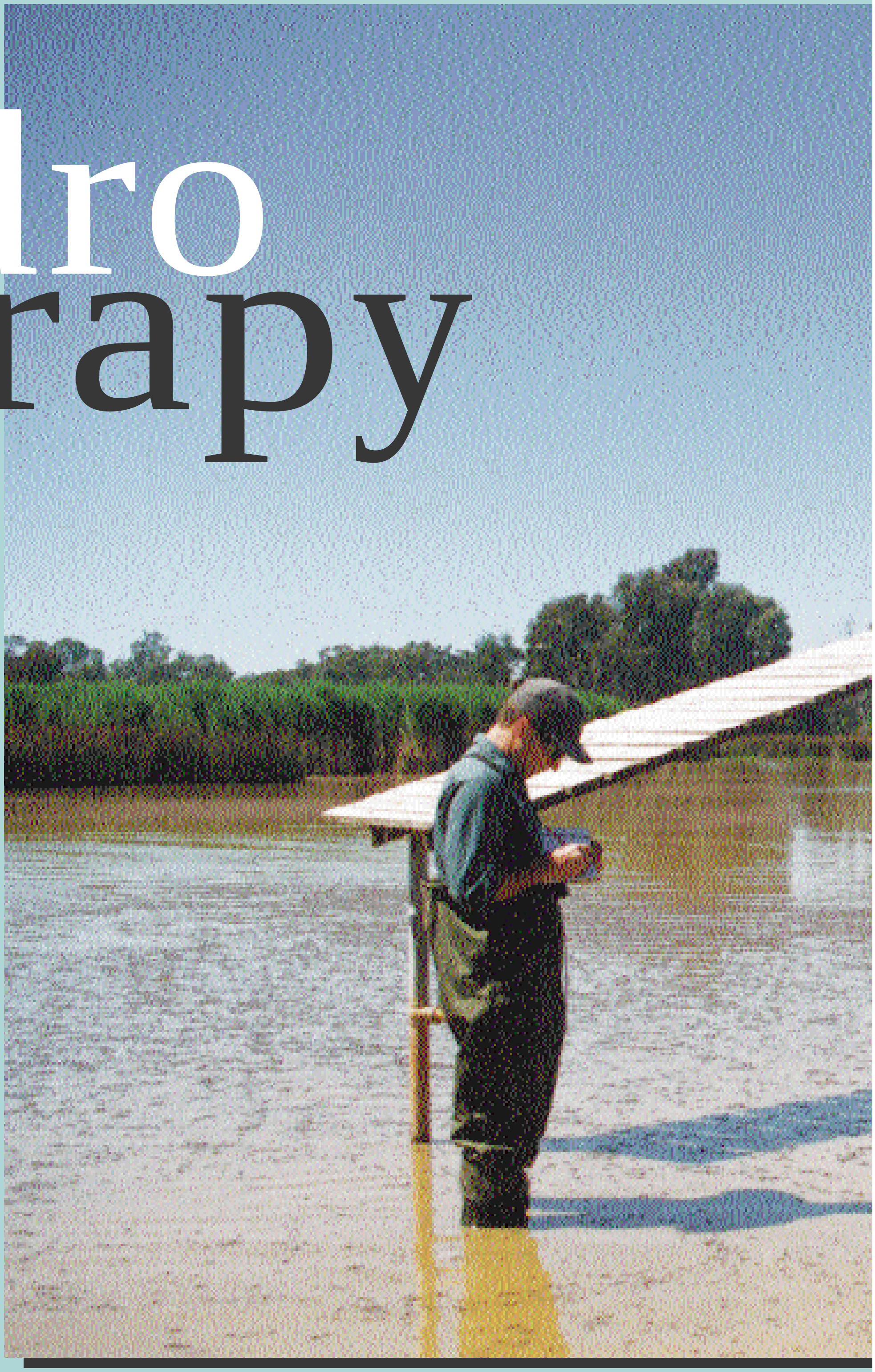
hydro therapy



Bryony Bennett considers the partial curing of a 60-year arrythmia in the once bountiful Barmah-Millewa Forest.

