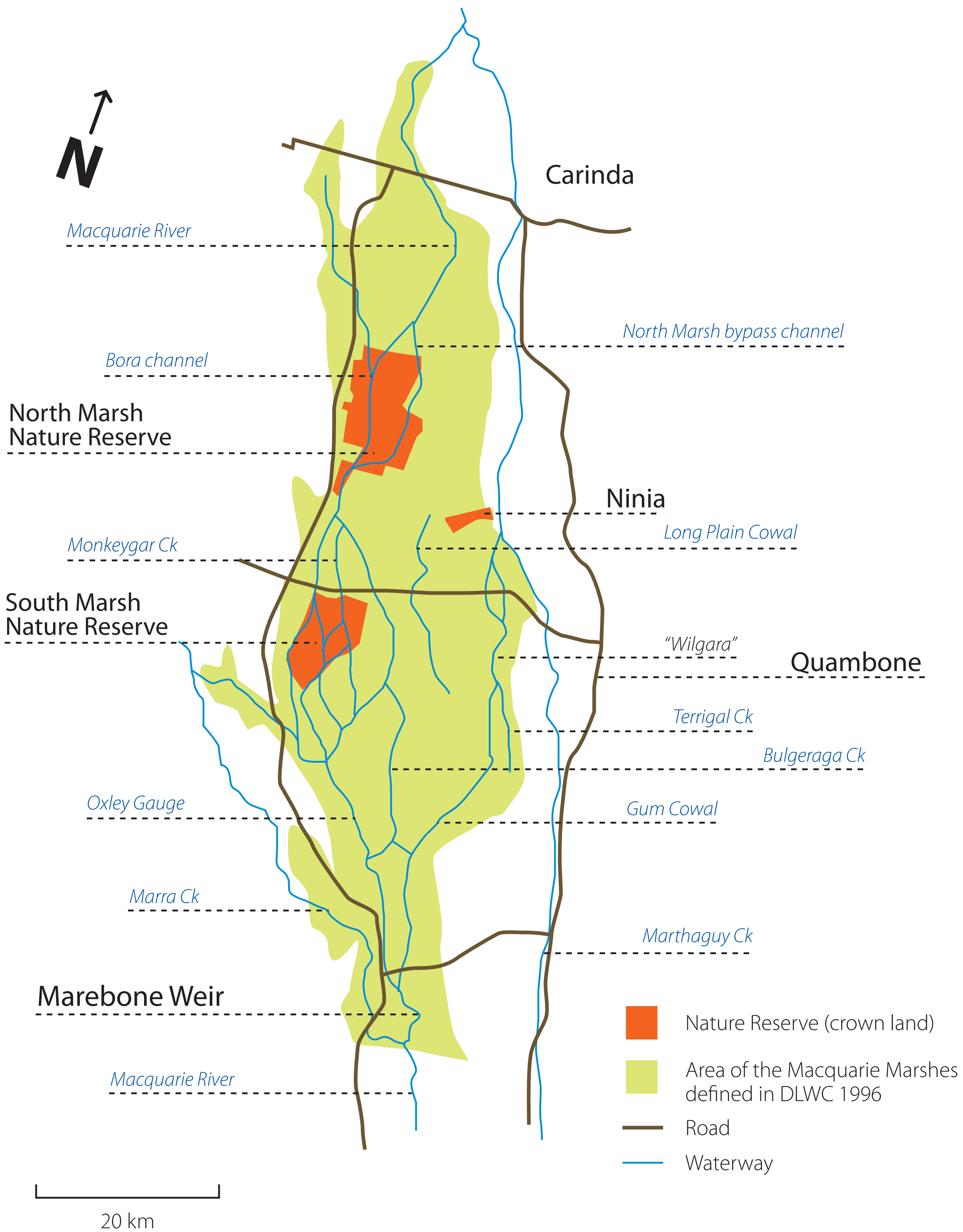
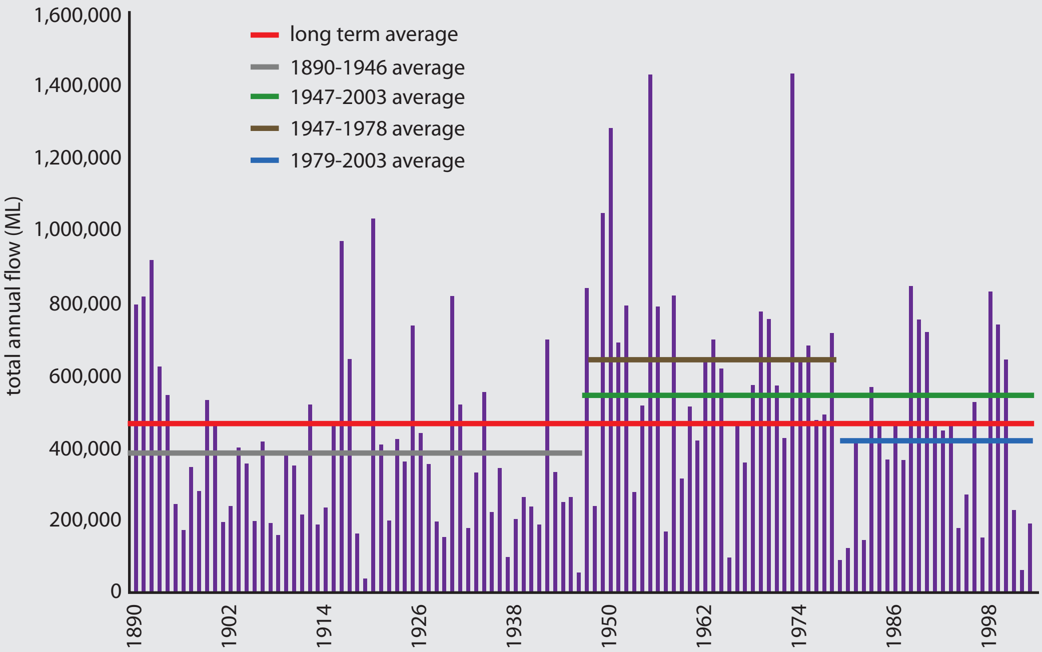


Figure 1: Total Annual Inflow to the Macquarie Marshes (ML) 1890-2003
Baseline Undeveloped Modelled Scenario.



Modelled overall 112 year average inflow to Marshes 466 GL/yr. Modelled average inflow 1890–1946: 385 GL/yr. Modelled average inflow 1947–1978: 644 GL/yr. Modelled average inflow 1979–2003: 420 GL/yr.

Source: NSW Department of Infrastructure, Planning and Natural Resources.

not too saline (See Chapter 5 'River Red Gum Dieback'). During droughts trees will drop some leaves and probably will not flower (Rankine & Hill 1979; Paijmans 1981; Cunningham *et al.* 1981). Investigations carried out in 1979 suggested that mature trees that survived the prolonged dry years of 1901-15 were killed by prolonged inundation in 1950-56 (Rankine & Hill 1979). See Chapter 3 'Drowned River Red Gums in the South Marsh'.

Black Box *Eucalyptus largiflorens* and **Coolibah *Eucalyptus coolabah*** trees also require flood conditions for germination, and also flower after flooding or rain. Once established these trees tolerate droughts well. However they do not tolerate prolonged inundation, therefore are only found on country that floods infrequently (Rankine & Hill 1979; Paijmans 1981; Cunningham *et al.* 1981).

Lignum *Muehlenbeckia florulenta* is a shrub that also establishes after flooding, but once established has 'a wide tolerance to both flooding and drought' (Paijmans 1981).

Common Reed *Phragmites australis* is a robust perennial grass that grows in situations that are periodically flooded. It 'appears to survive both prolonged inundation and years of no flooding' (Paijmans 1981) and forms large stands, especially in the North Marsh.

Cumbungi *Typha sp* is a perennial that prefers the more permanent waterways. It dies back during the winter. The underground 'rhizomes are capable of surviving in the soil for a considerable time without inundation' (Cunningham *et al.* 1981). This plant also produces 'masses of fluffed, wind-dispersed seed' (Paijmans 1981) from which it can regenerate.

Water Couch *Paspalum distichum* is a summer- growing perennial wetland grass that can 'withstand dry periods between seasonal floodings' (Cunningham *et al.* 1981). It is also a prolific seeder.

Water Couch, Cumbungi, and Common Reed all perform the important functions of slowing water flow through channels, encouraging overbank flooding and silt deposition, preventing erosion, and reducing evaporation in the Marshes. They are all impacted by cattle grazing (Rankine & Hill 1979; Paijmans 1981; Cunningham *et al.* 1981). See Chapter 2 'Loss of the South Marsh Reed Beds', and Chapter 5 'Long Term Vegetation Trends'.

Many aquatic plants will vary dramatically in their distribution from year to year depending on wetting and drying cycles. They survive drought periods as resilient seeds or spores (Rankine & Hill 1979; Cunningham *et al.* 1981).

Flood events are times of enormous plant and animal activity in the Marshes. This is especially true if flooding occurs over the summer months. All plant species grow rapidly, and the trees flower and seed.

Widespread flooding triggers breeding activity in at least 42 species of waterbirds. For this reason, the Macquarie Marshes are regarded as one of the most valuable locations for waterbird breeding in eastern Australia (Brooker 1992).

Some species of waterbirds will build their nests together in large colonies, and are therefore collectively known as the colonially-nesting waterbirds *viz.* ibis, herons and cormorants (see Chapter 2 Waterbird Breeding). These species require prolonged flooding over the summer months to complete their lifecycle. The Macquarie Marshes are a particularly important breeding site for these waterbirds (Brooker 1992).

The first century of European settlement

First Impressions

The Macquarie Marshes have a long history of human habitation. Fossil records from Cuddie Springs near Carinda, 30 km from the North Marsh, indicate the presence of Aboriginal people for over 30,000 years. The lower Macquarie was the home of the Wailwan people (Masman and Johnstone 2000).

When explorer John Oxley first attempted to trace the course of the Macquarie River in 1818, his journey was frustrated by flood conditions and the impenetrable reed beds of the South Macquarie Marsh. He was forced to abandon his attempt. At the time it was speculated that he may have found the shores of an inland sea.

Charles Sturt found a completely different picture when he retraced Oxley's path in 1828. NSW was in the grip of a severe drought that had commenced in 1826. Sturt was able to circumnavigate 'the great marshes', and find his way to the Darling River. At this time, both the Darling and Macquarie Rivers had 'wholly ceased to flow', and some waterholes in the Darling were highly saline. The Macquarie was a string of waterholes, some separated by up to half a kilometre of dry riverbed (Sturt 1833).

From his vantage point on Mt Foster overlooking the Macquarie Marshes, Sturt was able to see the smoke rising from numerous Aboriginal campfires along the banks of the Macquarie River channel. Many of the early records describe the Aboriginal people as strong and healthy, but in February 1829 Sturt found that those on the lower Macquarie floodplain 'were in a starving condition' due to the drought (Sturt 1833).

Sturt documented evidence of the Wailwan people actively managing both their land and water resources. Aboriginal land management here, as elsewhere in Australia, involved frequent burning. Sturt reported that in the midst of drought, 'the natives continue to fire the great marshes'. Within the marshes he found 'a singular scaffolding erected by the natives, on the side of the channel, to take fish; and also found a weir at the termination of it for the like purpose..' (Sturt 1833).

When Europeans first described the Marshes, the Aboriginal people had already been part of their ecology for a very long time. Elsewhere in the Murray Darling basin there are records of Aboriginals building weirs, cutting diversions into billabongs, and carrying fish to stock wetlands. Such management practises could have had a significant impact on the ecology of these wetlands (Humphries 2007).

Early European settlement was rapid and dramatic in the Marshes, as it was throughout inland NSW. The first official settler of the Marshes was Bryan Egan, who claimed the 'Mount Harris' run at the southern end of the South Marsh floodplain in 1839. The first recorded settler of the central Marsh area was George Gibson, who claimed the 'Wallamgambone' run around 1844. Cattle were grazed in the reed beds and wetlands, and sheep were grazed on the surrounding grasslands (Brennan 1975; McKenzie 1988; Masman and Johnstone 2000).

By the time Thomas Mitchell reached the Marshes in 1846, cattle stations had already become established in the South and Central Marsh area. Drought again prevailed, and Mitchell had persistent problems finding water for his bullocks. His Aboriginal guides took him to places where they expected to find water, only to be disappointed. At one such watering place, just downstream of the North Marsh Nature Reserve, Mitchell comments:

> Cattle find these places and come from stations often many miles distant, attracted by the rich verdure usually growing about them, and by thus treading the water to mud, or by drinking it up, they literally destroy the whole country for the aborigines, and thereby also banish from it the kangaroos, emus, and other animals on which they live. I felt more disgusted than the poor natives … that our 'cloven foot' should appear everywhere.
>
> *(Mitchell 1848)*

At this time it was estimated that the population of Wailwan people in the lower Macquarie district was around 800 (Masman and Johnstone 2000). Over the next 30 years the Aboriginal population declined. Food resources became scarce as settlers and their stock moved in, and this created escalating conflicts between tribes and with the settlers and police. European diseases such as smallpox, influenza, whooping cough, and tuberculosis also took their toll (Masman and Johnstone 2000).

