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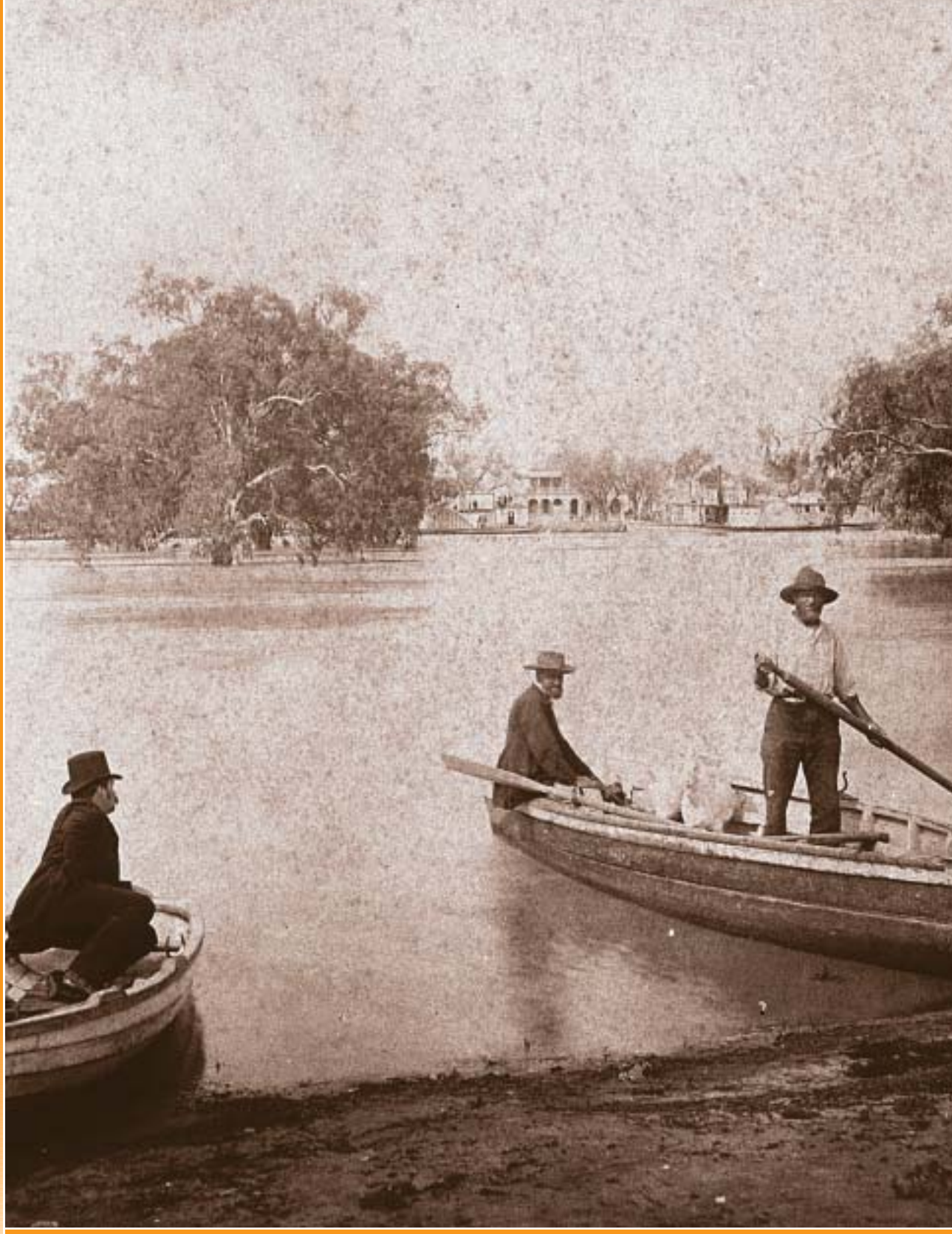

Settlement, erosion and muddy waters

LESSONS FROM THE PAST

Anthony Scott and Jon Olley

MURRAY-DARLING BASIN COMMISSION

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Anthony Scott and Jon Olley
CSIRO Land & Water

Authors: Anthony Scott and Jon Olley
CSIRO Land & Water

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Level 5, 15 Moore Street
Canberra ACT 2600

Telephone: (02) 6279 0100
from overseas + 61 2 6279 0100
Facsimile: (02) 6248 8053
from overseas + 61 2 6248 8053
Email: info@mdbc.gov.au
Internet: http://www.mdbc.gov.au

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Foreword

Moving towards the sustainable management of the natural resources of the Murray-Darling Basin requires a clear understanding of the complex set of factors that shape the natural and cultural environment of the Basin.

As our knowledge of surface drainage, erosion and groundwater flow systems becomes more sophisticated, natural resource managers are seeking to better understand the cultural, economic and social forces that shape our impact on the Basin's natural resources.

This report presents an overview of how settlement and agricultural development have changed the landscape of the Basin over the past 200 years.

This document draws on two CSIRO Land and Water technical reports and presents an historical overview of the major events that caused soil and stream bank erosion over the past two centuries.

This historical review illuminates how economics, limited scientific knowledge, exotic pests, climate variability and government policy have compounded to initiate major erosion events that have re-shaped the Basin landscape.

Importantly, the report argues that we have found a new equilibrium, with the overall rate of erosion declining over the past 50 years. However, this still leaves erosion rates many times higher than those prior to settlement and development of the Basin.