Tall clumps of rusty-hued giant rush fringe the edge of Reed Beds Swamp: a flick in the eye for the unwary.

'I never walk in here with anyone who can run faster than me,' says State Forests of New South Wales ecologist David Leslie. I trust he's joking about the risk of pursuit by rogue emus and pigs.

Inside the ring of rushes is a stretch of shallow, open water. Fifty or so waterbirds, mostly pelicans, a handful of royal spoonbills and white and straw-necked ibis, are dots in the distance. Some of the ibis tend nesting platforms on trampled down rushes, but Leslie says they'll soon abandon their vigil.

A group of nearer nesting platforms tells the story. On top of each are broken, white eggshells, neatly cleaned of their contents by raptors from the surrounding forest.

The ibis had begun mating here several weeks earlier in response to September and October rains delivered by Gulpa Creek, an anabranch of the Murray River. Water levels among the rushes had risen to 60 cm, providing a natural cue for the ibis to breed. But when the rains were not sustained the floodwaters receded, causing a 40-cm fall in water depth, and warning the birds to desert their nests.

In this scene at Reed Beds Swamp, nature has played out perfectly a simple truth about wetlands ecology: that without a period of prolonged flooding to provide sufficient food resources, waterbirds have little chance of fledging their young.

Understanding such relationships between the hydrology of wetlands and their inhabitants is vital to re-establishing more natural patterns of water delivery to the floodplains of Australia's regulated rivers. Dams, diversions and river management have altered the natural wetting and drying cycles in these areas, causing changes to the distribution and

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The Murray hereabouts is confined to a deep channel no broader than the Yarra at Richmond and, when a banker, spreads its overflow waters far and wide into the lakes on either side, thus affording breeding haunts for innumerable water fowl, and spawning ground for shoals of fish – a paradise for sportsmen in the open season.

– *The Australasian*, April 29,1898

Peak breeding season and hardly a waterbird in sight. State Forests of NSW ecologist David Leslie notes water level and temperature data as the floodwaters subside at Reed Beds Swamp.

health of vegetation, and declining numbers of waterbirds, invertebrates and native fish.

Ample evidence of these changes can be found at Millewa Forest, the New South Wales component of the 65 000-hectare Barmah-Millewa Forest, a vast patchwork of lakes, reed swamps, grasslands, streams and native forest that straddles the Murray River between the towns of Tocumwal, Deniliquin and Echuca.

This is a place where the Murray River drops its guard, where floodwaters spilling from the river's unusually low, narrow banks have etched a spidery web of creeks and ephemeral streams. For thousands of years the floodplain has evolved in concert with these flows, according to a seasonal pattern of drying in summer and autumn, and wetting in winter and spring.

The extraordinary diversity and abundance of the floodplain – well known to Aborigines of the Bangerang and Yorta Yorta tribes – was both admired and exploited by European settlers.

According to Leslie, an avid scholar of the local ecological history, the major attraction was Moira Lakes, a major wetland to the south of Reed Beds Swamp that offered more provender and 'sporting' opportunities than any enthusiast could hook, net, shoot or poke a stick at.

In its heyday, a commercial fishery established at Moira Lakes in 1855 caught 150 tons of fish annually from the wetland and its surroundings, thanks largely to the effective use of bag nets that stretched the entire width of streams. At the same time local authorities were busy stocking billabongs with European carp.