Photo 2: Lower Macquarie River from Mount Harris, 1900

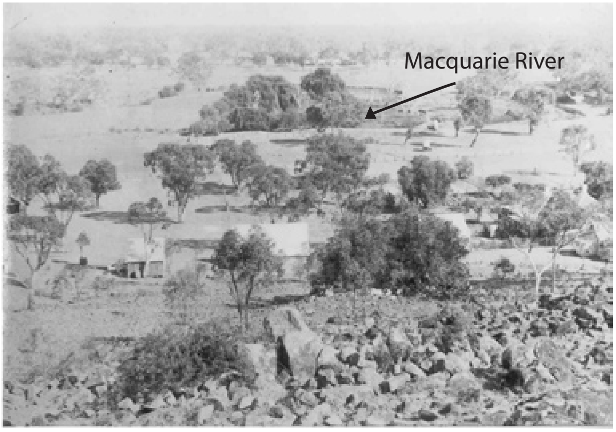
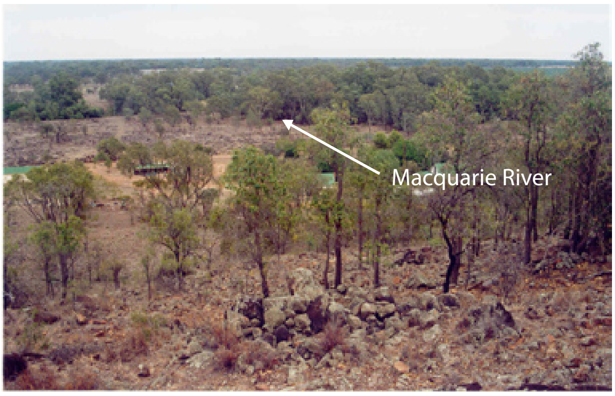


Photo 3: Lower Macquarie River from Mount Harris, 2000



The two photographs above are taken from the same position on Mount Harris, 100 years apart (note the distinctively shaped rocky outcrop in foreground). They overlook the lower Macquarie River just upstream of the Marsh floodplain. Note that tree vegetation, particularly along the river, is taller and denser in 2000 than it was in 1900. This also applies to the floodplain. Note that the banks of the river are visible in 1900, but not in 2000.

1900 photo supplied courtesy Jack Egan of 'Mount Harris'. 2000 photo supplied courtesy Tony Wass of 'Mount Foster'.

The Nineteenth Century

Native pastures throughout inland NSW fed an ever-increasing population of domestic stock. Sheep numbers flourished as a result of high wool prices in the 1870s and early 1880s. This coincided with above-average rainfall throughout western NSW over a 20-year period, from 1865 to 1885 (Barnes and Wise 2003). In the Western Division of NSW (which borders the Macquarie Marshes to the north and west), sheep numbers peaked at over 15.4 million in 1887 and again in 1891. This number has never been reached since. In fact, sheep numbers since 1900 have averaged 7.1 million and never exceeded 10 million in the Western Division (Barnes and Wise 2003).

In the Marshes, early records show that stocking rates[2] in the 1850s were higher than they are today (Cunningham 1996).

2 The stocking rate of land is measured in DSE (Dry Sheep Equivalents) per hectare. A cow or horse is equivalent to 10 DSEs. Stocking rates in 1850-1853 were calculated at 1.2 DSE/ha (Cunningham 1996). Canonbar Rural Lands Protection Board estimates the current average stocking rate on equivalent land at 0.8 DSE/ha.

Life in the Marshes—The Dry Phase 1895–1946

The 'dry phase' of 1895 to 1946 began with a particularly severe drought from 1895 to 1902 that affected the whole of western NSW. Throughout the first half of the twentieth century conditions continued to be basically dry, with more droughts than floods, and more bad seasons than good. The long-term average inflow to the Macquarie Marshes in the first half of the twentieth century was 30 per cent less than the average for the second half of the century, according to modelled flow data (Love *et al.* 2005).

In 1951, Lands Department Officer Lance Peacocke described the climate of the Marshes in these terms:

> during the last 51 years, including the present year to date, there have been only 15 major floods, and there have been long intervals amounting to several years between some of these.
>
> *(Peacocke 1951)*

This description was echoed by Carrick in 1962:

> In the Macquarie Marshes rains are unpredictable in season and quantity, so the Marshes are subject to prolonged or to flash floods at any time of year and are often dry for long periods.
>
> *(Carrick 1962)*

In 1995 John F Egan wrote:

> As a member of a pioneering family that first settled at 'Mount Harris' in 1839, and having lived all my life in the area, including jackarooing on 'Roubaix Station' in the Marshes, I fully support the maintenance of a viable Macquarie Marshes. However in its proper historical context that recognises that the River and Marshes dried up completely for prolonged periods during times of severe drought.
>
> *(Egan 1995)*

Some of the long-term local residents of the Macquarie Valley grew up during the dry phase, prior to river regulation. They recall that the river frequently ceased to flow, especially during summer. As children they played in the dry riverbed between deep water holes. 'My father told me that life in the Macquarie was just one long drought, with the occasional thunderstorm in between' (pers. comm. Tony McAlary: the McAlarys have been in the Macquarie Valley since 1880).

Catastrophic Drought

When the extended drought of 1895–1902 hit western NSW, the landscape was poised for disaster. Stocking rates were double the sustainable carrying capacity of the country. Stock were still almost entirely watered from natural watering points (apart from a small number of wells and tanks), and rabbits in plague numbers had reached northwestern NSW from Victoria (Barnes and Wise 2003).

Photo 4: Scalded country on the edge of the Macquarie Marshes 2005.

The Macquarie Marshes were not spared from this devastating drought, which followed a small flood in 1900 (Masman and Johnstone 2000). The North Marsh could dry out completely during severe droughts, and then the only watering point for stock became the Bora well. In 1901 it was the only water source for 5,000 cattle, 150 horses, and 2,000 sheep (Peacocke 1943). In the North Marsh 'adequate water was the problem for years with nearly all of the newcomers, there were no bores until about 1904/5'(Masman and Johnstone 2000, page 135).

The South Marsh was somewhat better supplied with surface water, being closer to the entry of the Macquarie River. Consequently, the South Marsh was more heavily stocked, particularly during dry times (Peacocke 1943). Today the South Marsh is a severely degraded wetland (REU 2000c).

On 'Willie', a run bordering the South Marsh, 'it was soon seen that the high stocking rates at that dry time are believed to have permanently removed the stands of thick saltbush (Old Man Saltbush *Atriplex nummularia*) for which the country was renowned' (Masman and Johnstone 2000, page 139). Sir Thomas Mitchell's description from 1846 also records the presence of saltbush plains, and luxuriant native grasslands that fringed the Marshes (Mitchell 1848). Native grasses such as Native Millet *Panicum decompositum* formed the basis of the Aboriginal diet of the region before white settlement. It was 'very rich on some parts of the open plains near the Marshes' (Mitchell 1848) but is now found in relatively few locations (Shelly 2004).

On 'Kiameron', a lower Macquarie property at the southern end of the Marshes floodplain, 75 per cent of stock died in 1902 because of the drought. In 1904, property records indicate that all remaining stock were away on agistment, as there was still no feed (Egan 1936). When good seasons began to return in 1905–06, rabbits bred up rapidly, creating a rabbit plague in 1906, followed by a grasshopper plague in 1907 (Masman and Johnstone 2000; Egan 1936). This removal of vegetation over vast areas of inland NSW caused the massive dust storms that were recorded towards the end of this drought (Masman and Johnstone 2000; Barnes and Wise 2003).

When the vegetation is removed, the soils surrounding the Marshes are vulnerable to wind erosion. The top soil blows away, leaving a hard, impenetrable clay pan or 'scald'. Extensive scalding has occurred on country surrounding the Marshes, and is still a problem today. See Photo 4.

In the Western Division of NSW, by the early 1900s, the demise of 38 per cent of ground-dwelling mammal species recorded in the 1800s was complete (Barnes and Wise 2003; Dickman 2004). These mammals, both marsupials and rodents, fell within the critical weight range of 35g to 5,500g (Dickman 2004). They are thought to have been unable to combat the combined assaults of the drought, removal of ground cover, competition from rabbits and domestic stock, change to Aboriginal burning practices, and the introduction of feral predators— foxes, cats and pigs (Barnes and Wise 2003; Dickman 2004). In the Marsh reed beds, domesticated pigs had gone feral and bred up, so that by 1896 they were 'very numerous and savage too' (Masman and Johnstone 2000, page 133). Since 1901, the number of mammal species present in western NSW has remained constant, despite ongoing threats (Barnes and Wise 2003).

Early Reservation and Land Use in the Marshes

The spectacular breeding of waterbirds that occurred in the Marshes during flood events had not gone unnoticed. In 1900, the Macquarie Marshes crown lands were declared a Game Reserve for the purpose of preserving the breeding grounds of game such as ducks. The area totalled 16,200 hectares, and encompassed the majority of the core wetland areas (Brereton 1994a). In the 1800s and early 1900s, wild food such as ducks, 'rat kangaroos' (probably bettongs, pers. comm. D. Shelly), and later rabbits, frequently formed part of the settler's diet (Masman and Johnstone 2000). In 1919, the Game Reserve was declared a Bird and Animal Sanctuary under the *Bird and Animal Protection Act 1918* (Brereton 1994a).

The Marshes were leased to graziers under leases controlled by the Lands Department up until 1971 when they were transferred to the National Parks and Wildlife Service (Brereton 1994a). The main land use within the Marshes was the grazing of cattle, which were far better suited to utilising the wetland than sheep. The highly palatable Water Couch, a summer-growing native grass that thrives on flooding, was found to be excellent cattle feed (Cunningham *et al.* 1981). Common Reed was also excellent cattle feed, especially in its young state (Cunningham *et al.* 1981). Consequently, the practice of annually burning the reed beds in late winter, in the hope of spring moisture and new growth, became traditional in the Marshes (Masman and Johnstone 2000; Peacocke 1943).

Loss of the South Marsh Reed Beds

Emerging Environmental Problems in the Bird and Animal Sanctuary

Mr Lance Peacocke was the Lands Department Officer who was responsible for managing the grazing leases in the Macquarie Marshes (the 'Marsh Blocks') in the 1930s, '40s, and '50s. He was a somewhat visionary character, spent a great deal of time in the Marshes, and kept extensive records (Masman and Johnstone 2000; also pers. comm. Gerry Peacocke, Lance's son). Peacocke observed the serious overgrazing, erosion and reed-bed loss in the South Marsh that was later documented by Brander (Brander 1987). He cancelled some grazing leases because overgrazing had caused destruction of reed beds (Peacocke 1943).

In 1943, the Lands Department decided to increase the number of grazing leases from 7 to 21. Peacocke proposed the following stringent conditions on the leases. These were adopted, but may not have been enforced in the long term.

Conditions of Grazing Leases 1943

- To prevent further loss of reed beds, 'reeds shall not be burned without the written consent of the District Surveyor, and after such burning, stock shall be excluded from all reed regrowth until it has attained a height of not less than three feet.' (Peacocke 1943).
- To minimise the impacts of stock and human disturbance of nesting waterbirds, 'where rookeries or community nesting places exist', the lessee 'shall completely enclose same with a sheep and cattle proof fence' (Peacocke 1943).
- To minimise the impacts of feral animals, 'the lessee shall take effective steps to keep the land free from foxes, wild pigs, rabbits, feral cats…' (Peacocke 1943).

The problem of feral predators, in particular feral pigs, is still a major management issue in the Marshes today. Pigs dig up and destroy the buried rhizomes of Common Reed and Cumbungi (Paijmans 1981) and eat the eggs and chicks of nesting waterbirds. The Department of Environment and Climate Change (DECC) carries out aerial helicopter shooting as well as baiting and trapping on a regular basis (NPWS 1993).

- To drought-proof the leases, the lessee was to dig a well ('excavated tank') in each paddock 'which exceeds 500 acres' i.e. 200 ha (Peacocke 1943).

Many of these wells provided only brackish water (Masman and Johnstone 2000, page 161). The remains of these wells are dotted throughout the current Nature Reserve. (NPWS 1993; Masman and Johnstone 2000).
Access to water in dry times was a continual problem in the Marshes.

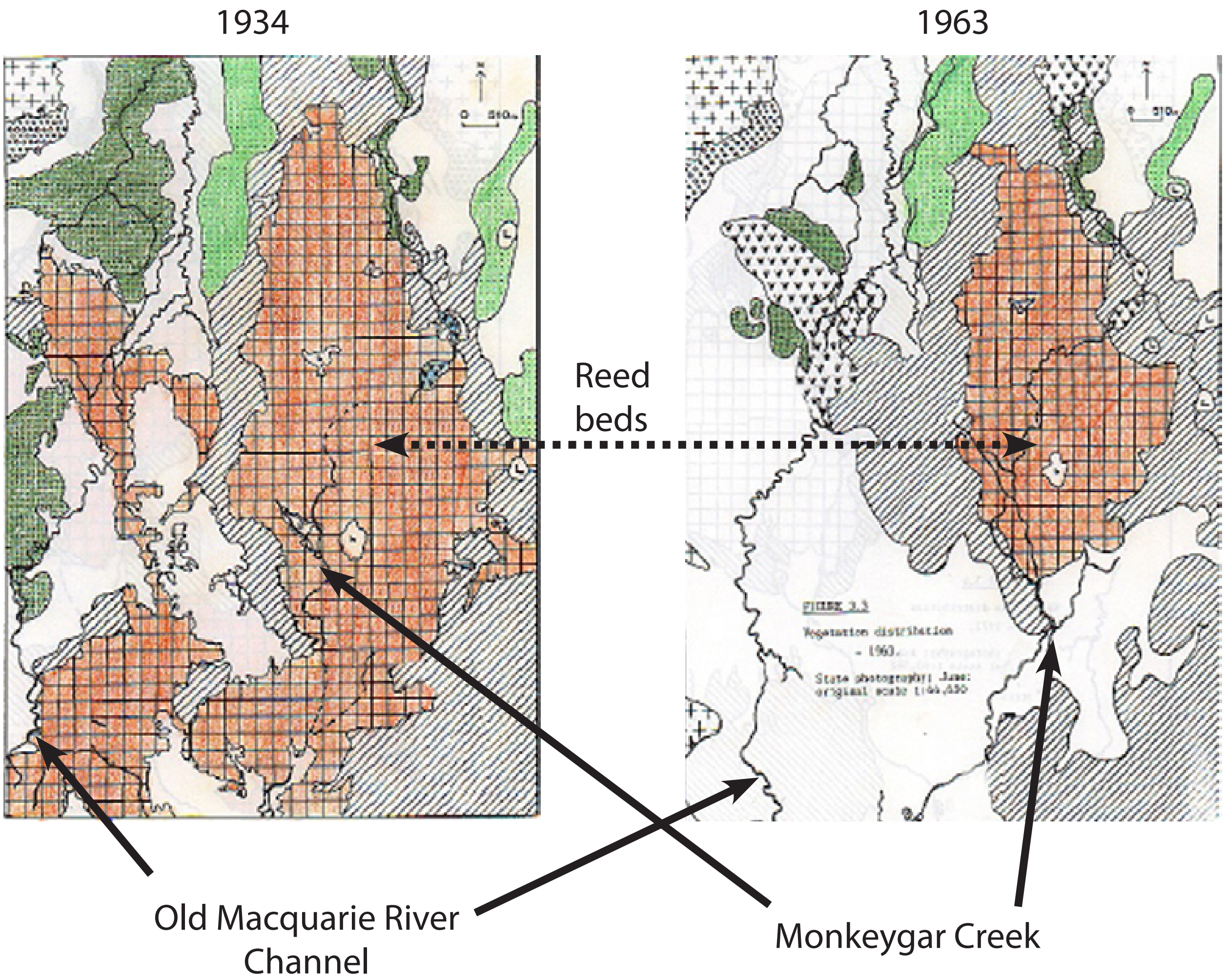
- Peacocke recommended sheep grazing to control the rapidly spreading weed Noogoora Burr *Xanthium occidentale*.