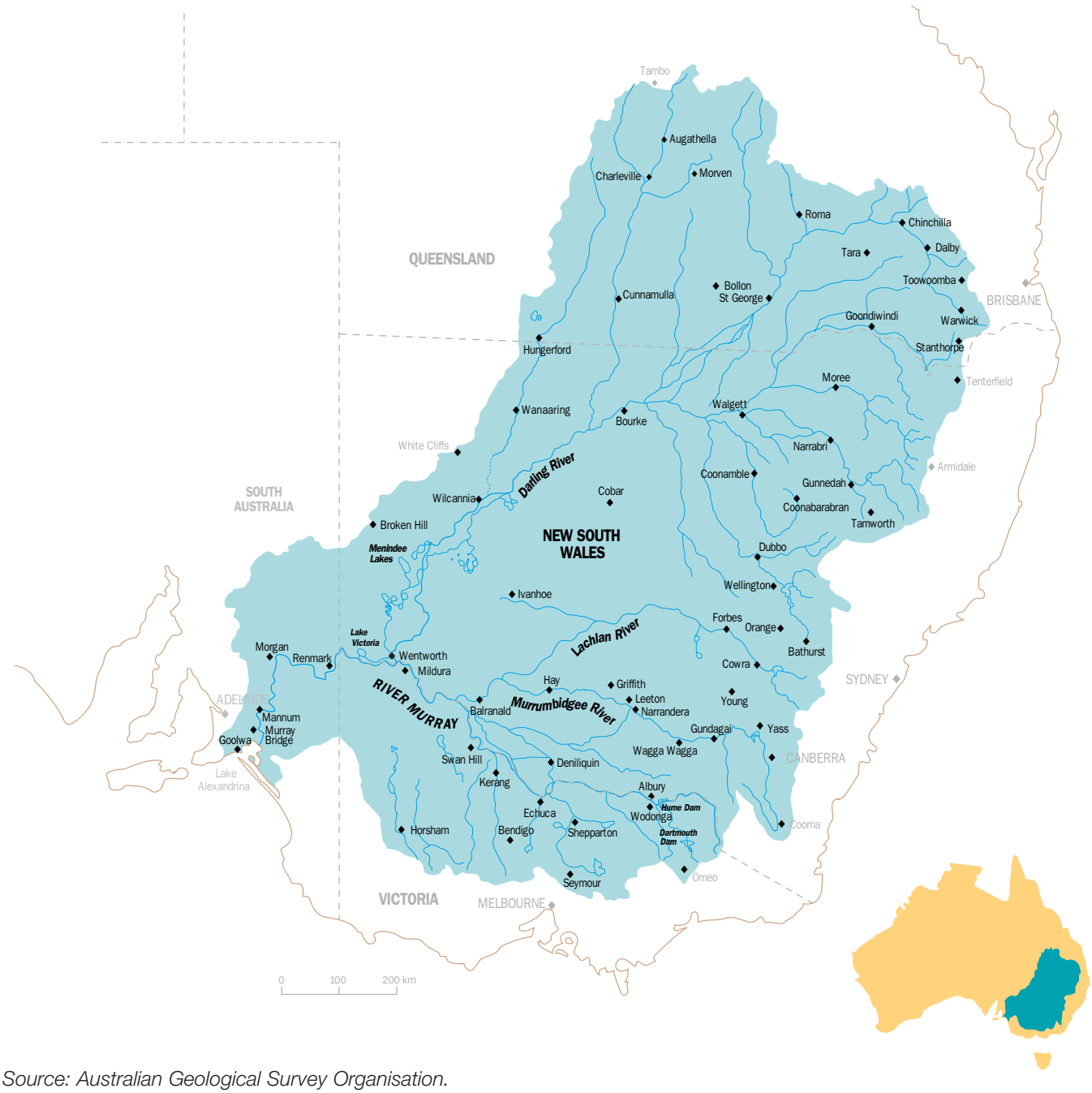
Researchers, land managers and policy makers will find this report a valuable summary of the history of the Basin and the forces that have changed the Basin landscape. The legacy of the past 200 years will continue to have a profound influence as the Basin community works towards achieving sustainable natural resource management in the future.

Scott Keyworth
Director, Landscapes & Industries Program
Murray-Darling Basin Commission

The Murray-Darling Basin

The Murray-Darling Basin is the catchment for the Murray and Darling Rivers and their many tributaries. Extending from north of Roma in Queensland to Goolwa in South Australia, and including three quarters of New South Wales (NSW) and half of Victoria, it is the heartland and the economic powerhouse of rural Australia.

It extends across one-seventh of the continent and has a population of nearly two million people. Another million people outside the region depend heavily upon its resources.



Source: Australian Geological Survey Organisation.

Introduction

It is said that those who can't learn from the past are forced to repeat it. Soil erosion costs Australia about $500 million every year in lost agricultural production and associated effects on water quality. A significant proportion of this cost is from the Murray-Darling Basin. Much of the erosion we see today commenced over 200 years ago when European settlers started farming the land.

Today, in many areas of the Basin, soil erosion and its effects on our rivers are evident to even the most casual of observers. This includes extensive gully networks, exposed subsoils, dirty waters, dams filled with silt and river beds drowned in sand.

In the words of Henry Bolte, (1949) Premier of Victoria:

"We could not have made a bigger mess of the soil of the country if its destruction had been carried out under supervision."

This booklet summarises two reports which examined the cause and effect of soil erosion in the Basin over the last 200 years and looks at the lessons we can learn from the past.

The muddy waters of the Goulburn River, Victoria. Photo: Anthony Scott.

Large quantities of sand deposited in the Murrumbidgee River at Tharwa. Photo: Anthony Scott.

Sheet and rill erosion associated with a salt scald in Gunning, NSW. Photo: Nicki Taws.

Prior to European settlement

Evidence uncovered at Lake Mungo in south-western NSW suggests that Aboriginal people have lived in the Basin for at least 40,000 years, or more than 1,000 generations. Their total population was relatively small and sparsely settled, and as subsistence hunter-gatherers, their overall impact on the environment was minimal.

Their biggest impact was to change the fire regime, from one of rare, high-intensity natural fires to one of more frequent low-intensity fires. These fires were used to flush out animals while hunting and to encourage new growth of grass, which would attract kangaroos and other grazing animals. The frequent, low-intensity fires allowed a quick recovery of vegetative cover and the effects on erosion were minimal.

> ... detailed studies of historical evidence indicate that the continuous networks of deeply eroded gullies now found in many catchments of the Basin, were not present prior to European settlement.

Descriptions of the Murray-Darling Basin at the time of European settlement are recorded in the journals and diaries of the first explorers and settlers, and also in the reports and maps of government surveyors. Essential to their survival was the availability and permanence of water, and hence their records provide detailed descriptions of the rivers, streams and waterholes. These descriptions provide evidence of what they looked like prior to the introduction of the pastoral and agricultural activities of the first settlers.

Early reports indicate that the broad valleys in upland regions often contained swampy meadows and chains of ponds. Due to the high efficiency of these areas as sediment traps, sediment transport in these systems would have been inefficient with flood waters spreading out across the valley floors.

In drier areas along the western slopes, valleys often contained channels which were dry for most of the year, linked to deeper water holes. Some larger streams had well defined channels and a semi-permanent flow of water during wetter periods. In the drier semi-arid regions throughout the western half of the Basin, flow was highly erratic and drainage lines consisted of shallow meandering sandy streambeds bordered by trees.

Most importantly, detailed studies of historical evidence indicate that the continuous networks of deeply eroded gullies, now found in many catchments of the Basin, were not present prior to European settlement.

Inland Rivers

The journals of the first explorers and settlers also provide quite detailed descriptions of the inland rivers, including information on aquatic life, river vegetation and water quality. In these reports there are quite frequent descriptions of cobble and gravel bedded rivers with clear flowing water. This indicates that in many of the rivers the supply of fine suspended sediment was limited, and sediment transport generally exceeded the supply of sand and mud. For instance Sturt, in 1829, described the waters of the Murrumbidgee River at Jugiong, NSW, as *"hard and transparent"* and for the Murray River where it joins the Murrumbidgee, he reported that, *"its transparent waters were running over a sandy bed."*

The Lachlan River, however, is one river which appears to have always been more turbid than most. Oxley refers to this in 1818 when he compares the Macquarie River as being:

"in every respect different from the Lachlan; its waters are pure and transparent." The Darling River was also often described as muddy. In 1829 Sturt compared the Murray and Darling Rivers at their junction:

"There was as distinct a line between their respective waters, to a considerable distance below the junction, as if a thin board alone separated them. The one half of the channel contained the turbid waters of the northern stream, the other still preserved their original transparency."