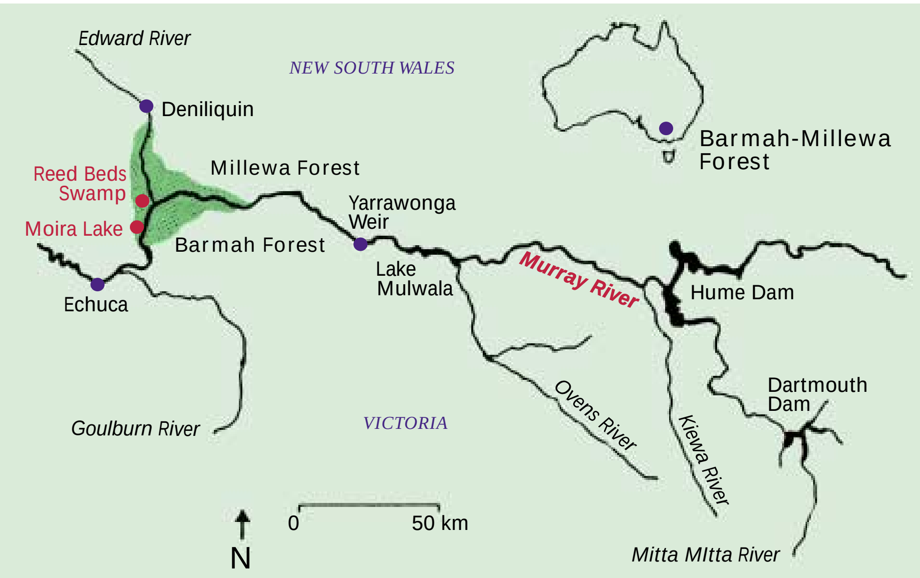
Another lucrative, yet insidious, scheme involved shooting egrets during the breeding season so that ladies' hats could be adorned with their feathers and plumes. There was even an export industry built around the Murray leech. These were lured by the thousand to blooded animal hides draped overnight in the lake's shallow waters, then packed off to Europe where they were farmed for letting blood.

Despite this ongoing plunder, descriptions of the floodplain teeming with fish and bird life continued well into the 1940s. Regulation of the fisheries in the 1890s, amid concerns about falling catch levels and the decline of Murray cod, and the proclamation of Moira Marshes as a sanctuary in 1925, had won the wildlife a temporary reprieve.

Anyone angling at Moira Lakes today, however, would snag little more than the descendants of those migrant carp. Sampling by NSW Fisheries in 1993 yielded 90% European carp and no valuable native species such as golden or silver perch, or Murray cod. Nor does the wetland support regular breeding of colonially-nesting waterbirds. Of the 20 or so formerly abundant species, breeding numbers of 11 have fallen significantly, and eight don't nest there at all.

To find the cause of this dramatic decline, you have to look back 60 years, to the construction of Hume Dam near Albury, the main operating storage of the River Murray System.

Since the early 1940s, Hume Dam has conspired with Yarrawonga Weir and Mulwala Canal to deliver water to farming communities near Deniliquin, enabling extensive irrigation of the central Murray plains. It has also secured domestic water supplies for industry, towns and farms, and supported downstream irrigation developments in Victoria and South Australia. The capacity of this network was augmented by the late 1970s with the Snowy Mountains Hydro-Electric Scheme and Dartmouth Dam.



The highly variable rainfall and river flows that spawned oases such as Moira Lakes was the nemesis of intensive agriculture.

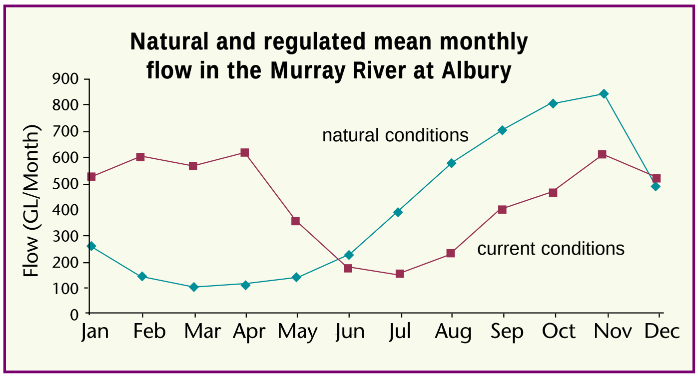
Irrigation enterprises that rely on the River Murray System – rice and cereal growing, horticulture, and pasture production for dairy, beef and sheep – have required less erratic patterns of water delivery. Small irrigation diversions start in June and July, increasing from August to November. During these months, rain and snowmelts are stored to meet rising irrigation needs through December to May, when natural flows along the Murray are low.

Because Barmah-Millewa Forest intersects this system, its flows have for the past 60 years been attuned to the demands of irrigated agriculture and only partially

Left (main picture): Australian white ibis on their nest platforms.