This weed was introduced to the Marshes by stock in 1920, and had already become widespread in the North Marsh by 1927 (Peacocke 1943). When it is very young, Noogoora Burr is palatable to sheep if little else is available (Cunningham 1981). It is still a major weed problem in the Marshes today. Biological control measures are ongoing, with some success (NPWS 1993).

Loss of the South Marsh Reed Beds

The loss of vast reed beds in the South Marsh has been attributed to upstream irrigators extracting the water they require (Kingsford and Thomas 1995; Kingsford 2004). However, Brander documented major reed bed loss in the South Marsh before 1963 (Brander 1987). Local residents also recall that there were no reed beds in the South Marsh, on the plains between the Monkeygar Creek and the Old

Map 3: South Marsh Nature Reserve Vegetation Mapping 1934 and 1963



The maps above show the distribution of reed beds (orange cross hatch) in the South Marsh Nature Reserve in 1934 (left) and 1963 (right). 1934-1949: 1,421 ha reed bed were lost. 1949-1963: 938 ha reed bed were lost.

Source: Brander 1987.

Macquarie River, by 1962 (pers. comm. Tony Wass, long-term local resident). This was probably the very place where Oxley had encountered impenetrable reed beds 144 years earlier. Burrendong Dam, which supplies the irrigation industry, was completed in 1967.

Brander used aerial photography to map vegetation changes in the South Marsh between 1934 and 1981. She found that, between 1934 and 1963, some 2,200 ha of reed bed were lost from the South Marsh, representing almost 60 per cent of the reed bed present there in 1934 (see Map 3). From 1963 to 1981, there was a slight increase in reed bed area (Brander 1987).

Brander attributed the loss of these reed beds to the combined effects of transfer of the Macquarie River flow into the Monkeygar Creek, and grazing and burning practices within the South Marsh.

Transfer of the Macquarie River flow into the Monkeygar Creek, a process known as channel avulsion,[3] is thought to have commenced in the late 1800s, and to have been complete by around 1960 (Brander 1987; pers. comm. Dr Paul Hesse and PhD student Tim Ralph from Macquarie University, who are currently gathering evidence of this process). As a consequence of the avulsion process, the reed beds associated with the Old Macquarie River channel no longer received the flooding they required.

Brander found that aerial photography showed a marked fence-line effect as the reed beds disappeared. This indicated that burning, and injudicious grazing too soon after burning, probably contributed to the reed-bed loss (Brander 1987; Peacocke 1943). Paijmans concurred with this view, noting in 1980 that 'fences forming a sharp artificial boundary between grazed water couch meadow and ungrazed (or little grazed) reed, indicate that reed probably once covered larger areas, and now appears to be retreating in favour mainly of water couch meadow' (Paijmans 1981).

Erosion can also be made worse where reed beds are removed by overgrazing on country that is still being flooded. This is because reed beds have an important role in slowing water flow by choking up channels (Rankine and Hill 1979).

Old parish maps dating back to the early 1900s show that the original Bird and Animal Sanctuary once included wetlands along the Macquarie River that were probably lost during the 1930s, 1940s and 1950s (see parish maps of Wullamgambone, Willie, and The Mole, County of Gregory).

3 In general terms an 'avulsion' may be defined as 'a tearing away'. More specifically in geographical terms it denotes 'the sudden loss of land by the action of water' (Wikipedia 2007).

Waterbird Breeding

In the Macquarie Marshes, large-scale breeding events of waterbirds are triggered by widespread flooding, which provides the necessary food resources to complete their breeding cycle (Carrick 1962; McGrath 1991; Brooker 1992). An annual inflow of over 200GL at Oxley gauge,[4] just upstream of the South Marsh Nature Reserve, will trigger breeding of the colonial nesting waterbirds—*viz.*, ibis, herons and cormorants (Kingsford and Johnson 1998). However, if feeding grounds dry out too rapidly, the parent birds will abandon their chicks (Carrick 1962).

Peacocke documented aspects of the spectacular bird-breeding events that occurred in the Marshes. In the 'Dry Phase', some of these were spectacular failures: 'Often the water in the Marshes has receded before the young birds are strong enough to fly and then there is great mortality by starvation or destruction from predatory animals' (Peacocke 1951). In January 1930, 'the water gave out in the Marshes when thousands of birds were almost on the wing. As a result they all died. Sadly, the birds only needed two or three weeks more water and they would have been on the wing' (Peacocke in Masman and Johnstone 2000, page 172). 'During the drought of 1940 exhausted birds again died in the Marshes when the water gave out' (Peacocke in Masman and Johnstone 2000, page 172).

During dry years when no flooding occurs, 'when the Marshes dry up, the birds travel north and stay away until flooding recurs' (Peacocke 1951).

Rabbits

Rural families experienced some hard times in the early 1900s, particularly during droughts and economic depression. At these times, rabbits provided an important source of food and income for many families. Their overall destructive impact on pastures, however, was soon recognised (Barnes and Wise 2003).

In the Macquarie Valley, rabbits were brought under some level of control by 1935 due to a combination of droughts, rabbit 'drives', rabbit warren destruction, poisoning, trapping, and destruction of rabbit habitat (Brennan 1975; McKenzie 1988; Masman and Johnstone 2000). Poisoning of rabbits also caused the death of 'thousands of birds' (McKenzie 1988), presumably from eating poisoned wheat.

By the late 1940s, economic recovery from World War 2 was in full swing, and profits from wool-growing peaked in 1950–51. These were the 'wool boom' years when Australia 'rode on the sheep's back' (Barnes and Wise 2003). Coincidentally, a run of good seasons occurred. In

4 Oxley gauge is not a correct measure of total Marsh inflow, as some creeks that supply the Marshes exit the Macquarie River upstream of Oxley (Love *et al.* 2005).

much of western NSW, including in the Macquarie, this led to more rabbit plagues. The situation was exacerbated by a shortage of labour and wire netting caused by World War 2.

In the early 1950s, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) introduced the virus myxomatosis to the rabbit population. The successful control of this pest must rate as one of the most important scientific achievements in the history of western NSW (McKenzie 1988; Masman and Johnstone 2000; Barnes and Wise 2003).

According to vegetation mapping of the tree species of the Macquarie Marshes floodplain (1949 compared with 1991), there has been an overall expansion in the distribution of acacias and other dry land tree species (DLWC 2000b). One possible explanation for this could be the recovery of the landscape from rabbits, since rabbits eat tree seedlings and ringbark young trees when all the grasses have been eaten (Barnes and Wise 2003).

Life in the Marshes—the Wet Phase 1947-1978

Much higher rainfall in the late 1940s marked the beginning of a second climatic phase in the Marshes, 'the wet phase', which lasted for three decades from 1947 to 1978 (see Figure 1). During this phase there were more good seasons and floods than droughts, and the average inflow to the Marshes due to climate alone was 67 per cent higher than the average inflow for the 1890–1946 period, according to modelled data (Love *et al.* 2005).

Major Flooding 1950–1956

Extensive flooding occurred throughout the Macquarie Valley in 1950, 1951, 1955 and 1956. The floods of 1955 and 1956 were extreme valley-wide events. Serious flooding occurred in 1955 in Bathurst, Wellington and Dubbo. The 1955 flood level in Dubbo was the highest ever recorded (Sinclair, Knight and Partners 1984). Narromine and Warren were completely inundated. Long-term local residents on properties downstream of Warren recall being isolated for weeks by floodwaters, sustained by food drops from the RAAF.

Waterbird Breeding in the Marshes in the 1950s

The CSIRO investigated the breeding and feeding biology of Australian ibises *Threskiornis spp* during the 1950s (Carrick 1959; Carrick 1962). The years of widespread and continuous flooding throughout 1955 and 1956 resulted in prolonged ibis breeding activity. This occurred throughout inland NSW, including in the Macquarie Marshes (Carrick 1962).

There was a drought in eastern Australia in 1957. Presumably due to the population explosion of ibis, they 'were forced to seek food in unusual places'. White Ibis *Threskiornis aethiopica* were reported in Tasmania for the first time. Straw-necked Ibis *Threskiornis spinicollis* were sighted in unusual numbers in Canberra and Cairns (Carrick 1962).

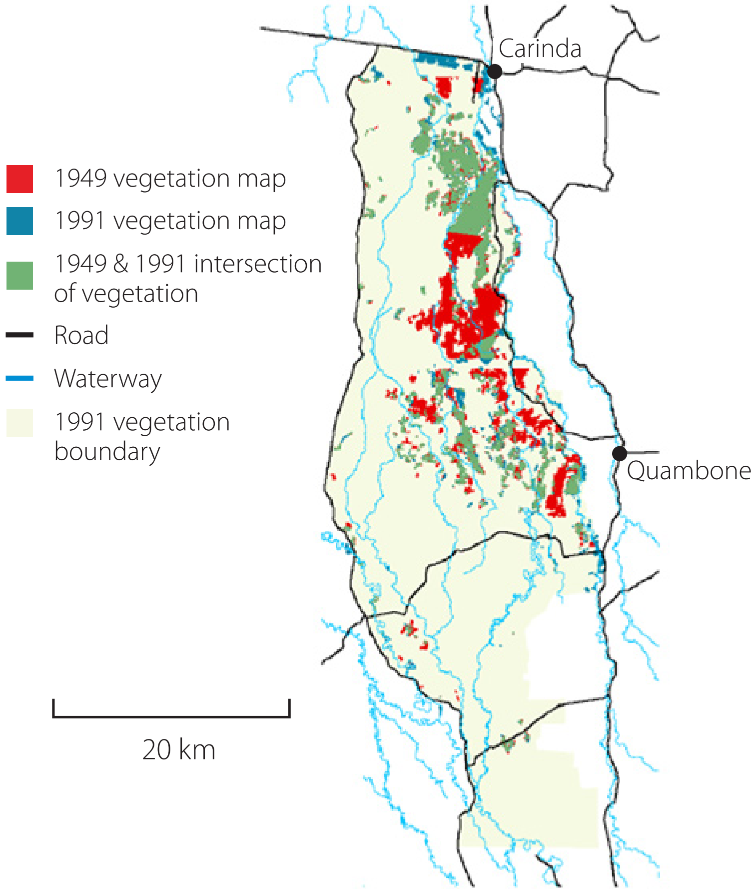
Carrick proved that newly fledged young ibis scatter widely from their place of birth and may not return for many years, depending on conditions. He banded 2,600 young ibis in the Macquarie Marshes in 1955, and subsequently recovered banded birds from coastal NSW, coastal Queensland, Cape York peninsular, and wetlands along the lower Murray River (Carrick 1962).

Drowned River Red Gums in the South Marsh

Large areas of River Red Gum woodland in the core South Marsh area died between 1949 and 1963 due to prolonged inundation (Brander 1987; DLWC 2000). Brander found that River Red Gum woodland halved in area in the South Marsh between 1934 (1,407 ha) and 1963 (556 ha) due to a combination of clearing followed by drowning (Brander 1987). Silt carried down by the floodwaters probably blocked drainage channels, prolonging the inundation of these trees (Rankine and Hill 1979; Brander 1987).

Local residents suggest that, during the floods of the 1950s, a large amount of silt was deposited on the plains of the South Marsh. This raised the level of the floodplain so that more water would be required to inundate it, and exacerbated the further loss of flooding, and loss of reed beds, in the South Marsh. Brander corroborated this suggestion by photographing half-buried fences on the floodplain (Brander 1987). This silt probably came from upstream riparian areas, which had been overgrazed and badly impacted by rabbits. According to locals the riverbank just upstream of Warren collapsed during these floods, having been undermined by rabbit warrens. This created what is now called the Reddenville Break.

Map 4: Black Box Distribution on Macquarie Marshes Floodplain—Comparison of 1949 distribution with 1991 distribution.



Note red colour in areas where Black Box woodlands existed in 1949 and have been removed by 1991.

Source: REU 2000b

Clearing and Ringbarking in the 1960s and 1970s

In 2000, the Riverine Environment Unit (REU) published detailed vegetation mapping covering the entire 200,000 ha floodplain between the Macquarie River and Marthaguy Creek (REU 2000b). The mapping looked closely at tree distribution, and compared the total area of different tree types in 1949 with their area in 1991.

The most dramatic finding of this report was that there had been a net loss of 38 per cent of Black Box woodland (see Map 4). Black Box woodlands are found on infrequently inundated, but highly productive, black soil country. The report recommended that 'Black Box requires special conservation status within the Macquarie Marshes' (REU 2000b). Coolibah and River Red Gum woodlands had also declined in net total area by 16 per cent and 7 per cent respectively. The report concluded that 'Clearing, particularly in the Central Marsh and Marthaguy zones, represents the biggest causal agent of reduced tree distribution in the Macquarie Marshes'.

Local residents explain that during the 1960s and 1970s gangs of ring-barkers were employed on 'Sandy Camp', which at that time was an enormous property of 40,891 ha (Brereton 1994a). The manager held a strong belief that trees compete with grasses for moisture and that removal of all the trees would improve his carrying capacity for stock. Apparently he was successful in ring-barking almost the entire property (pers. comm. M. Carpenter, employed on Sandy Camp in the 1970s; pers. comm. E. Hayden who held a Marsh lease in the 1970s; Masman and Johnstone 2000). This belief was widespread at the time, and other properties also carried out ring-barking and clearing.

Government policy of the period, both State and Federal, encouraged clearing and ring-barking. Farmers were provided with a wide variety of tax concessions. The most significant one allowed the costs of 'the destruction and removal of timber, scrub or undergrowth indigenous to the land' to be fully tax deductible (Australian Greenhouse Office 2000). This law was amended in 1973 and abolished in 1983.