Although many of the reports by early explorers and settlers indicate that the rivers of the Murray-Darling Basin were less muddy than in present times, heavy rainfall could quickly change their appearance, as Oxley discovered when camping on the banks of the Castlereagh River in 1818:

"The river during the night had risen upwards of eight feet; and still continued rising with surprising rapidity, running at the rate of from five to six miles per hour, bringing down with it great quantities of driftwood and other wreck. …. The water was so extremely turbid, that we could not use it; but were forced to send back to the marshes for what we wanted. .... Now the quantity of matter is astonishing, and such as must take some years to remove."

... the journals and diaries of the first explorers and settlers ... provide evidence of what drainage lines looked like prior to the introduction of the pastoral and agricultural activities of the first settlers.

Prior to European settlement many of the rivers within the Murray-Darling contained less turbid water, due to the lower supply of fine sediment from the upper catchments. Most of the rivers also contained numerous freshwater fish, a good indication of a healthy aquatic environment.

In pre-European times many streams in the Southern Tablelands contained chains of ponds similar to this. Photo: Ian Prosser.

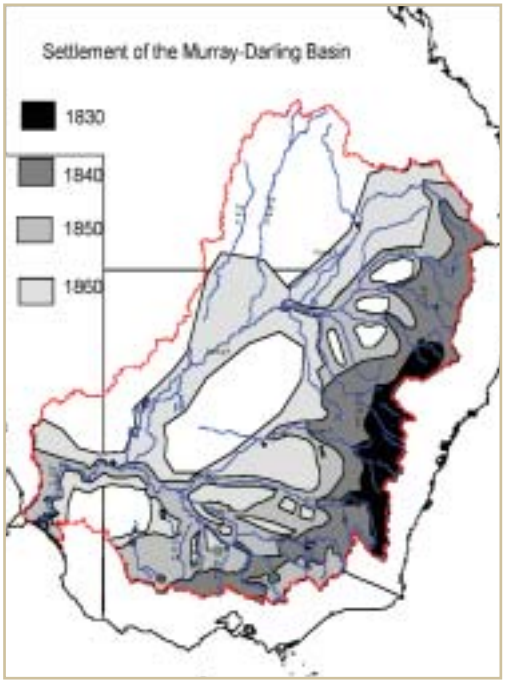
Explorers and squatters

Although the First Fleet arrived at Port Jackson (Sydney) in 1788, it was not until 1813 that the explorers Blaxland, Lawson and Wentworth crossed the Blue Mountains and established a gateway to the interior of New South Wales.

Initially, settlers were slow to follow in the footsteps of these explorers, and in 1819, there were only about eight settlers in the Bathurst district, along with 24 flocks of sheep and about 1,400 head of cattle. By the 1820s, however, explorers such as Hume and Hovell, Cunningham and Sturt were discovering new lands to the south, west and north of Port Jackson, and settlers were following soon after. The pastoral expansion of the colony had commenced.

This phase of exploration and settlement expanded rapidly in the 1830s, with Thomas Mitchell conducting expeditions into the north-west of NSW in 1831 and 1832, and then in 1836 travelling through south-west NSW and into western Victoria. Within months of Mitchell's return, squatters with large herds of cattle and flocks of sheep followed his tracks to the new pastoral lands. By 1840, squatters had established themselves in a continuous belt from Port Phillip in the south, sweeping up between the Lachlan River and the coast, to the Darling Downs in the north.

> By 1850 there were more than 12 million sheep grazing the whole of south-eastern Australia ... and the first signs of landscape change were observed.



Settlement of the Murray-Darling Basin from 1830 to 1860. Source: CSIRO.

In 1821 NSW had only 139,000 sheep, essentially producing meat for a restricted local market, but by 1850 there were more than 12 million sheep grazing across south-eastern Australia. This expansion required little capital apart from livestock itself. Land cost either nothing or a nominal amount for a lease, instead of building fences shepherds were employed, and accommodation was primitive. Initially there was ample land and the runs must have been lightly stocked. However, stock numbers increased rapidly and the first signs of landscape change were observed.

The pastoral system meant that up to 2,000 sheep were gathered together each night, on an area rarely exceeding a hectare, for several nights at a time. This created severely trampled and bare areas of one or two hectares in extent. Cattle were not held in closely bunched herds, and therefore generally spread out more than sheep. However, the cattle tended to feed along the moister valley floors where disturbance to sensitive vegetation in swampy meadows and along streamlines was greatest.

The gold rush era

In 1851, Edward Hargreaves discovered gold in a creek at Ophir, not far from Bathurst, NSW. This led to a rush and when gold was discovered at numerous sites in the uplands and slopes of NSW and Victoria, tens of thousands of people flocked to these goldfields, hoping to make their fortune.

The mining activities and associated settlements quickly degraded the streams and surrounding countryside. The initial phase of mining involved individuals or small groups digging and washing soil from shallow alluvial deposits along rivers and streams. This required a great deal of water to sort the gold from the washdirt using small wooden puddling tubs, cradles and pans.

Later, horse-driven puddling machines were introduced wherever a sufficient water supply was available. The creek beds were often so ravaged that the evidence can still be seen today. In some instances the entire stream was diverted so that the sediment in the stream bed and banks could be processed more easily. Beautiful valleys were stripped bare of soil, which was processed in the puddlers and then flushed downstream. Vast quantities of sludge moved down the valleys, frequently blocking the natural watercourses and depositing on the lower floodplains.

Where the source of gold was traced to underlying rocks, companies were formed to sink deep shafts. The underground mining industry produced huge quantities

A miner sluicing for gold along a creek in the Castlemaine district in 1894. Photo: Reproduced courtesy of Museum of Victoria.

of waste and sludge which flowed into nearby streams.

Gold mining also created a huge appetite for timber, and the surrounding forests rapidly disappeared. Initially timber was used for firewood and for building shelters, but when underground mining commenced in the 1860s, timber was also needed as boiler feed and as props in mineshafts. Throughout the gold mining districts, particularly Central Victoria, hundreds of square kilometres of forest disappeared, leaving the fragile soils prone to surface and gully erosion.

Throughout the gold mining districts ... hundreds of square kilometres of forest disappeared, leaving the fragile soils prone to surface and gully erosion.

With advances in technology during the latter half of the 19th century, a second phase of mining occurred. Hydraulic mining was introduced into Victoria's north-eastern fields by Californian miners. Its most devastating procedure involved the undercutting of hillsides and steep stream banks down to bedrock, using powerful water jets.

In the early 20th century giant dredges were also being used to rework enormous quantities of sediment both in the river beds and on the floodplains. Large quantities of fine sediment were discharged into the river system.

Sediment from mining and dredging contributed towards the in-filling of Laanecoorie Reservoir on the Loddon River. Constructed in 1891, the initial capacity of 17,000 ML was reduced by over half during its first 41 years of operation.