Clearing was also encouraged through a range of financial incentives, including the Rural Credits Development Fund (set up by the Commonwealth Government in 1925 and abolished in 1987), and low interest loans provided by the Commonwealth Development Bank (CDB) from 1960. Other financial institutions soon offered similar loans to those offered by the CDB (Australian Greenhouse Office 2000).

It was not until 1995 that specific land clearing controls were introduced in NSW (Australian Greenhouse Office 2000).

Management of the Nature Reserve

In 1955, the Bird and Animal Sanctuary was declared a Fauna Reserve under the NSW *Fauna Protection Act 1948*. In 1971, the Macquarie Marshes Fauna Reserve was declared a Nature Reserve under the *Fauna Protection Act 1948-67*. Its management was handed over from the Lands Department to the NSW National Parks and Wildlife Service. Grazing under leasehold continued in the reserve until 1990 (Brereton 1994a).

Burrendong Dam

Burrendong Dam was originally proposed and designed in the 1940s with the purpose of drought-proofing the Macquarie Valley (Sinclair, Knight and Partners 1984). Building work commenced in 1946 but was suspended in 1952 due to budget cutbacks (DWR 1991). After the floods of 1955 and 1956, the dam was redesigned to allow for flood mitigation. Construction recommenced in 1958, to finally be completed in 1967 (DWR 1991). The flood mitigation capabilities of the dam were called upon almost continuously throughout the wet 1970s. Major inflows occurred in 1971, 1973 and 1978 (Sinclair, Knight and Partners 1984; DWR 1991).[5]

5 Burrendong Dam facts: catchment area 13,900 square km, storage capacity 1,189 GL plus 489 GL in flood mitigation zone; average annual inflow to Burrendong Dam 1,000 GL. Total average annual inflow to Macquarie River 1,500GL (DLWC 2004).

Irrigated Agriculture Commences in the Macquarie Valley

Landholders in the Macquarie Valley had been experimenting with irrigated cropping and pastures on a small scale since the 1890s. Today the Macquarie Valley supports a range of irrigated crops, including cotton, vegetables, citrus, grapes, olives and roses. Cotton is currently the most important irrigated crop in the valley (MRFF 2007).

Queensland farmers had been experimenting with rain-grown cotton crops throughout the 1900s, with varying degrees of success. In the 1960s, the Federal Government strongly encouraged the development of the fledgling irrigated cotton industry in Australia by providing a bounty for good quality cotton. Sometimes the bounty was similar to the mill price of the crop (Auscott Ltd 2005).

In 1963, successful American cotton farmers, the Boswell Company, began investing in Australia with the initial purchase of a property on the Namoi River near Narrabri. In 1967 the Boswell Company purchased the current Auscott Macquarie property near Warren, 50 km upstream of the South Marsh. Within the space of three years, a second property in the Macquarie Valley had been purchased and two gins[6] constructed, again with strong encouragement from the Federal Government (Auscott Ltd 2005).

In 1971 the Federal Government discontinued the cotton bounty subsidy on the basis that the industry had become self-sufficient. In 1972 the Cotton Research Centre was formed at Narrabri, and in 1973 Best Management Practice for insect pests was initiated (Auscott Ltd 2005).

From its flying start, the cotton industry struck difficult times throughout the wet 1970s. Floods, prolonged wet harvests, and serious crop damage due to insect pests brought the viability of cotton-growing into question. Insect pests rapidly built up resistance to available insecticides, making frequent spraying a necessity. The industry had to develop new technologies quickly to respond to these emerging problems.

A strong research base and rapid uptake of new technologies has been the main factor responsible for the survival, and later success, of the cotton industry.

6 A gin is the term for the initial processing plant of cotton. The lint or fibre is separated from the cotton seed and processed into bales, which can then be transported to the shipping port by train. Most of Australia's cotton crop is exported.

The Macquaries Marshes, 1979 onwards—A Second Dry Phase

River Regulation and the Macquarie Marshes

The drought years of 1979–82 throughout NSW, including in the Macquarie Valley, heralded the onset of a second dry phase, or perhaps more normal climatic conditions than the 1947–78 wet phase. Modelled average inflows to the Marshes in the period 1979–2003 due to climate alone were significantly lower than average inflows for the wet phase, but still not as low as the earlier 1890–1946 average (see Figure 1).

The Wild Life Allocation

The floods of the 1950s convinced both public opinion and the Water Conservation and Irrigation Commission (WCIC) that Burrendong Dam was required, not only for drought-proofing but also for flood mitigation (Sinclair, Knight and Partners 1984). Concerns were raised throughout the planning phase of the Dam that it could adversely affect the fortunes of the floodplain graziers and the breeding waterbirds (Peacocke 1951). The WCIC agreed with NPWS that a Wild Life Allocation (WLA) might be required in case waterbird breeding was adversely affected. The amount was originally set at around 18.5 GL (Brereton 1994a).

The very wet decade that succeeded the completion of Burrendong Dam in 1967 meant that flood, not drought, was the primary concern until 1979, and no WLA was requested (DWR 1991). Dry conditions in 1980 resulted in the first Wild Life Allocation release of 27 GL. Much of this water was lost in transmission as the water passed down the dry riverbed, so that only 17 GL reached the Marshes, and only 3,500 ha were inundated (Brereton 1994a). This release highlighted the importance of transmission loss in the Macquarie River, especially during drought. 'Transmission loss' is the water absorbed by the river channel and associated wetlands as it passes down the river. It accounts for 20 per cent of the annual average flow in the Macquarie River (see Figure 4).

Further releases in 1983 and 1985 with much wetter antecedent conditions showed that conditions prior to the release of environmental water will greatly affect the area of inundation achieved in the Marshes (Brereton 1994a, DWR and NPWS 1986). Wet antecedent conditions will result in a much greater area of inundation for two reasons. Firstly, transmission loss is reduced, as the river channel and some associated wetlands are already wet. Secondly there is often more riparian vegetation during wet seasons. This vegetation slows the flow of the water, allowing it to spread out further across the remarkably flat landscape of the Marshes. It was therefore decided that the WLA should in general be released with wet antecedent conditions to maximise the area of inundation achieved in the Marshes (DWR and NPWS 1986).

The 1986 Water Management Plan for the Macquarie Marshes

During the 1980s, public opinion and political pressure began to focus on water allocation for inland rivers more generally. The Macquarie Marshes Nature Reserve was listed as a wetland of international importance under the Ramsar Convention in 1986. A rapidly expanding irrigation industry, and a lack of formalised rules governing the release of the WLA, highlighted the need for an agreed water-sharing plan for the Valley.

With the 1986 Water Management Plan, the Macquarie Valley became a leader in the Murray–Darling Basin with its provision for environmental flows. This new Plan

> provided significant protection of water flows to the Marshes and created restrictions to the level of irrigation development. No other river in the Murray–Darling Basin had both a Plan like the 1986 Plan and delivery of environmental flows as had occurred in the Macquarie Valley.
>
> *(DLWC 2002)*

The Plan increased the WLA to 50 GL of high security water, and was to be reviewed in five years (DWR and NPWS 1986). 'High security' water is water that must be available to be delivered every year if required. Water for irrigation is 'general security' water. This water is allocated to water users on a per centage basis each year, and the per centage allocated will depend on Dam inflows. The average per centage of allocation of general security water in the Macquarie Valley is 55 per cent, and during severe droughts the allocation can be zero.

The 1986 Plan exposed significant gaps in our understanding of the complex ecology of the Macquarie Marshes. Consequently, the Murray Darling Basin Commission helped to fund a number of joint research projects that were initiated in the late 1980s and early 1990s. These included vegetation mapping, groundwater investigations, erosion measurements, river modelling systems, River Red Gum health studies, and other vegetation studies (Brereton 1994a; DWR and NPWS 1994a; DWR and NPWS 1994b; DLWC 2002). Community involvement was encouraged through the creation of the Macquarie Marshes Catchment Committee (MMCC).

This increase in research effort in the Marshes coincided with a decline in inflows to the Marshes due to climate, and a decline in inflows to the Marshes due to a rapidly expanding irrigation industry upstream of the Marshes. Many researchers therefore attributed the decline in inflows entirely to the irrigation industry, and failed to recognise the important influence of climate. During the 1970s there were a number of consecutive years of well above-average inflows, and major flooding in 1971, 1973 and 1978 (DWR 1991). By contrast the early 1980s were drought years, with well below average inflows due to climate alone. Figure 1 clearly shows the difference between modelled inflows due to climate alone in the 1970s compared with the 1980s (Love *et al.* 2005). This lack of understanding of the influence of climate variability on the Marshes was a persistent feature of research in the 1980s and 1990s.

Figure 2 shows the annual inflows to the Macquarie Marshes compared with the annual extraction for irrigation use[7] for the period 1986/7 to 2005/6.

7 Cotton is a summer crop, planted in September/October and harvested in March/April. For this reason, annual cotton statistics, including water use, refer to the financial year 1st July to the following 30th June.

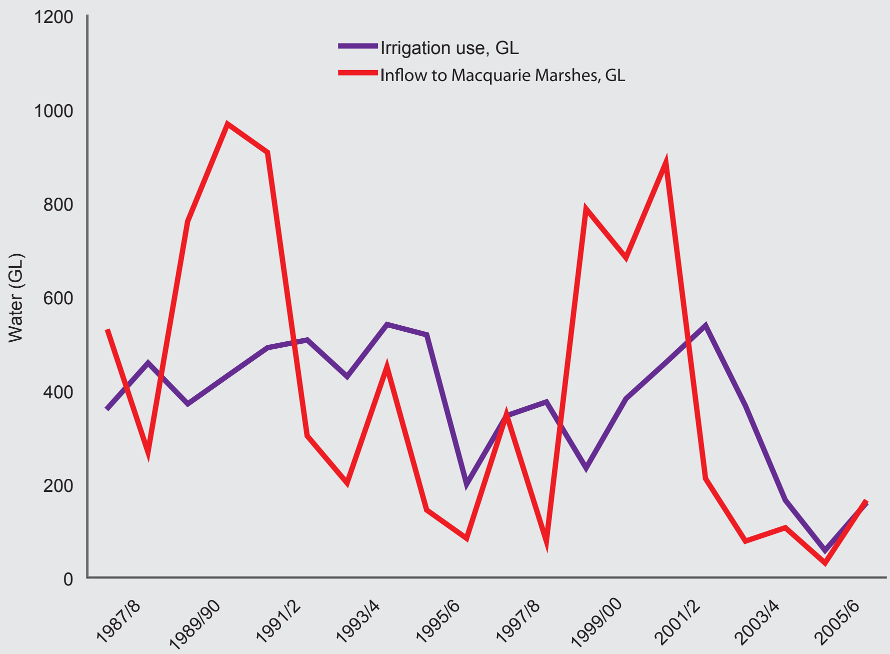
Both curves show a sharp decline between 2001/2 and 2005/6, in line with the climate trend for the period. Of the two curves, the Marsh inflows are much more variable, which is compatible with ecosystem objectives. There were high inflows in 1988, 1989 and 1990 and again in 1998, 1999 and 2000; with resulting large waterbird breeding events in 1990, 1998 and 2000 (see Figure 7).

Irrigation use in Figure 2 is a flatter curve, which is more compatible with an industry dependent on regular returns. This is due to the storage capacity of Burrendong Dam. Since 1996 irrigators have had the option of storing allocated but unused irrigation water in the dam as 'carryover water', to be used in later years. Irrigation water use will depend on allocation per centage, carryover from the previous year, the area of cotton planted, and rainfall over the summer.

The 1996 Macquarie Marshes Water Management Plan

The 1996 Macquarie Marshes Management Plan provided a further significant increase in the water allocation of the Marshes. In addition to the 50 GL of high security water, the Plan added a further 75 GL of general security water

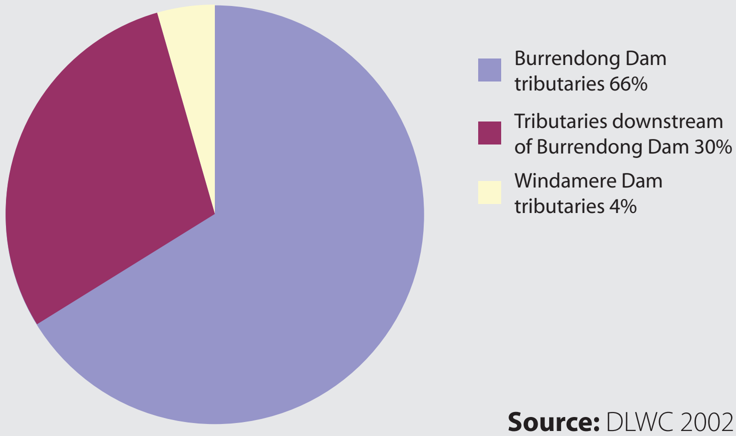
Figure 2: Macquarie Valley Water Use for Irrigation (GL) and Inflow to the Macquarie Marshes (GL) 1986/7 to 2005/6.



Source: State Water Information 2007 to the WLA. Off-allocation extraction[8] by water users was limited to 50 GL in any one year. Under this Plan, river modelling predicted that 'the long term annual average inflow to the Marshes will increase by 50 GL/yr to 450 GL/yr compared with an estimated 525[9] GL/yr under natural conditions' (DLWC and NPWS 1996). This represented an increase in annual average inflows from 76 per cent of natural inflow under the 1986 Plan, to 85 per cent under the 1996 Plan. In other words, the net result of these changes for the Marshes was that the Marshes would now receive an estimated 85 per cent of their long-term average natural inflow.