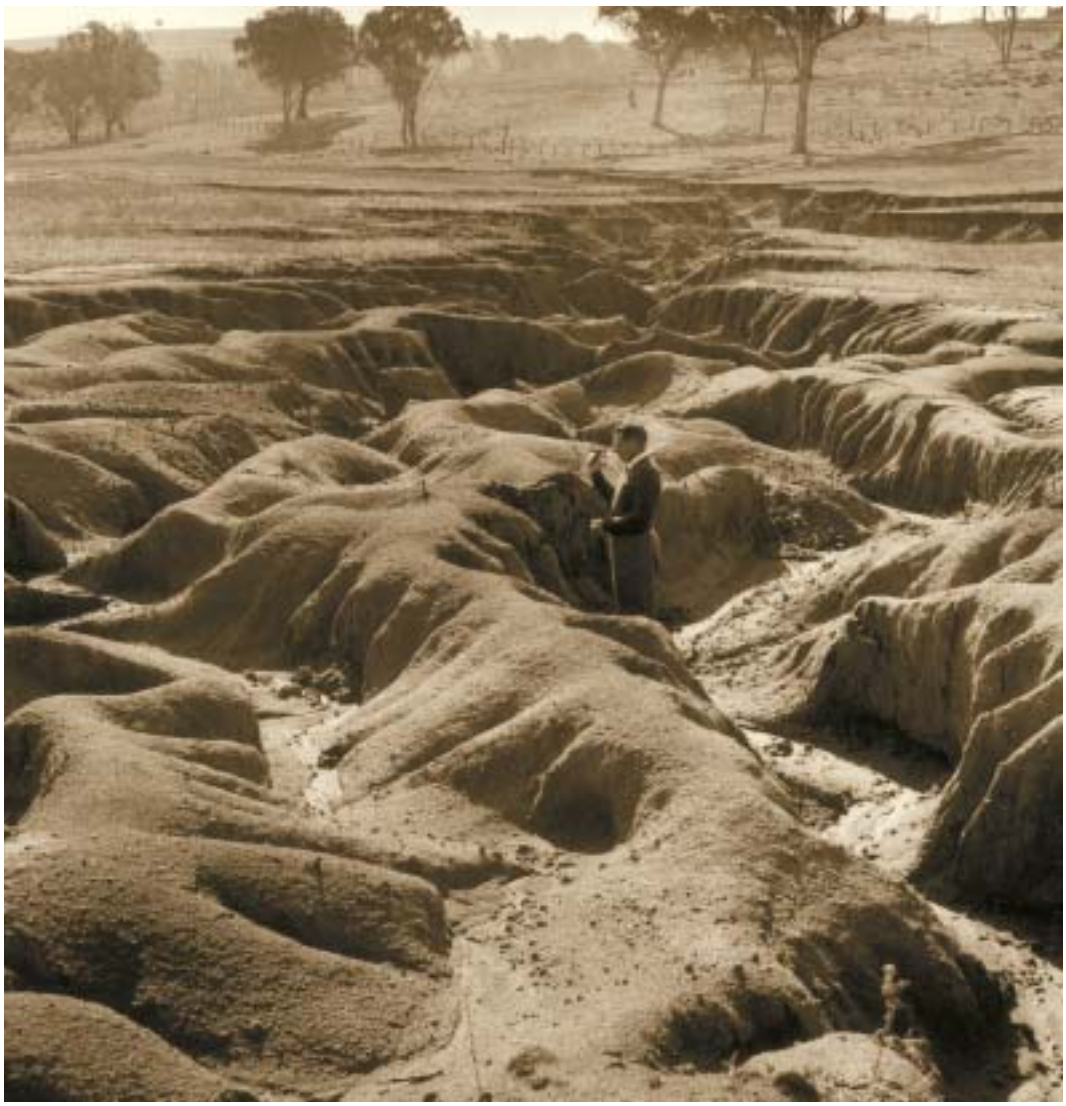
Increased settlement

In NSW, the Robertson Land Acts (or Free Selection Acts) were passed in 1861. The outcome of these Acts was that any person could select a holding of between 40 and 320 acres (16 to 130 ha) on any vacant Crown Land, even land that had previously been under pastoral lease. Similar laws were introduced in other States, and were a response to the very large pastoral holdings that were held by a very small number of people. The Free Selection Acts were intended to assist rural development by encouraging more people onto the land.

Until the introduction of the Free Selection Acts, many large landholders had done little to improve the land or to increase its productivity, except for the small cleared and fenced cultivation paddocks close to the homestead. The new farmers realised that to make a living on these smaller sized farms required more intensive farming practices, including higher stocking rates and the clearing of trees to encourage pasture growth. This led to an accelerated rate of land clearing and a higher potential for land degradation.

The Commissioner of Crown Lands in Monaro described this problem in 1879:

"There is a very great number of stock now kept on the same area of land than formerly, throughout the whole of the Monaro, on those parts where selection has been going on rapidly, as the lessees of the runs have not decreased their stock in the same proportion that large areas of their runs have been taken from them by conditional purchasers, and as most of the selectors have got sheep the land has been made to carry twice the number it formerly did, and which overstocking is, and has done, an immense harm to the grazing capabilities of the country." (NSW Department of Mines 1879)



Severe erosion of pastoral land near Wellington, NSW, in 1960. Photo: Reproduced courtesy of Mitchell Library.

The sinking of wells, construction of earth dams and erection of galvanized tanks in the late 1860s enabled the drier western half of the Basin to be stocked on a more permanent basis. The most spectacular developments were achieved following the discovery of groundwater in the Great Artesian Basin in 1879, which had the effect of opening up the north-west of NSW and the south-west of Queensland.

In the 1860s the railway system started to expand rapidly from Melbourne, Sydney and Brisbane and by the 1890s most large towns in the Murray-Darling Basin were connected by a network of railway lines. With better transport and prices, wool production became an increasingly popular rural enterprise, and outstripped beef and sheep meat production.

> ... overstocking is, and has done, an immense harm to the grazing capabilities of the country.

Ringbarking

From the 1870s onwards, pastoralists started to use ringbarking (the removal of a ring of bark to kill the tree). William Farrer was one who, in 1873, promoted ringbarking as the cheapest and easiest method of improving pasture growth by the removal of competition of trees for soil, water and sunlight. In a number of districts travellers, no longer able to make a living from gold mining, offered their services as cheap and hard-working contractors for ringbarking.

The introduction of railways in the late 19th century opened up the NSW western slopes and plains to cropping. In 1860, 91% of wheat growing in NSW was on the coast and Tablelands; by 1890, 71% was grown on the slopes and plains. However, crop yields declined and by 1902 wheat yields in south-eastern Australia plummeted to about one third (ie 0.5 t/ha) of yields obtained a few decades earlier. The practice of frequent cropping without adequate fallow encouraged soil-borne diseases, and the lack of fertilisers (or rotation with nitrogen fixing crops) reduced the supply of available nutrients.

By 1900 many of the forests and woodlands throughout the Murray-Darling Basin, particularly in the highlands and western slopes of the Basin, had been ringbarked or cleared to improve productivity for grazing and cropping.

From its high point in 1891 the wool industry also started to slump. Overgrazing and the arrival of devastating rabbit plagues in the mid-1880s caused problems, but it was the prolonged drought, coupled with a severe economic depression in the second half of the 1890s, that triggered the collapse of the pastoral industry. Overstocking, particularly in the western districts of the Basin, resulted in severe soil erosion and the spread of salt-scalded plains. Many graziers went broke and their pastoral leases were passed on to the banks or larger pastoral companies. Evidence to a NSW Royal Commission in 1901 provided a graphic description of huge areas of windswept and scalded land in the western districts, with sand drift covering fences, water troughs, stock-yards and even silting up earthen tanks. Extensive areas of edible saltbush and bluebush, often found on the more erodible soils, were also wiped out.

By 1900 many of the forests and woodlands throughout the Murray-Darling Basin, particularly in the highlands and western slopes of the Basin, had been ringbarked or cleared to improve productivity for grazing. The deep-rooted perennial grasses also slowly disappeared under the heavy grazing pressure, and were replaced by faster growing annual grasses which have a shallower root system.

The overall effects of clearing and grazing increased the amount and speed of surface runoff, and removed most of the binding effects of root systems. This led to accelerated rates of erosion, particularly along drainage lines where cattle tended to congregate and trample the stream bank vegetation. Other factors, such as the ploughing of hill slopes, digging channels to drain swampy meadows, the construction of roads, and the formation of animal tracks, often accelerated the erosion process by disturbing the soil and concentrating the surface flow along a particular line.

In September 1892, the academic, A.G. Hamilton, wrote a paper presented to the Royal Society of NSW, which described the erosion process:

"In clearing land and during the progress of settlement, the surface of the ground is injured in many ways; in the formation of paths and roads; and in ploughing the ground. When the surface is broken on a slope, no matter how gentle, the protection afforded by the grasses and herbaceous plants to the soil is removed and the surface drainage is altered. Small runlets of water begin to travel along the line of disturbance and to cut channels which become deeper and deeper. The amount of earth cut away of course depends greatly on the slope, the nature of the soil and the amount of rainfall; being greatest in light soils and on steep slopes. In a light sandy soil I have seen on a very slight slope, channels nine feet deep and twelve or fourteen feet wide cut in a single wet winter."

Gully erosion near Gulgong, NSW, 1945. Photo: Reproduced courtesy of Mitchell Library.

It is assumed that Hamilton's understanding of erosion processes was gained through direct observation. The statement describes the creation of a small rill, and concentration of flow to form a gully.

The massive increase in erosion was also affecting the rivers, and some academics were expressing concern as early as 1865:

"Mining, ploughing, roadmaking, the cutting of drains, the formation of tracks, all aid in diminishing the conservative powers of the natural herbage, and it is not surprising that our best streams, such as the Loddon, Campaspe, and Avoca, are fast becoming mere channels for the efflux of sludge and sand. Even in those parts not touched by the gold-miner, the rivers are rapidly changing their character. The mere occupation of the country for pastoral purposes has produced great changes, and it is well to consider whether anything can be done to compensate for, if we cannot check, this kind of devastation. The reservation of large tracts of forest land is our first duty," (The Argus newspaper, 1865, Melbourne).

Despite the far-sighted statements by a few academics and scientists, the primary aim of the State Governments was for rural development and the clearing of land in pastoral and agricultural districts to continue unrestricted through the second half of the 19th century and early 20th century.

Prior to European settlement, the western slopes of the Murray-Darling Basin contained large areas of grassy woodland. Today, only small remnants remain, such as this reserve near Tarcutta, NSW. Photo: Nicki Taws.

Rabbits

Although rabbits had been introduced to Australia previously, it was the wild grey rabbits that Thomas Austin, a farmer near Geelong, Victoria, brought out from England in 1859 that acclimatised so successfully and rapidly spread throughout the countryside. In 1865 Austin had 20,000 rabbits on his property, and by 1874 they were spreading north into the Wimmera region. By the end of the 1870s, they had crossed the border into South Australia and by 1880 were across the Murray River and heading north through NSW. By 1886 they were reported in Queensland.

Many farmers erected netting along the boundaries of their properties and used poisoning, trapping and shooting to kill the rabbits. However, in most districts of the Murray-Darling Basin, rabbits had reached plague proportions by the 1890s and early 1900s.

The main effect of the rabbit was to increase the overgrazing already being caused by the sheep and cattle during dry periods. This left the land bare and prone to erosion from wind or water. In the semi-arid zone, rabbits also ringbarked edible trees and contributed to the loss of perennial grasses and bushes.

Farmhouse and shearing shed near Corowa, NSW, surrounded by bare ground, denuded by rabbits. Picture: by Robert Ingpen, from McKay 1976. Reproduced courtesy CSIRO.

Rabbit plagues continued throughout the first half of the 20th century, and were particularly bad after World War II in the late 1940s. Farmers and graziers had been away at the war, unable to carry out normal trapping, shooting and poisoning, and rabbits swarmed across the countryside. This scene changed in 1950 when the myxoma virus was introduced to control the rabbit population.

Myxomatosis reduced the rabbit population very markedly, especially in the better watered areas of the Basin. In areas where the grazing pressure from rabbits declined, the increased ground cover helped protect the soil surface from erosion.

The expansion of cropping

In the last few decades of the 19th century the development of a railway network provided better access to markets and with the introduction of new strains of wheat, there was a rapid expansion of cropping throughout the Basin. In South Australia and New South Wales, the wheat frontier was pushed well beyond its present limits, but often with disastrous results, particularly during the drought of the 1890s. At this time, the farming frontier was steadily changing massive areas of grassland, mallee scrub and open woodland into cropland.

From the early 1880s to the 1920s, the use of 'bare fallow' in wheat production to increase soil moisture, break down organic matter, and to control weeds, was actively promoted by the State departments of agriculture. However, on sloping land this technique left the soils exposed to the forces of running water. Every storm had the potential to remove large quantities of topsoil. In a few hours of heavy rain, soil that had taken many thousands of years to form, was washed off the paddocks and down the nearest stream. Similarly, on the plains, the loosened topsoil was quickly removed and carried away by strong winds.

For instance, heavy rainfall in the summers of 1927-1930 caused severe erosion in the wheat growing areas in the south-west slopes of New South Wales:

"Land that ten years ago could be cultivated and drilled across is now in many instances cut by gullies 7 and 8 feet deep and 9 and 10 feet wide. The damage has to be seen to be believed." (Clayton 1931).

Soil conservation campaign

In the late 1920s, Sam Clayton, a senior officer of the NSW Department of Agriculture, became acutely aware of the serious soil erosion throughout the wheat lands in the western slopes of the Basin. Despite reservations from many of his colleagues, he began constructing contour banks in eroded wheat paddocks at the Cowra Experimental Farm to demonstrate the principles of soil conservation to farmers. In 1930 Clayton organised the first soil conservation field day in Australia, and then continued his campaign by holding lectures in country towns and writing articles for newspapers and the Agricultural Gazette.