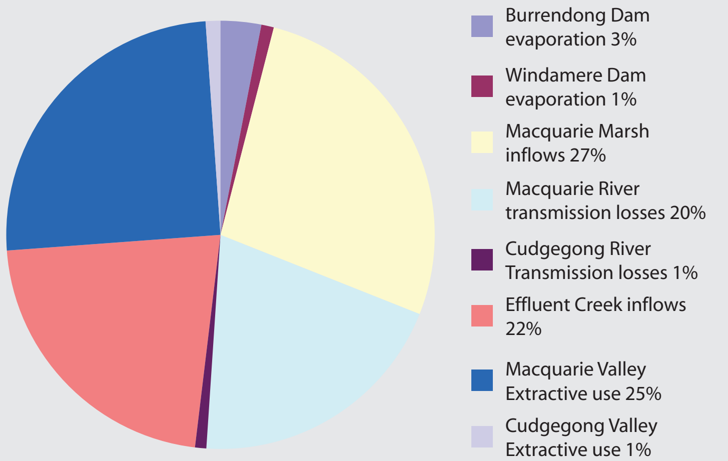
Local residents suggest that this per centage is likely to be an underestimate. According to them extensive floodplain development now prevents water from flowing out of the Macquarie River to the west via the effluent creeks, as it once did during high flows. This tends to favour flows into the Marshes.

Figure 3: Average Annual Inflows to the Macquarie River System



Source: DLWC 2002

Figure 4: Distribution of Macquarie River Water under current Water Sharing Arrangements



Source: DLWC 2002

The Irrigation Industry

In 1982 the Water Resources Commission placed an embargo on the granting of new water access licences in the Macquarie Valley (DIPNR 2004). This was as a result of irrigators' concerns that the Commission was handing out too many licences.

Drier climatic conditions, which are more suitable for irrigated cotton cropping, and good cotton prices stimulated the rapid expansion of the cotton industry in the 1980s and early 1990s in the Macquarie Valley. Many landholders within the Narromine and Warren Shires developed some part of their property for irrigated agriculture.

In 1995 a limit was imposed on the volume of water that could be extracted from each river in the Murray Darling Basin. This limit was called 'the cap' and is defined as 'the volume of water that would have been diverted under 1993/4 levels of development.' (MDBC 2001) Therefore any further increase in cotton production in the valley will need to be driven by improved technology and water efficiency, not increased water allocation. In the 1996 Water Sharing Plan, the allocation to the Macquarie Marshes was increased, and the reliability of irrigation water was reduced by around 12 per cent on average (DLWC 2002).

Irrigated agriculture is a significant contributor to the economic well-being of the Macquarie Valley communities. It contributes 30 per cent of the value of all agricultural production, while using 1 per cent of the land area of

8 Off-allocation extraction is water not counted in the allocation of a water user. It may be legally extracted when river flows exceed an agreed flow.

9 There are some discrepancies in the estimated long-term natural annual average inflow to the Marshes. Later modelling done in 2005 estimated the annual average natural inflow at 466GL/yr. See Figure 1.

the Macquarie catchment. Agriculture is the third largest employer in the catchment, with irrigated agriculture employing two thirds of all agricultural workers (MRFF 2007). Irrigated agriculture extracts on average 23 per cent of the total annual average flow in the Macquarie River[10] (DLWC 2002). See Figure 4.

2004 Macquarie Cudgegong Water Sharing Plan

The current Water Sharing Plan commenced on 1st July 2004 and applies for a 10 year period until 30th June 2014. Under this plan environmental flows will be delivered to the Cudgegong River, a major tributary of the Macquarie River, for the first time (DIPNR 2004).

The Plan states that 'The environmental water rules in this Plan do not change the environmental shares of the 1996 Plan, but include further revisions to improve river health management' (DIPNR 2004). Therefore the Macquarie Marshes' share of environmental water is unchanged, but this water can be released in a more variable and natural manner. This was achieved by transferring the environmental water from 50 GL of high security water plus 75 GL of general security water, into 160 GL of general security water. All stakeholders were represented on the 31-member River Management Committee that developed the Plan.

A new group, the Environmental Flows Reference Group (EFRG), again inclusive of all stakeholders, was set up under the new Plan to administer the environmental flows. The first release of environmental water under the new plan (30 GL) occurred in late October/early November 2005.

Figures 3 and 4 give background information on the sources and distribution of the Macquarie River's water (DLWC 2002). The total annual average flow of the Macquarie River is 1,500GL/yr. It is measured at 'Baroona' which is between Dubbo and Narromine. Figure 3 shows the per centage contribution of inflow sources. Seventy per cent of Macquarie river inflows are upstream of Burrendong Dam and 30 per cent are downstream. Note that Windamere Dam is upstream of Burrendong Dam on the Cudgegong River.

Figure 4 shows how the Macquarie Rivers' water is distributed on an annual average basis. The Macquarie Marshes currently receive 27 per cent of the Macquarie Rivers' annual average flow, whereas under natural conditions they would have received around 33[11] per cent (DLWC and NPWS 1996; DLWC 2002; Love *et al.* 2005).

On average, 26 per cent of total Macquarie River flows are extracted for irrigated crops, stock and domestic water, and towns. Four per cent is lost to evaporation from the dams; therefore 70 per cent of the flows are available to the environment.

The Impact of River Regulation on Water Regime in the Marshes

The water regime of a river or wetland is an integral part of its ecology. It describes the volumes and timing of delivery of water.

Annual Inflows

The annual Marsh inflow varies enormously between the extremes of 0 GL/yr and 2,000 GL/yr. River regulation has reduced the frequency and duration of small to medium flood events in the Marshes. This is because river regulation has the most impact on the low to medium Marsh inflows of 150 to 600 GL/yr, according to recent modelling (Love and Burton 2004).

Under the current Water Sharing Plan there should be little alteration in the seasonality of inflows to the Marshes. This is because, even though the majority of water allocated for extraction is delivered over the summer months, most of this is extracted before it reaches the Marshes. Environmental water is generally delivered when natural flows occur in the river (Love and Burton 2004).

It has been claimed that the Marshes now receive less than half their natural inflow (Kingsford and Thomas 1995; Kingsford and Johnson 1998; Kingsford 2004). This claim (Kingsford and Thomas 1995) is based on a limited data set, from which a number of key readings are missing. It is also based on Marsh inflows measured at Oxley gauge, but on average only 53 per cent of the water entering the Marshes passes the Oxley gauge. Marsh inflows are correctly measured upstream of Oxley gauge at Marebone gauge (Love *et al.* 2005). Therefore this claim is directly contradicted by the Departments' information in the 1996 and 2004 Water Sharing Plans, and modelling based on river gauging data (DLWC and NPWS 1996; DLWC 2004; Love *et al.* 2005).

10 Total annual average extractive use is 26 per cent. Irrigated agriculture accounts for the majority of this, but town and stock and domestic use is also included.

11 Estimates of this figure vary between 31 and 36 per cent

Figure 5: Areas inundated in the Macquarie Marshes during the major floods of 1990, 1998 and 2000

Flood Event	Date	Area Inundated	Source
1990	20/06/1990	**154,000 ha**	DIPNR data 2004
1990	August* 1990	**228,235 ha** (outline)	DLWC and NPWS 1996; Button 2004
1990	26/10/1990	**151,003 ha**	DIPNR data 2004
1998	30/09/1998	**186,797 ha**	DLWC and NPWS 1999
2000	30/11/2000	**133,994 ha**	DIPNR 2001
2000	16/12/2000	**173,725 ha**	DIPNR 2001

* The 1990 flood reached its maximum extent in August. The actual area inundated in the Marshes in August was not mapped, but the outline of the estimated area inundated enclosed 228,235 ha (Button 2004). This included some high ground that did not become inundated. This outline formed the definition of the extent of the Macquarie Marshes in the 1996 Water Sharing Plan (DLWC and NPWS 1996).

Areas Inundated by Major Flood Events

It has been claimed that the area of inundation in the Marshes in major flood events has halved due to diversions by upstream irrigators (Kingsford and Thomas 1995; Kingsford 2004). The evidence does not support this claim. Department sources are clear that river regulation and development has had little impact on Marsh inflows during major flood years, and therefore the area inundated in the Marshes in major flood years (Love and Burton 2004; Love *et al.* 2005).

Before Landsat imaging techniques, areas of inundation were estimated from known flood extents. The area inundated by the 1978 flood was estimated to be 150,000 ha (Brooker 1992).

The area of the Marsh floodplain inundated on specified dates has been mapped using Landsat imagery from 1990 onwards. See Figure 5. A major flood event will inundate approx 150,000 ha or more. Once the floodplain is fully inundated, excess water will spill over into the Barwon River.

Constant Low Flows

One important alteration in flow regime has resulted in the Marsh channels no longer drying out completely as they once did under natural conditions. Low inflows of less than 0.4 GL/day have generally decreased, and very low inflows of less than 0.1GL/day have dramatically decreased (Love and Burton 2004). This could have negative impacts on the Marsh's ecology, as the drying cycle of ephemeral wetlands performs a number of ecological functions important to their productivity (MDBC 2001).

The Macquaries Marshes, 1979 onwards— A Second Dry Phase

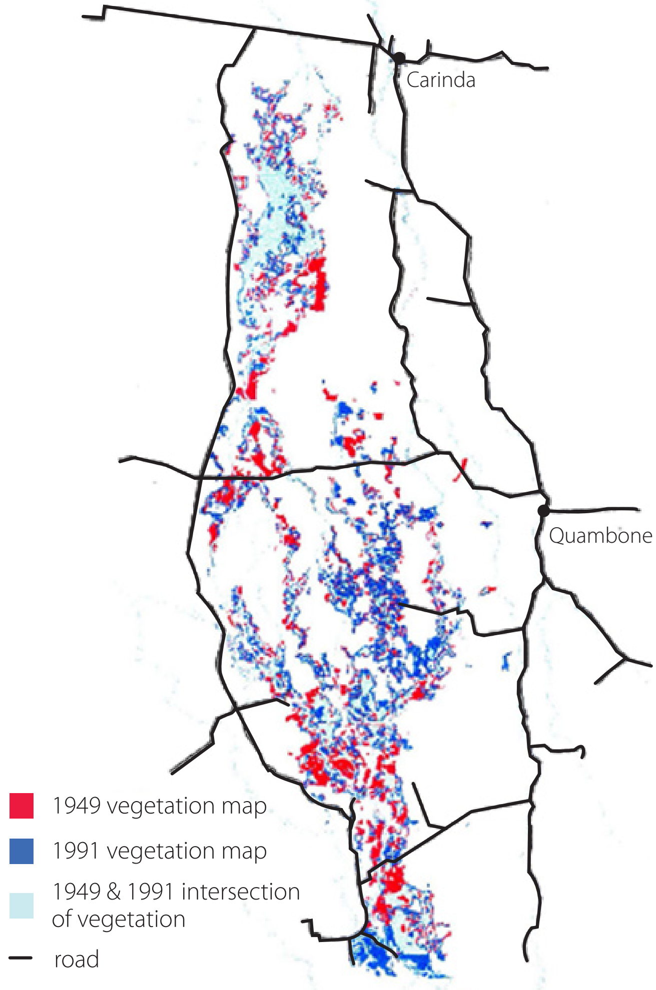
Local Water Manipulation and Grazing Impacts

Marebone Weir—New Wetlands Emerge

It seems clear that new wetland habitat has probably been created by the manipulation of water into the Gum Cowal–Terrigal Creek wetlands, on the eastern side of the floodplain, since 1979. See map 2.

Evidence for this conclusion comes from vegetation mapping comparing tree distribution in 1949 with 1991. It was found that extensive areas of new River Red Gums had grown along the waterways of the Gum Cowal, Long Plain Cowal, and Terrigal Creek over this period, while Black Box in this area had declined (REU 2000b). See Map 5.

Map 5: River Red Gum Distribution on Macquarie Marshes Floodplain—Comparison of 1949 distribution with 1991 distribution



Note the blue colour in areas where new River Red gums have grown between 1949 and 1991.

Source: REU 2000b

Locals suggest that, under natural conditions, the Terrigal Creek and Gum Cowal were generally dry, only filling during high flows in the river. They refer to the Marshes as the wetlands associated with the Macquarie River, including the current Nature Reserves, not the new wetlands now found on the Gum Cowal and Terrigal Creek. John F Egan is a third generation local resident of the South Marsh. In 1995 he wrote to the Department of Water resources: "The Macquarie River below Marebone is in a state of continual decline. This is a major area of concern regarding water quantity to the Marshes. Excessive amounts of water are being lost to the Marshes at the Reddenville and Marebone Breaks and at the Duffity regulator on the Gum Cowal". His letter explains that this water, which is now being diverted into the Gum Cowal, is "water that traditionally stayed in the river and ended up in the Marshes." (Egan 1995) Old parish maps held by the Department of Lands corroborate this suggestion. On the County of Gregory map 1920 (covering the South Marsh and Terrigal Creek areas), permanent wetlands along the Macquarie River are clearly marked, but no permanent wetlands are marked on the Terrigal Creek.

Marebone Weir was constructed on the Macquarie in 1977 (SWCA 2005) so that water could be diverted to properties along the Gum Cowal, Terrigal, and Marra Creeks for stock and irrigation. The tree distribution can be explained as a response to this diversion:

> The response of these two species (i.e. River Red Gum and Black Box) is consistent with more water being present in this zone in the period after 1949. The installation of Marebone weir at the south end of the Marsh in 1979[12] provided a capacity to divert flow from the Macquarie into the Gum Cowal–Terrigal Creek systems. It is possible that additional

12 Note: there is a small discrepancy in the literature as to the date of construction of Marebone Weir. It is possible that construction was completed in 1977, but due to the 1978 flood, the weir was not operational until 1979.

> water in this system (especially in-channel flow) has favoured the establishment of River Red Gum, to the detriment of Black Box, which cannot survive regular flooding.
>
> *(REU 2000b)*

See also Photo 12, which shows Black Box and Coolibah trees in the Terrigal Creek channel that have died from prolonged inundation.

These new wetlands have become the new breeding sites of colonial nesting waterbirds. The most important difference from the old sites is that these new sites are on private land. In the major waterbird breeding event of 2000–01, more than half of the colonial nesting waterbirds that bred on the floodplain bred in colonies located on the Terrigal Creek (see Map 10).

Management of Environmental Water

Environmental water was released in the drought years of 2002 and 2003 to water the core wetlands of the Macquarie Marshes. It was later found that a significant amount of this water had been diverted into the Terrigal Creek, impacting on the amount reaching the core wetlands.