In the 1920s, there was increasing concern about the siltation of reservoirs, and in 1925 the River Murray Commission requested that action be taken to prevent destruction of forests in the catchment of the Hume Dam – the major water storage on the Murray River.

A series of droughts in the late 1920s and 1930s intensified wind erosion throughout the western plains of the Basin, and public awareness increased dramatically as huge dust storms moved across eastern Australia. The growing realisation of the importance of soil erosion in relation to the national economy led to agitation by various public organisations, government departments and members of Parliament. In August 1936, soil erosion was one of the subjects discussed by a conference of Commonwealth and State Ministers in Adelaide. The conference decided that all State Governments should be asked to form soil erosion committees.

The social climate was now ready for some major government initiatives to combat soil erosion, and in 1933 a soil conservation bill was passed in the NSW Parliament, leading to the formation of the first Soil Conservation Service in Australia.

Similar bills were passed in South Australia in 1939, Victoria in 1940 and Queensland in 1951. After a little more than a century of continuous degradation of the soil and water resources, governments began taking steps to address the problem.

Improved management

In the late 1940s and early 1950s, initial soil conservation efforts were centred around the construction of mechanical protection works and rehabilitation of individual paddocks.

Demonstration sites were set up and a major education campaign was carried out in the early 1950s. Field days on these demonstration sites were particularly successful with up to 800 people attending. The success of these field days played a large part in the promotion of extension programs.

It soon became apparent that soil conservation works needed to be co-ordinated over the whole farm. This led to the development of whole farm planning. The first step involved a survey of soil types, vegetation, existing erosion and history of land use. The plan included changes in land use, relocation of paddock boundaries to conform with various land classes and, if needed, construction of mechanical works to arrest erosion.

The next step was to develop plans for larger catchment areas covering many properties. This approach was adopted in Queensland in the mid 1950s, and by 1959 catchment plans covering 80,940 hectares had been prepared. The first co-operative project in Victoria was started near Stawell in 1952, and by 1961, 39 co-operative projects were in operation. These projects were aimed entirely at erosion control and were often set up to protect the catchments of major water supply reservoirs. Similar projects were set up by the NSW Soil Conservation Service to protect the catchments of major water supply reservoirs throughout the State.

In NSW the move to planning soil conservation and land resource management activities on a whole catchment basis became known in the 1980s as 'total

As a result of a national assessment of land degradation in the 1970s, the Federal Government established the National Soil Conservation Program in 1983.

Contour banks to reduce streamflow velocities and trap sediments are part of improved management plans. Photo: Anthony Scott.

Soil conservation works in the Cowra district, NSW, in 1952. Photo: Reproduced courtesy of Mitchell Library.

catchment management'. This move co-incided with the realisation that extension efforts must be directed at the whole community, not only the farmers who have a direct interest in the maintenance of soil resources. The community participation approach has been promoted by various forms of state programs which encourage the establishment of catchment committees, advisory groups and local action groups.

As a result of a national assessment of land degradation in the 1970s, the Federal Government established the National Soil Conservation Program in 1983. This program provided funds to tackle soil degradation, and in the five years 1984-89, the program contributed to over 400 projects.

In 1987 the Commonwealth and the three States along the Murray River – Victoria, South Australia and NSW – agreed to form the 'Murray-Darling Basin Commission'. This historic agreement allowed for the first time a co-ordinated management of natural resources within the Basin. In the same year a review of the Murray-Darling Basin's environmental resources was compiled by more than 100 scientists and resource managers from State and Federal Government departments, CSIRO and universities. The 'Environmental Resources Study', summarised existing scientific knowledge of the Basin, and included proposals for remedying its ecological ills such as erosion, salinity and loss of native vegetation. This led to the launch in 1989 of a 'Natural Resources Management Strategy' which promoted the 'integrated catchment management (ICM)' of the Basin through a community-government partnership.

Decade of Landcare

More progress was made on a national basis when the Prime Minister of Australia issued a 'Statement on the Environment' declaring 1990 the 'Year of Landcare' and the following ten years as the 'Decade of Landcare'. A rapidly increasing number of Landcare groups were operating throughout the country and have been very active in planting trees and rehabilitating degraded land. Since the mid 1990s these community groups have received funding through the Natural Heritage Trust (NHT), jointly funded by the Commonwealth and State Governments.

Soil conservation is now regarded as a necessary part of farm and catchment management. The implementation of soil conservation measures is also an accepted initial step when developing new land for cropping. In established areas, contour bank systems, stubble mulching and minimum tillage are now an integral part of farming. Agencies prepare co-ordinated plans for whole catchments using information such as topography, land use, soil types and location of existing erosion. Research and field trials continually refine knowledge and education programs for both farmers and the general community.

Forming contour banks to prevent further erosion. Photo: Reproduced courtesy of Museum of Victoria.

A new equilibrium

After reaching a peak in the late 19th century and early 20th century, soil erosion throughout much of the Murray-Darling Basin appears to be slowly declining and the landscape is gradually adjusting towards a new 'equilibrium'. However, these new rates of erosion are still many times higher than those of pre-European times, and the legacy of the past 200 years continues to have a significant impact on both the environment and agricultural productivity.

There are a number of reasons why the overall rate of erosion (in particular gully erosion) within the Basin has declined over the past 50 years:

Adjusting to the new landscape. After initial incision, followed by deepening and widening, many gully networks have adjusted to the increased rates of surface runoff and are now gradually stabilising, and in some areas revegetating with wetland plants.

Better land management has increased the protective ground cover. This has included lower stocking rates, pasture improvement, and the replacement of conventional tillage with conservation farming practices.

Reduction in rabbit numbers. Myxomatosis was introduced in 1950 and it reduced the rabbit population very markedly, especially in the better watered areas of the Basin. However, less virulent strains of the virus appeared very rapidly, enabling the rabbit population to gradually acquire a degree of resistance to the disease. In 1996 the introduction of rabbit calicivirus reduced rabbit numbers to low levels in the drier regions of the Basin but it had less effect in the cooler, wetter regions.

Erosion control works. Since the 1940s, many farmers have started to build contour banks, and repair eroded gullies, with the assistance of State soil conservation agencies. Education programs have also helped increase awareness of soil erosion and its impact on farm productivity.