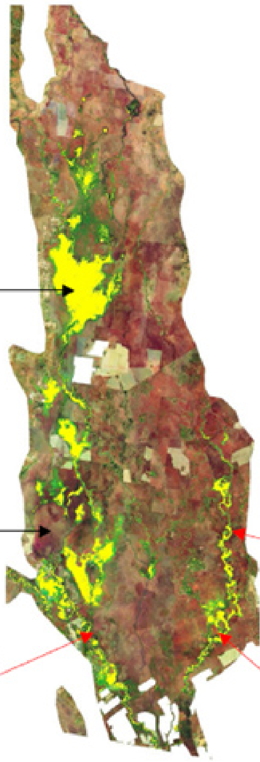
Since 2001 much of NSW has been experiencing drought conditions. In the Macquarie Marshes 'the impact of climate alone in the last three years (1/7/01 to 30/6/04) has been sufficient to make it the driest 3-year period on record for Marsh inflows. 2002/3 was the driest on record for Marsh inflows' (Love *et al.* 2005). More recently the inflow for 2004/05 was even lower, see Figure 2.

Environmental water was released in September 2002 with no triggering rain event, and in 2003 with a triggering rain event. Macquarie River Food and Fibre[13] (MRFF) commissioned maps of the areas inundated in the Marshes by these releases. The response of the vegetation to water post-release was measured and mapped (Button 2004). The purpose of the mapping was to better inform decision-making on environmental water releases.

The map of the 2003 environmental release showed a surprisingly significant response in the Gum Cowal/Terrigal Creek systems as a result of this release (see Map 6).

State Water information showed that environmental water had been actively diverted into this creek system. In 2002, 18 per cent of the environmental water released, or 12.2 GL, was diverted. In 2003, 27 per

Map 6: Vegetation Response to the Environmental Water Release 2003



Post-release imagery showing vegetation responding (yellow) to the 2003 release of environmental water in the Macquarie Marshes.

Source: Button 2004

Photo 5: Man Made Levee Bank in the Macquarie Marshes 2005.

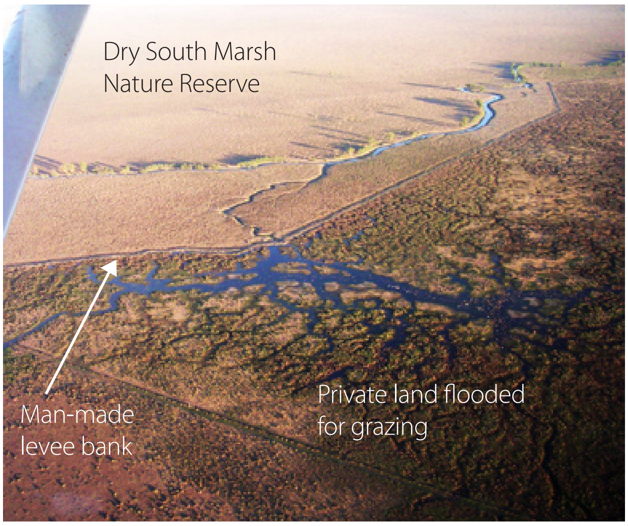


Photo taken by Chris Hogendyk.

13 This organisation represents the interests of the irrigation communities within the Macquarie Valley.

cent of the environmental water, or 15 GL, had been diverted into the Gum Cowal–Terrigal Creek system. This water does not benefit the Nature Reserve, and largely goes onto private land to irrigate pastures for grazing. Under the Water Sharing Plan rules, there is an allowance of 10 GL/yr from uncontrolled flows for the replenishment of this creek system (DLWC 2002).

Water Management on Private Land

Aerial photography has shown that an increasing number of banks are being constructed on the Macquarie Marshes floodplain to create irrigated pastures for grazing. These new wetlands will support an increasing number of cattle. Many of these levee banks are upstream of the South and North Marsh Nature Reserves. This has the effect of decreasing inflows into these reserves. Photo 5 is an aerial view of a man-made levee bank in the Macquarie Marshes that is trapping water and spreading it out to irrigate pastures for grazing. This bank is just upstream of the South Marsh Nature Reserve.

Colonially-nesting Waterbird Breeding in the Macquarie Marshes

Overall Trends

The Macquarie Marshes are an important nesting site for ten colonially-nesting waterbirds (Kingsford and Auld 2003).

In 2003, Birds Australia published *The New Atlas of Australian Birds* (Barrett *et al.* 2003). This contained the results of two comprehensive surveys of all Australian birds. The surveys were done 20 years apart, in 1977–81 and 1998–2002. It was hoped that any major trends in bird populations in Australia over this 20-year period could be detected by comparing these two 'snapshots' in time.

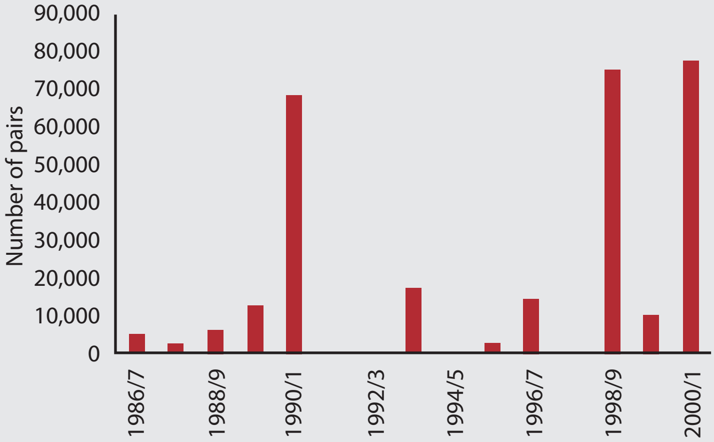
The reporting rate of nine of the ten colonially-nesting waterbirds increased within the Darling Riverine Plains Bioregion, which contains the Macquarie Marshes and the Gwydir Wetlands. This probably reflects the wetter climatic conditions in the second survey period. Australia-wide, the reporting rate of seven of the ten was stable, two decreased, and one increased (see Figure 6).

Figure 6: Reporting Rates of Colonially-nesting Waterbirds 1977/81 to 1998/2002

Colonial Nesting Waterbirds	Darling Riverine Plains Bioregion	Australia
Straw necked Ibis	Increase	Stable
Australian White Ibis	Increase	Stable
Glossy Ibis	Increase	Decrease
Little Pied Cormorant	Increase	Stable
Little Black Cormorant	Increase	Stable
Intermediate Egret	Increase	Increase
Cattle Egret	Stable	Stable
Great Egret	Increase	Stable
Little Egret	Increase	Stable
Rufous Night Heron	Increase	Decrease

Source: Barrett *et al.* 2003

Figure 7: Estimated Number of Breeding Pairs of Colonial Waterbirds in the Macquarie Marshes 1986/7 to 2000/1



Source: Kingsford and Auld 2003, page 14

Since 1995, it has been repeatedly claimed that waterbird breeding in the Macquarie Marshes is in serious decline (Kingsford and Thomas 1995; Kingsford and Johnson 1998; Trute 2005). However, quantitative monitoring of waterbird breeding in the Marshes from 1986 to 2002 gives a different picture. In this period, there were three major waterbird breeding events which corresponded with three major floods: 1990, 1998, and 2000. Each of these breeding events was larger than the one before. The greatest total number of breeding pairs was recorded in 2000 (Kingsford and Auld 2003). See Figure 7.

The spectacular breeding event of 2000 was also highly successful. It followed major flooding in November 2000. By January 2001, with large numbers of chicks in the nest, the water began to recede. A total of 45.5 GL of environmental water was delivered to the Marshes in January and February 2001 to successfully complete the breeding event (DIPNR 2001). This is an example of how river regulation can be used to benefit waterbird breeding in the Marshes.

Photo 6: Overgrazing of Reed Beds, May 2005

This photograph shows the boundary of the North Marsh Nature Reserve in May 2005. On the right of the fence is private land that has been grazed. Note the absence of reed beds on the grazed country. The dead trees in the Nature Reserve were burnt in a reed bed fire.

Colony Location Trends

Four maps showing the location of waterbird nesting colonies have been published since 1962, and they show a trend of colony movement out of the Nature Reserves and on to private land.

In 1962, Carrick mapped the known breeding sites of ibises within the Macquarie Marshes from 1948 to 1962. All the breeding sites mapped were along the Macquarie River and associated wetlands. See Map 7(Carrick 1962).

Brooker mapped prime waterbird breeding and feeding habitat in the Macquarie Marshes between 1977 and 1980 (Brooker 1992). Waterbird numbers and breeding activity peaked in the summer of 1978–79 following the 1978 flood. Again, the prime waterbird breeding and feeding habitat was mapped along the Macquarie River and associated wetlands. See Map 8. Brooker's mapping is likely to be accurate because researchers stayed at 'Sandy Camp' (near Quambone), consulted extensively with the local community, did aerial surveys on a fortnightly basis, and did monthly ground surveys of 53 sites during the breeding events. One of these sites was on the Terrigal Creek, and one was on the Marthaguy Creek nearby. Furthermore this was a joint project between CSIRO, DWR, and NPWS (Brooker 1992; Brereton 1994a; pers. comm. M. Brooker).

McGrath reported the locations of colonially-nesting waterbird breeding colonies in the Macquarie Marshes in 1989, again using aerial and ground surveys (McGrath 1991). He reported two new breeding sites on the Gum Cowal–Terrigal wetland system. (The Long Plain Cowal is part of this wetland system - see Map 9.)

Kingsford and Auld mapped the locations of colonially-nesting waterbird breeding colonies in 2000 (Kingsford and Auld 2003). Five of the twelve colonies mapped were in the Gum Cowal-Terrigal wetland system. (Map 10)

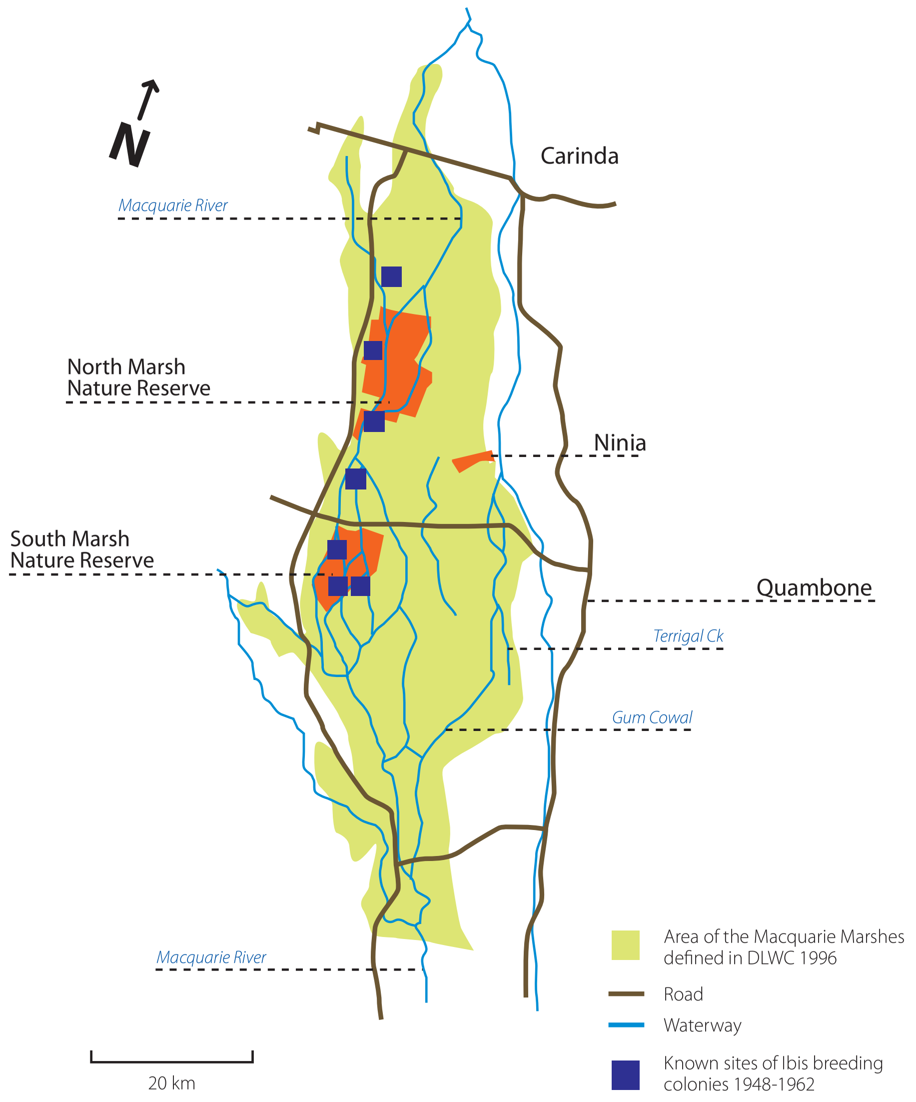
By comparing these four maps it appears that colonially-nesting waterbird breeding sites, originally found along the Macquarie River system and its associated wetlands, have extended to the new wetlands of the Terrigal Creek–Gum Cowal system over the last 20 years.