Changes in weather patterns. Long term changes in the weather patterns have resulted in increased rainfall over the last 50 years. It has been suggested that this might have caused an increase in pasture cover and hence better protection of the soil. However, an analysis of weather data for the period 1910 to 1995 indicates that some regions have also experienced increases in heavy rainfall, which is when the greatest

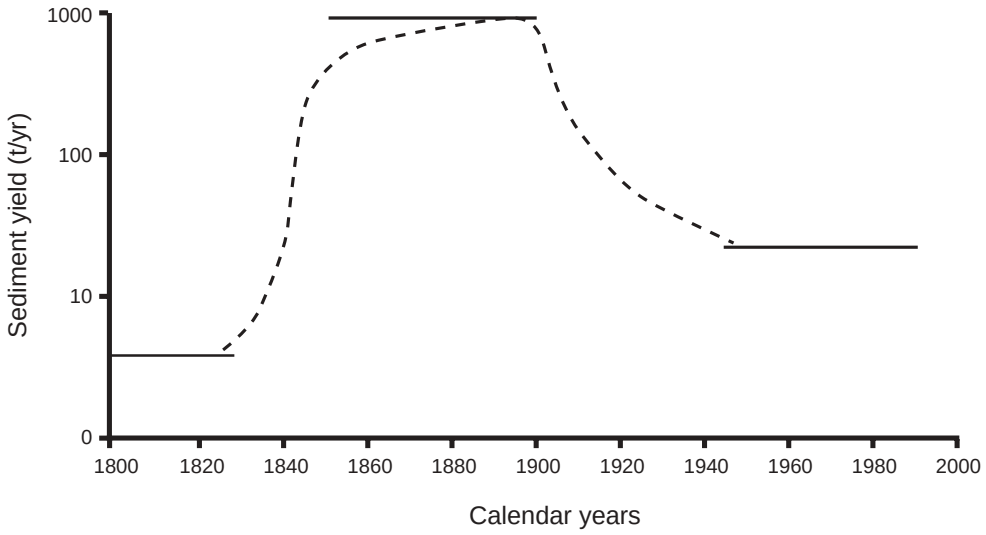


Figure 1: *Estimated trend in sediment yield since the 1820s, for Jerrabomberra Ck, southern NSW. Source: RJ Wasson.*

erosion tends to occur. The new equilibrium for soil erosion in the Basin can be seen in Figure 1.

Erosion incidents continue. Although there is a general decline in erosion rates throughout the Basin, in some catchments heavy rainfall causes the collapse of unstable gully walls or stream banks and moves sediment that has been deposited along the gully floors further downstream. In catchments where poor land management practices continue, or recent land clearing has occurred, incision and extension of new gully networks remains a serious problem. In some districts there has been a trend to convert previously cleared pastoral country into cropping land. The erosion rates from cropped land can be tens or hundreds of times higher than that from native or improved pasture.

Although most areas cleared long ago are showing signs of stabilisation, there are some catchments which have eroded badly in the last few decades, and continue to supply high sediment loads to rivers and streams. In other parts of the Basin, land clearing has continued into the latter half of the 20th century and these areas will remain unstable for many decades to come. In some districts, particularly in the western slopes of the Basin, the continuing trend of converting pastoral land to cropping land will also result in increasing rates of erosion. In these regions riparian 'buffer strips' can be used to trap the sediment in surface runoff before it contaminates the nearby rivers and streams.

The sequence of erosion events in the Murray-Darling Basin is summarised as a timeline on pages 16 and 17.

Erosion in the Basin – key events

Pre-1813	**Aboriginal people** had been inhabiting the Basin for over 40,000 years. Their total population was small and sparsely settled, and as subsistence hunter-gatherers, their overall impact on the environment was minimal. Streams had a good cover of aquatic plants and grasses along their banks and showed little sign of erosion.
1813	**Blue Mountains** were crossed by Blaxland, Lawson and Wentworth. This marked the beginning of an era of exploration, settlement and exploitation of the Murray-Darling Basin by European Australians.
1820s and 1830s	**Exploration of the Murray-Darling Basin** by explorers such as Hume and Hovell, Sturt, Oxley, Mitchell and Cunningham travelled throughout the Basin, opening it up to the first settlers who quickly followed in their footsteps.
1830s and 1840s	**Squatting** was in full swing and settlers rapidly took up land throughout the eastern half of the Basin. Large herds of sheep and cattle were established, and the first impacts from these hard hoofed animals commenced, such as overgrazing of pasture and the trampling of stream banks. Grazing caused the deep rooted perennial grasses to be slowly replaced by faster growing annual grasses with a shallower root system. In these first years of settlement, there was only minimal clearing of trees from the landscape.
1840s	**Settlement of the western half of the Basin** commenced, initially along the waterfronts of the major rivers.
1850s and 1860s	**Gold rushes** attracted thousands of gold miners who initiated the destruction of alluvial land throughout much of central Victoria and in scattered sites along the Tablelands and slopes of NSW. Large scale timber cutting for firewood, housing and for props in mineshafts, caused major loss of forests around the gold fields. These disturbances initiated severe gully erosion and caused massive increases in sediment loads down some rivers, particularly in Victoria.
1860s	**Closer settlement of rural areas** was encouraged by State Governments through a series of Land Acts. This resulted in smaller farms, higher stocking rates and accelerated land clearing. Evidence of land degradation on some farms was starting to become apparent, particularly during dry spells when the soil was bare. From the 1870s onwards, pastoralists started to use ringbarking as a quick and cheap way of clearing the land.
mid 1860s	**Rapid land clearing** was a growing concern expressed by a few scientists and academics. The primary concern was about the perceived effect of land clearing on rainfall and water supply in streams. These concerns eventually prompted the creation of some timber reserves, but had no effect on the rate of clearing in pastoral and agricultural districts.
1870s	**A sequence of wet years** encouraged pastoral settlement on the back blocks and heavy grazing of perennial plant species, such as saltbush. By 1870 pastoralists had established themselves on the best pastures and waterholes of every large river in the Basin, including the Paroo and Bulloo Rivers in Queensland. These properties were marginal and not viable during drought. By 1875 virtually all land in the western half of the Basin had been granted under lease.
	Rabbits spread throughout the Basin and reached plague proportions by the 1890s. This increased the grazing pressure on the land, leaving it prone to erosion during heavy rainfall events, particularly after droughts when grass cover was at its lowest.
1880s onwards	**Cropping** expanded across massive areas of grassland, mallee scrub and open woodland. Between the 1880s and 1920s the use of 'bare fallow' was actively promoted by the State departments of agriculture. This left the bare, loose soil exposed to severe erosion during heavy rainfall. In the mallee districts, the loosened soil was also carried away by strong winds.

1895-1903	**Severe and extended drought** combined with rabbit plagues and overgrazing caused extensive land degradation, particularly in the semi-arid regions. Many graziers went broke and their pastoral leases were passed on to the banks or to larger pastoral companies. Evidence to a Royal Commission in NSW in 1901 provided a graphic description of huge areas of windswept and dry, scalded land, with sand drifts covering fences, water troughs and stock yards, and silting up earthen tanks. Extensive areas of edible saltbush were wiped out.
1920s	**'Soldier Settlement Schemes'** were set up after World War I, as an extension of State Governments' closer settlement policies. The allotments were often unsuitable for small-scale farming and could not sustain a family. These attempts at closer settlement placed great pressure on the land and resulted in further land degradation.
1920s and 1930s	**Erosion problems** became a growing concern amongst members of the farming and scientific communities. These groups started to question whether increased crop yields could be sustained when the basic resource upon which they depended, the soil, was being washed and blown away. There was also a slow but increasing awareness that the capacities of some water storage dams were being threatened by high rates of siltation.
1930	**Australia's first soil conservation field day** was held near Cowra.
1930s and 1940s	**Drought and associated dust storms**, particularly in the mallee of NSW, Victoria and South Australia, highlighted the severe problems of erosion to the general public. This placed greater pressure on the State Governments to take action.
Late 1930s and 1940s	**Soil Conservation Acts** were introduced by most states, along with advisory committees within the departments of agriculture or separate soil conservation agencies, to assist farmers with the control of soil erosion.
1945 onwards	**Improved soil conservation measures** were implemented by farmers, with the assistance of soil conservation officers. Initially this consisted of the construction of mechanical protection works in eroded gullies and the use of contour banks. This slowly developed into 'whole farm planning' and later to the rehabilitation of whole catchments.
1950s	**Introduction of myxomatosis** reduced rabbit numbers. However, the rabbit population slowly developed resistance. (In 1996 the Calicivirus further reduced numbers.)
1980s	**'Total catchment management',** as a concept, was introduced, recognising the many land degradation issues being faced by farmers that needed to be addressed on a catchment basis.
1990s	**'Year of Landcare'** (1990) and **'Decade of Landcare'** (1991-2000) became the cornerstone of the Prime Minister of Australia's 1989 'Statement on the Environment'. Landcare groups operated throughout the Murray-Darling Basin, actively planting trees and rehabilitating degraded land.
Today	**Land clearing** in the western slopes of the Basin, to convert pastoral land to cropping, increases the rate of erosion in affected catchments. Today, many of the areas cleared during the 19th and 20th centuries are gradually stabilising, as land management practices change, and the rates of erosion are slowly declining from their peaks. However, the current levels of erosion are still many times higher than those of 200 years ago. The legacy of two centuries of settlement continues to have a significant impact on both the environment and agricultural productivity.

Lessons from the past

The past 200 years has demonstrated that many of the imported European agricultural practices have been unsuitable for the soils and climate of the Murray-Darling Basin. Short-term productivity was achieved at the expense of long-term sustainability.

Improved farming practices that protect the soil from erosion are now being adopted on many farms throughout the Basin. This includes practices such as maintaining vegetation cover, avoiding overgrazing and minimising tillage. In some regions, however, long-term sustainability might only be achieved by replacing existing land uses with alternative farming enterprises that place less demands on the soil.

In other areas, particularly low rainfall areas, sustainable agriculture might not be possible, and alternative production systems involving native vegetation and farm forestry need to be explored.

A major source of the sediment in rivers is derived from erosion of gullies. This has led to an increased awareness of the importance of vegetation along streams and rivers and it is essential that future land management continues to target the protection of this vegetation.

When the first soil conservation agencies started to take action, they initially concentrated on earthworks that targeted highly eroded sections of specific farms. Although these efforts were quite successful in controlling erosion, it soon became clear that it would be far too expensive to treat every erosion gully on every farm. Therefore, an increasing amount of effort was placed on the prevention of further erosion by treating the causes rather than the symptoms. The idea of catchment-wide planning, and the changing of land management practices on a large scale, was gradually accepted as a better option for the long-term reduction of erosion. This broader catchment-wide perspective needs to be the basis of all land management in the future, not only for the control of erosion, but also for other sustainability issues such as dryland salinity.

Recent tree planting and fencing along an erosion gully on a property near Bendigo in Central Victoria. In recent years, Federal and State funds, through community organisations such as Landcare groups and Greening Australia, have assisted farmers with such work. Photo: Anthony Scott.

The Future

When the Governments of the Basin signed the *Murray-Darling Basin Initiative* in 1987 they created the largest integrated catchment management (ICM) program in the world.

A new phase of natural resource management started in 2001 with the release of the policy statement 'Integrated Catchment Management in the Murray-Darling Basin 2001-2010'. The ICM policy statement establishes a timetable for setting catchment health targets across the Basin for water quality, water sharing, terrestrial biodiversity and riverine ecosystems.

Consideration of the erosion of soil will be an important part of this target setting process.

This report forms one part of a larger research project that aims to identify where these areas of high priority are in the Basin. This information will enable communities and Governments to allocate scarce resources to the most cost-effective remediation works.

In the past 200 years, we have learnt a great deal about how the landscape of the Murray-Darling Basin has responded to settlement and development. These lessons from the past serve to inform the implementation of the ICM policy statement, together with the knowledge we draw from research.

FURTHER READING

THIS REPORT IS A SUMMARY OF TWO REPORTS:

• Scott A (2001) *"Water Erosion in the Murray-Darling Basin: Learning from the past"*, CSIRO Land & Water Technical Report 43/01

• Olley J and Scott A (2002) "Sediment supply and transport in the Murrumbidgee and Namoi Rivers since European settlement", CSIRO Land & Water Technical Report 09/02

These reports contain more extensive references and are available from CSIRO Land & Water.

Integrated catchment management in the Murray-Darling Basin

A process through which people can develop a vision, agree on shared values and behaviours, make informed decisions and act together to manage the natural resources of their catchment: their decisions on the use of land, water and other environmental resources are made by considering the effect of that use on all those resources and on all people within the catchment.

Our values

We agree to work together, and ensure that our behaviour reflects that following values.

Courage

- We will take a visionary approach, provide leadership and be prepared to make difficult decisions.

Inclusiveness

- We will build relationships based on trust and sharing, considering the needs of future generations, and working together in a true partnership.
- We will engage all partners, including Indigenous communities, and ensure that partners have the capacity to be fully engaged.

Commitment

- We will act with passion and decisiveness, taking the long-term view and aiming for stability in decision-making.
- We will take a Basin perspective and a non-partisan approach to Basin management.

Respect and honesty

- We will respect different views, respect each other and acknowledge the reality of each other's situation.
- We will act with integrity, openness and honesty, be fair and credible and share knowledge and information.
- We will use resources equitably and respect the environment.

Flexibility

- We will accept reform where it is needed, be willing to change, and continuously improve our actions through a learning approach.

Practicability

- We will choose practicable, long-term outcomes and select viable solutions to achieve these outcomes.

Mutual obligation

- We will share responsibility and accountability, and act responsibly, with fairness and justice.
- We will support each other through the necessary change.

Our principles

We agree, in a spirit of partnership, to use the following principles to guide our actions.

Integration

- We will manage catchments holistically; that is, decisions on the use of land, water and other environmental resources are made by considering the effect of that use on all those resources and on all people within the catchment.

Accountability

- We will assign responsibilities and accountabilities.
- We will manage resources wisely, being accountable and reporting to our partners.

Transparency

- We will clarify the outcomes sought.
- We will be open about how to achieve outcomes and what is expected from each partner.

Effectiveness

- We will act to achieve agreed outcomes.
- We will learn from our successes and failures and continuously improve our actions.

Efficiency

- We will maximise the benefits and minimise the cost of actions.

Full accounting

- We will take account of the full range of costs and benefits, including economic, environmental, social and off-site costs and benefits.

Informed decision-making

- We will make decisions at the most appropriate scale.
- We will make decisions on the best available information, and continuously improve knowledge.
- We will support the involvement of Indigenous people in decision-making, understanding the value of this involvement and respecting the living knowledge of Indigenous people.

Learning approach

- We will learn from our failures and successes.
- We will learn from each other.