Colony Size Trends

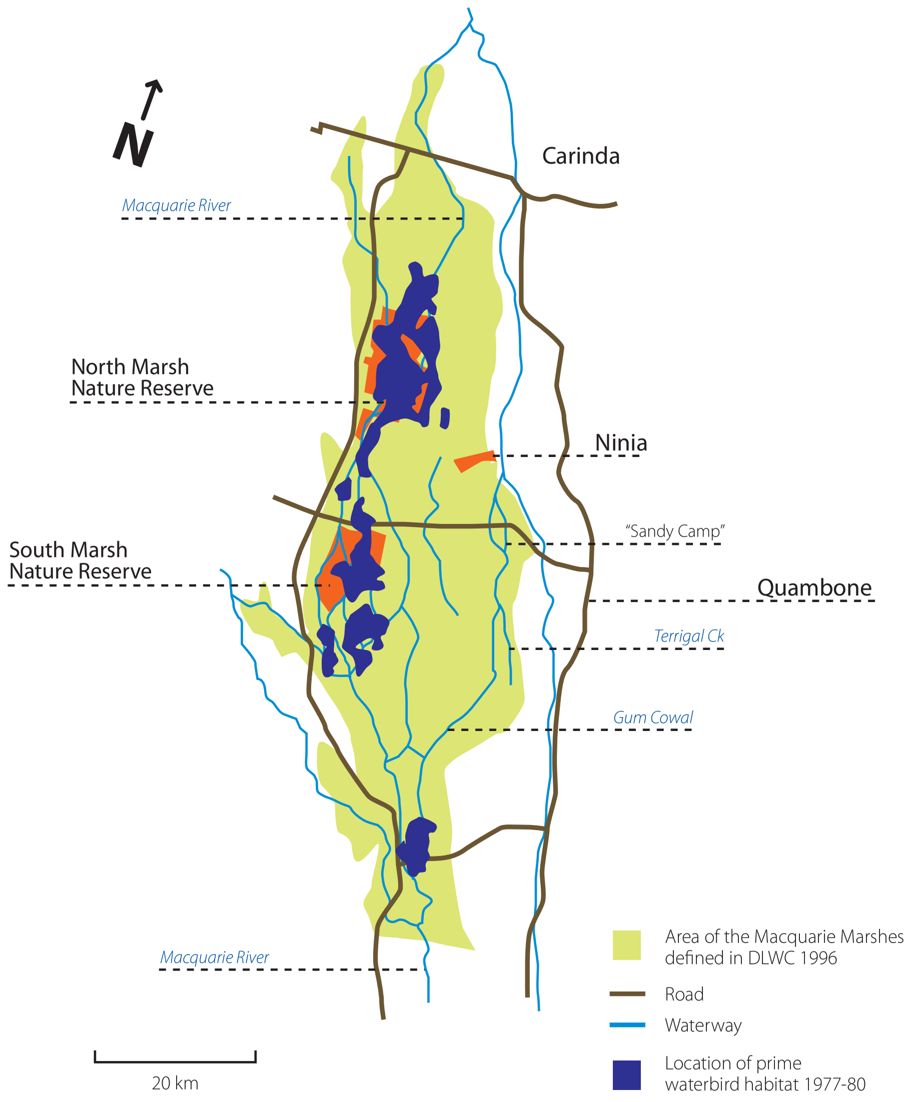
Kingsford and Auld recorded the details of colony size and location during waterbird breeding events between 1986 and 2001. Estimations from the graphs supplied show that the Terrigal system supported more than half the total number of nests in the Macquarie Marshes in 2000—that is, approximately 31,000 nests in the Terrigal system, and approximately 25,000 in the Macquarie system (Kingsford and Auld 2003, page 47). In 2000, ten of the twelve main breeding colonies were located on private land, and only two were within the Nature Reserve (see Map 10).

Colonies associated with the Terrigal–Gum Cowal wetlands showed a rising trend in colony size in successive breeding events over the study period 1986 to 2002. Some of the colonies associated with the Macquarie River wetlands showed a declining trend (Kingsford and Auld 2003, page 47).

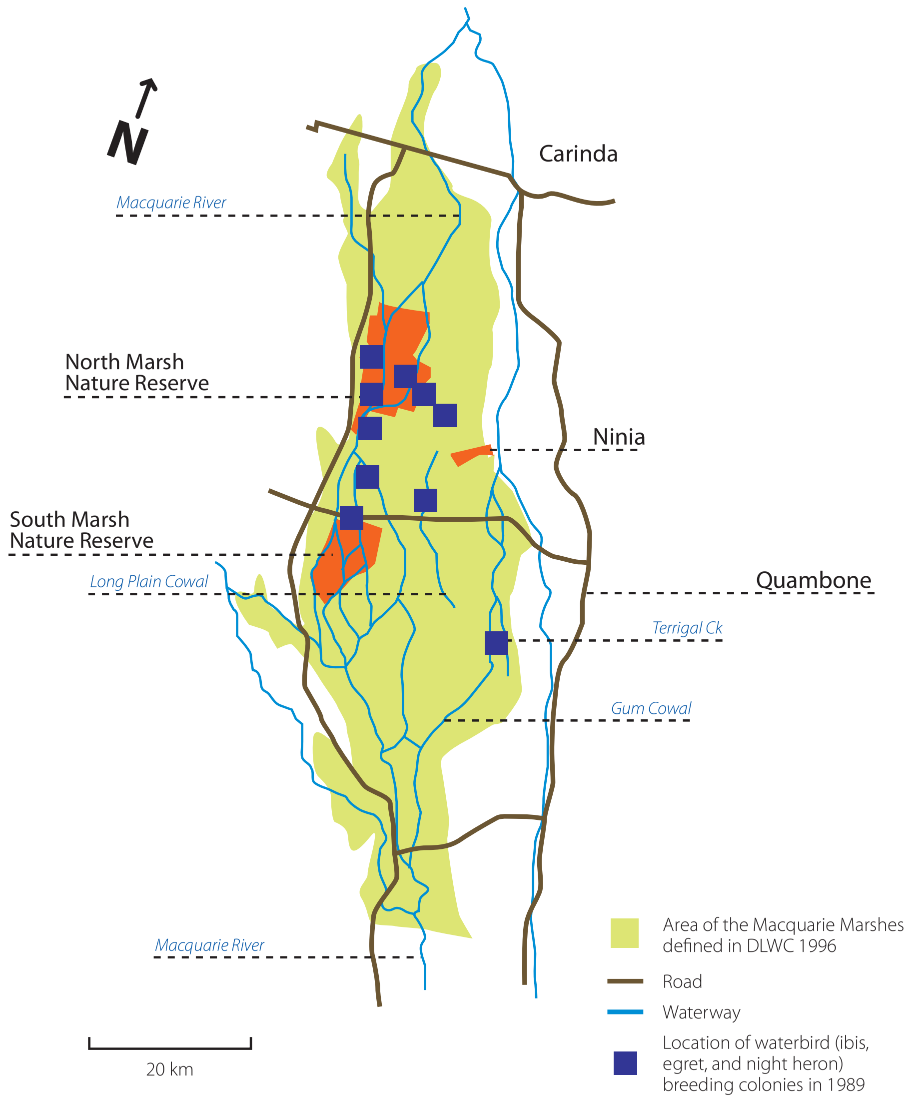
Map 7: Known Sites of Ibis Breeding Colonies 1948-1962 (from Carrick, 1962)



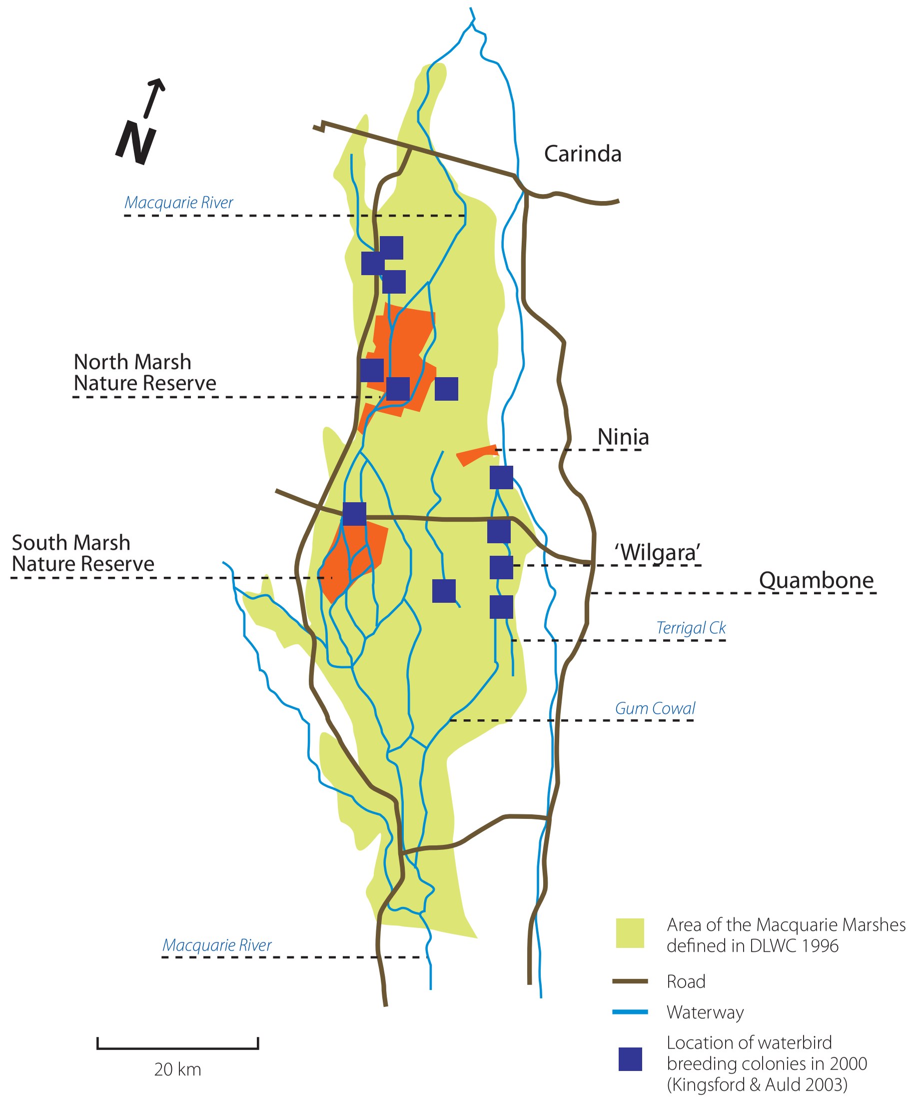
Map 8: Location of Prime Waterbird Habitat 1977-1980 (from Brooker, 1992)



Map 9: Location of Waterbird Breeding Colonies in 1989 (from McGrath, 1991)



Map 10: Location of Waterbird Breeding Colonies in 2000 (from Kingsford & Auld 2003)



There are no specific controls over the management of nesting sites found on private land in the Macquarie Marshes (DLWC and NPWS 1996). Such land is subject to the *Native Vegetation Act 2003*, as is all land in NSW.

The Importance of Nesting Vegetation Substrate

McGrath found that, in 1989, 'Almost all ibis were nesting in flooded lignum or phragmites. Straw-necked Ibises were exclusively in lignum. This highlights the significance of these vegetation types as nest substrates for ibises in the Macquarie Marshes' (McGrath 1991). During dry periods, overgrazing can seriously damage Common Reed (see photo 6), and young Lignum plants can be destroyed by grazing (Paijmans 1981). Lignum has also been cleared for cropping.

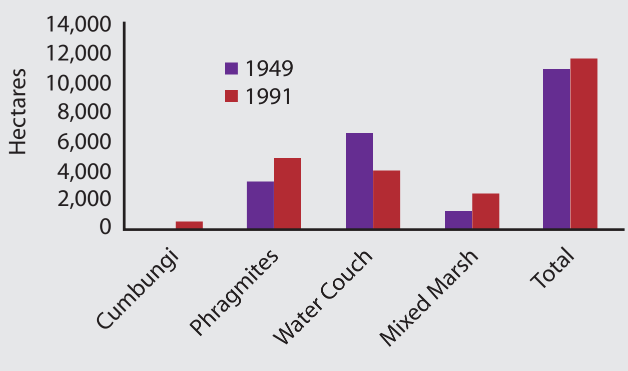
If nesting substrate were the limiting factor to waterbird breeding in the Marshes, one would predict a decline in the ibis species and an increase in the species that utilise River Red Gums for nesting over time. Australia-wide, the Macquarie Marshes are a most important breeding site for the Glossy Ibis *Plegadis falcinellus* and the Intermediate Egret *Ardea intermedia* (Barrett *et al.* 2003). The latter nests in living River Red Gums.

Birds Australia found a decline in Glossy Ibis and an increase in Intermediate Egrets Australia-wide over the last 20 years (Barrett *et al.* 2003). See Figure 6.

Long-term Vegetation Trends

It has been claimed that the Macquarie Marshes have declined in area by at least 50 per cent (Kingsford 2004). However the area of permanent wetland vegetation increased by 6 per cent over the 42-year period from 1949 to 1991, according to DLWC vegetation mapping (Brereton 1994a) See Figure 8. The vegetation mapping covered an area of 86,750 ha and included both North and South Marsh Nature Reserves and private wetlands along the Macquarie River. The increase had mainly occurred in the North Marsh, while the South Marsh declined (Brereton 1994a).

Figure 8: Area of Permanent Wetland Vegetation types in the Macquarie Wetlands 1949 vs 1991



Source: Brereton 1994a

The causes of the overall increase could be a combination of wetter climatic conditions, more regular inflows after the construction of Burrendong Dam, and local water-ponding against the North Marsh Bypass Channel. This channel was constructed in 1972 to deliver water to users downstream of the Marshes (Brereton 1994a). See Figure 1, which shows that climatic conditions were much wetter in the second half of the 20th century than in the first.

The mapping showed that all types of permanent wetland vegetation increased in area with the exception of Water Couch, which declined by 40 per cent (Brereton 1994a). See Figure 8.

It is highly probable that overgrazing caused the decline in Water Couch. Water Couch is 'an important vegetation type for graziers and feeding of waterbirds' (Brereton 1994a). Water Couch is a perennial summer-growing grass that is highly palatable to cattle (Cunningham *et al.* 1981). Its distribution will be influenced by the grazing pressure and the availability of moisture in the seasons preceding mapping. In the Macquarie, 1988, 1989 and 1990 were all wet seasons, with major flooding in 1990. Therefore, moisture would be unlikely to be the factor limiting Water Couch distribution in this study. Grazing was permitted in the Nature Reserves until August 1990. Water Couch can grow in dense mats along the edge of shallow, still, or running water, and in this way protects against erosion (Cunningham *et al.* 1981). Photos 7 and 8 illustrate the impact of grazing on Water Couch in a shallow waterhole near Trangie, NSW.

The Impact of Grazing

In 1996, the Macquarie Marshes Catchment Committee began work on a Land and Water Management Plan for the Macquarie Marshes. There was little available data on the impacts of grazing

Photo 7 & 8: The Effect of Grazing on Water Couch in the Goan Waterhole, Trangie, NSW 2004

These two photographs show the same waterhole on the same day. Part of the waterhole has been fenced off from stock. Top photo grazed, bottom photo ungrazed

Photo 9: The Effect of Overgrazing on the Macquarie Marshes, 2002

This photograph was taken at the height of the drought in 2002. It was first printed in Australian Geographic, *March 2005. It shows the boundary between private land (grazed) on the left and the North Marsh Nature Reserve (ungrazed) on the right. Permission to use this photograph has been obtained.*

on the Macquarie Marshes, so the Committee commissioned consultant Geoff Cunningham to carry out a study of grazing practices in the Marshes floodplain area. Cunningham concluded that 'it would be impossible to conclusively and unequivocally state that the grazing industry is sustainable in the long term' (Cunningham 1996). However, this study has been widely quoted as supporting the idea that grazing is not affecting the Macquarie Marshes, for example the Management Plan cites Cunningham when stating that 'existing grazing practises do not appear to have a significant impact on the planning area' (MMCC 1997). Photo 9 illustrates that overgrazing can have an enormous impact on the Macquarie Marshes wetland vegetation in dry times.

Cunningham found that there were no long-term vegetation monitoring sites, so his study took the form of a survey of the grazing practices of 27 marsh graziers. The survey found that 85 per cent of marsh graziers were of the opinion that grazing had little impact on the Marsh vegetation. The other 15 per cent raised issues of 'cattle pugging up damp soil, pushing over tree saplings, making pads through reed beds, reducing vegetation in wetlands,' and that on the higher country grazing had destroyed saltbush communities (Cunningham 1996).

Cunningham found that stocking rates on the majority of vegetation types were between 0.7 and 2 DSE/ha, however wetter River Gum/Water Couch grasslands were stocked at 1.7–12.4 DSE/ha, and Reed Beds at up to 25 DSE/ha (Cunningham 1996). Although the survey provided a number of best-management practice recommendations, it did not explore the impacts of current grazing practices on the wetland.

In 2006 Shelly compared grazed with ungrazed vegetation on some dryland (rarely flooded) sites in the Marshes. He found that ungrazed sites had significantly greater ground cover and plant diversity than grazed sites (Shelly 2007).

The long-term cumulative effects of grazing in the Marsh wetlands during repeated or extended dry periods have not been investigated. Lance Peacocke observed and raised the issue of overgrazing during his tenure with the Lands Department (Peacocke 1943). A CSIRO vegetation study in 1981 concluded that: 'Within the Nature Reserve, River Red Gum forests and some of the herbaceous swamp communities are in danger of permanent damage through overstocking with cattle. Major areas of wetland outside the Reserve are unprotected' (Paijmans 1981, page 13).

To date there has been no attempt to determine the effect of grazing during the current drought on the nesting sites of colonially breeding waterbirds that are situated on private land.

Photo 10: Dead trees in reed beds on private land, South Marsh, November 2005

Photo 11: Dead Trees, unknown cause, on private land, Macquarie Marshes, 2006

Photo 12: Dead trees on private land in the Terrigal Creek channel, Macquarie Marshes, 2005

Dead Trees in the Marshes

Dead trees are a feature of the Macquarie Marshes today (see Photos 10, 11, and 12). Those scattered throughout the core marsh reed beds have probably been drowned (Brander 1987; DLWC 2000) or burnt in reed bed fires. Others have been ringbarked (DLWC 2000), or poisoned (pers. comm. D. Shelly DNR).

Coolibah and Black Box trees have also died from drowning in areas where water manipulation has resulted in increased inundation. See Photo 12.
More recently, some River Red Gums in the North Marsh have also died, possibly due to salinity (see Chapter Five: River Red Gum Dieback).

The South Marsh—A Seriously Degraded Wetland

When cattle graze reeds heavily during dry times, they create pathways or pads through the reed beds. See Photo 13. Water follows these pathways when the next flow occurs, creating channels. Over time, the channels erode, deepening and widening due to the continual removal of vegetation by grazing, and trampling of the channel edges. In time, a deep channel passing through a wetland acts as a drain, preventing overbank flooding. Consequently the permanent wetland vegetation suffers from lack of flooding, and the wetland degrades.

The Monkeygar Creek is the main water supply for the reed beds of the South Marsh Nature Reserve. Lance Peacocke first noted erosion of the Monkeygar Creek in 1949 (Brereton 1994a). In 1987, Brander was the first to measure this erosion, by comparing the size of the channel with measurements taken 19 years earlier in 1968 (Brander 1987). By 1992, three times the flow required in 1968 to cause overbank flooding was required to create flooding from the Monkeygar Creek. This was due to the progressive deepening and widening of the channel, which had begun prior to the 1950s (Brereton 1994a). A new avulsion, 'the Breakaway', had also commenced in the 1960s (Brander 1987) and was complete by 1998 (DNR advice).

A number of factors have been suggested as the cause of the erosion, including overgrazing, continuous regulated flows, and carp. Brander found that continuous low flows were probably not the main cause of the erosion (Brander 1987). Paijmans found 'A more obvious threat to the ecology of the Marshes (than the effects of Burrendong Dam) is the large number of cattle and sheep grazing in the Marshes. Damage caused by trampling is most apparent in times of drought, when

Photo 13: Cattle pads through reed beds in the Macquarie Marshes. Note the trampling and erosion of the channel edge.

cattle congregate on the few wet areas where green feed is still available' (Paijmans 1981, page 13).

In 1987, Brander studied the Monkeygar Creek by canoe, and commented on the effect of cattle on the channel: 'In many places along the creek low vertical banks had been completely flattened due to trampling' (Brander 1987, page 59). In 2000, researchers on private land near the South Marsh observed 'uncontrolled stock access along most stream reaches in the Southern Macquarie Marshes is a highly visible contributor to bank erosion' (REU 2000c, page 16).

During the wet 1970s, the reed beds of the South Marsh appeared to stabilise, and even increased slightly in area. This occurred despite rapidly worsening erosion of the Monkeygar Creek (Brander 1987). However, reed-bed mapping in 1981 (Paijmans 1981; Brander 1987) compared with 1991 (DNR vegetation map 1991) showed that they declined again in the drier 1980s.

In the 1980s, a large levee bank was built on private land upstream of the South Marsh Nature Reserve (DNR advice). This structure was built to control erosion of the associated wetland on private land, but also appears to hold water out of the Nature Reserve. (See Photo 5.)

In 1997, four small erosion control structures were built in the South Marsh Nature Reserve, and three on private land near the South Marsh boundary (REU 2000c). In 2002 an additional five rock walls were placed in "The Breakaway" in the South Marsh in an attempt to control erosion (NPWS 2002). To date these structures appear to have had limited success in reversing the erosion problems in the South Marsh. More recent vegetation mapping than the 1991 map is needed to assess the effectiveness of these structures. Much larger structures with levee wings have been successful in halting erosion and causing overbank flooding on private land nearby.

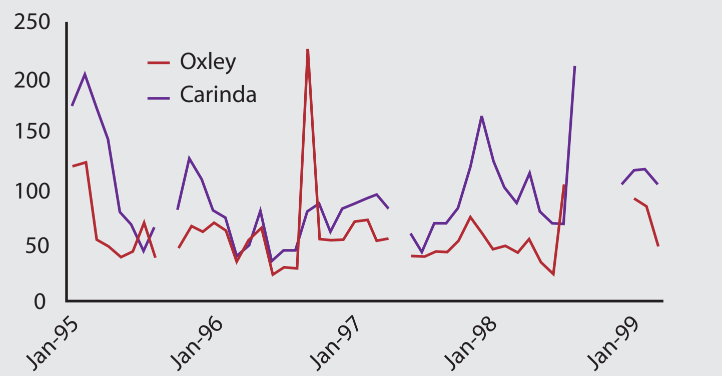
The South Marsh Nature Reserve was classified as prime waterbird breeding and feeding habitat up until 1980 (see Maps 7 and 8). It had no significant colonially-nesting waterbird breeding in 1989 or 2000 (see Maps 9 and 10). In 2000, the Riverine Environment Unit described the South Marsh as a 'seriously degraded wetland' (REU 2000c).

Water Quality

Following an outbreak of blue-green algae in the Darling River in 1991, the Department of Water Resources carried out comprehensive water quality monitoring throughout the Darling catchment in 1993–4 (DWR 1994).

It was found that the total phosphorus concentration in water sampled at Carinda, downstream of the Marshes, was greater than at Oxley, just upstream of the South Marsh. The report highlighted 'the fact that Carinda had the highest phosphorus concentrations in the Macquarie Basin during 1993/94 came as rather a surprise, since it had been expected that passage of water through the Marshes would have reduced nutrient concentrations in the River' (DWR 1994). This increased nutrient load was not correlated with an increased turbidity. The report concluded a need 'to investigate the effect of the Macquarie Marshes on nutrient loads coming out of the Macquarie Basin' (DWR 1994).

Figure 9: Total Phosphorous (mg/l) in Water at Carinda vs Oxley 1995 to 1999



Source: DNR 2005a

Figure 9 shows the total phosphorus concentrations in water samples collected from Oxley and Carinda between 1993–1999. There is a consistent trend of higher total phosphorus concentrations at Carinda when compared with Oxley (DNR 2005a). No investigations have been made into the cause of this anomaly.

Photo 14: Stressed River Red Gum trees, North Marsh, May 2005

Photo 15: Bora Channel, North Marsh, May 2005

Emerging Environmental Problems—Salinity and Dieback

Salinity

Shallow saline groundwater has been known to exist beneath the Macquarie Marshes, especially the North Marsh, from earliest settlement. Many of the wells dug in the North Marsh produced brackish water, and some were abandoned, as the water was too saline (Masman and Johnstone 2000). NPWS officers noted the increasing appearance of surface salt crystals in the North Marsh in 1992 (TEC 2002).

In 1992, DLWC officers placed 79 piezometers throughout the Macquarie Marsh floodplain (Brereton 1994b). Piezometers measure the depth and chemical composition of groundwater. This 'identified an area of 2,600 ha of shallow saline watertables outside permanent lagoon areas in the Northern Marshes' (Brereton 1994b). The salinity of the groundwater ranged from 9 dS/m to 45 dS/m. By comparison, seawater has a salinity of 55 dS/m, indicating that the groundwater under the North Marsh is highly saline in some areas.

River Red Gum Dieback

The River Red Gum is a common tree throughout western NSW. It requires flooding to establish, and is always found in association with watercourses and wetlands (Cunningham *et al.* 1981). It can withstand prolonged periods of drought and saline conditions not tolerated by other species. However, it will not flourish under such conditions, instead surviving them by shedding leaves (Cunningham *et al.* 1981; Sinclair, Knight and Merz 2001).

The Macquarie Marshes Plan of Management 1993 noted that some areas of the River Red Gum forest in the North Marsh were suffering from declining health, or 'dieback'(NPWS 1993). The Plan placed a priority on mapping the area of unhealthy trees. No such mapping has been done so far.

However, preliminary investigations were carried out into the cause of tree health decline in 1994–95 (Bacon 1996). Unhealthy trees were found to be utilising a much greater proportion of their water requirements from the highly saline groundwater, measured at 24-29dS/m. Dr Bacon reached the conclusion that the trees were suffering from a decline in surface flooding that would leach salts from the soil (Bacon 1996).

Despite extensive surface flooding in both 1998 and 2000, tree health continued to decline. In 2004, the Macquarie Marshes Management Committee (MMMC) alerted the media to a 300 ha patch of River Red Gums in the North Marsh that were severely stressed, many having died, see Photo 14. These trees were in a different area from the monitoring sites set up by Bacon. The MMMC called for an immediate release of 100GL of water from Burrendong dam. Dr Bacon was called in to confirm that this was required, which he did (Bacon 2004). He did not measure soil salinity in 2004, so a comparison could not be made with his 1994 measurements.

Diversion by upstream irrigators was blamed; however minimal water was allocated for irrigation in the Macquarie Valley throughout the drought. Allocations for irrigation prior to cotton planting (September) were 0 per cent in 2002, 19 per cent in 2003, 2 per cent in 2004, and 1 per cent in 2005 (DNR 2005b). Most of the water used for irrigation in 2001/2 and 2002/3 was carryover water stored in the dam from 2000/1. See Figure 2.

Locals have raised the question of the role of salinity in this problem. River Red Gums in the North Marsh are dependent on surface flooding to leach salts from the soil (Bacon 1996). In dry seasons, soil salinity increases as capillary action brings salts from saline groundwater to the surface. Tree health therefore depends on groundwater levels dropping rapidly during dry seasons. Anything that prevents or slows this rapid fall in groundwater levels will create salinity problems.

The Bora channel, a major channel within the North Marsh, flows through the middle of the dieback area, and was flowing throughout the drought, see Photo 15. Under natural circumstances, the North Marsh would be expected to dry out completely in a major drought.

The Bora channel has been taking an increasing percentage of the flow through the North Marsh since the 1980's, according to Department of Water and Energy flow data. This is due to erosion at its bifurcation with the Macquarie River channel, which feeds the North Marsh reed beds. As a result these reed beds are losing surface flooding.

Locals ask: could the constant flows in this channel be leaking into the groundwater? Has the clearing of thousands of hectares of trees in the 1960s and 1970s in the vicinity of the North Marsh changed the level of the groundwater? Could tree death during droughts in some areas, and regeneration during floods in others, be part of the natural dynamics of this wetland?

All these questions remain unanswered and uninvestigated. Clearly, there is a need for a thorough investigation into the surface water/groundwater/salinity dynamics of this wetland.

Conclusion— Towards a solution for the Macquarie Marshes

The Macquarie Marshes are suffering from a complex range of land degradation issues, for which there is no quick or simple solution. Success will be achieved by remaining objective and including a range of actions in the recovery plan.

Private land with significant wetlands should be purchased from willing sellers. This land should be actively managed for conservation outcomes, with important waterbird rookeries prioritised.

The ongoing problems of levee bank construction and local water manipulation need to be solved. This would mean that environmental water could be better targeted to significant wetlands.

Water purchase should be one component only of a recovery plan. Without solving other problems, simply buying water to increase flows to this wetland will have the negative result of increasing the cattle population and therefore the grazing pressure on the vegetation.

Research should be directed towards understanding salinity/groundwater/surface water interactions, addressing water quality questions, and measuring sedimentation. There should be ongoing monitoring of vegetation responses to any initiatives.

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Note some name changes to NSW Government Departments:

- Department of Water Resources (DWR) changed to Department of Land and Water Conservation (DLWC) changed to Department of Infrastructure, Planning and Natural Resources (DIPNR) changed to Department of Natural Resources (DNR) currently Department Water and Energy (DWE).
- National Parks and Wildlife Service (NPWS) changed to Department of Environment and Conservation (DEC) currently Department of Environment and Climate Change (DECC).

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