Left inset: A matter of life or death. Waterbirds that breed at Reed Beds Swamp continue tending their nests as long as floodwaters are sustained. A rapid fall in water levels is a natural cue to abandon the breeding attempt, as insufficient food resources will be available for the birds to fledge their young.

Below: Natural and regulated mean monthly flow in the Murray River at Albury. The flow patterns of the river have been changed by regulation, with higher flows over summer. Most wetlands along the Murray floodplain are adapted to the natural pattern of flooding in winter and spring and drying in summer.
Before regulation, this type of water regime provided the major impetus for wetland productivity and habitat diversity. It triggered many wetland processes such as nutrient cycling, plant germination, hatching and breeding of macroinvertebrates (a major food source for wetland fauna) and waterbird and native fish breeding.



to the natural rise and fall of the Murray River. This has reduced the frequency, depth and extent of natural winter / spring flooding, while increasing the duration of non-flood periods and unnatural flooding in summer.

The direct impact of prolonged high summer flows became apparent at Millewa Forests just three years after the commissioning of Hume Dam. Creeks fed by the Murray, which normally ran dry in summer, continued flowing into low lying forests and wetlands year round, drowning hundreds of hectares of river red gums.

Ever since these first signs of deterioration, forest managers have tried to temper the effects of river regulation by modifying the forests' internal waterways. They've raised levees on the banks of the Murray, installed regulators to patrol the mouths of major creeks, and blocked forest-draining streams.

Initially their aim was to protect the timber resource by minimising tree deaths. But now it is recognised that the entire ecology of the floodplain – from microscopic processes in wetland sediments to the recruitment of waterbirds and fish – is inextricably linked to river flows. And the productivity of the river in turn depends on the calibre of its floodplain links. So the emphasis has shifted to managing water regimes to benefit the floodplain as a whole. The obvious remedy is to emulate more natural wetting and drying patterns: but how?

A fork in the river

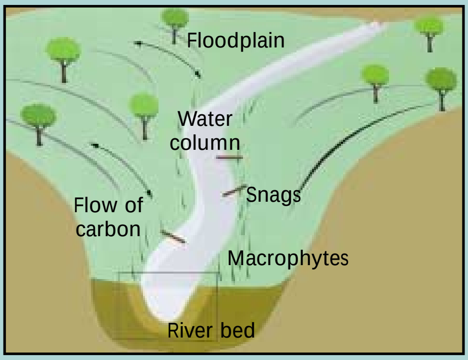
Efforts to establish an ecological approach to flow management at Barmah-Millewa Forest are being made against a background of a national water reform that aims to achieve an efficient and sustainable Australian water industry by 2001. A major element of the reform process, which was endorsed by the Council of Australian Governments in 1994, is the provision of specific water allocations for the environment. This shift in water policy is reflected in the interstate agreement to cap total water diversions from all sources in the Murray-Darling Basin at 1994 levels.

A 100-gigalitre (GL) water allocation for Barmah-Millewa Forest was agreed to in principle by the Murray-Darling Basin Ministerial Council in 1993. The volume is equivalent to four days of regulated releases from Hume Dam during the peak irrigation season (enough water to fill 100 000 Olympic-sized swimming pools).

The purpose of the allocation is to supplement minor 'freshes' that swell the river, but don't now produce landscape floods of sufficient peak or duration to enable key ecological outcomes such as plant and animal recruitment.

In New South Wales, community-based river management committees have been established to advise the NSW Government on its delivery of water reforms. They've been set the ominous task of producing measurable environmental outcomes without reducing water availability to irrigators by more than 10%. For the Murray-Lower Darling Community Reference Committee, management of a water allocation for Barmah-Millewa Forest is high on the agenda.

But the committee has yet to decide how to manage the allocation for the maximum ecological benefit, which so far has been used only once, in 1998.



Two models of carbon cycling are being evaluated during the study of lowland river ecology.

The first model **predicts that organic carbon enters the Murray River from three main sources: living and dead material from the floodplain, fine particulate and dissolved material from upstream, and algae and large aquatic plants (macrophytes) in the river itself.**

The relative contribution of each carbon source is thought to depend on environmental factors such as the extent of interaction between the river and its floodplain.

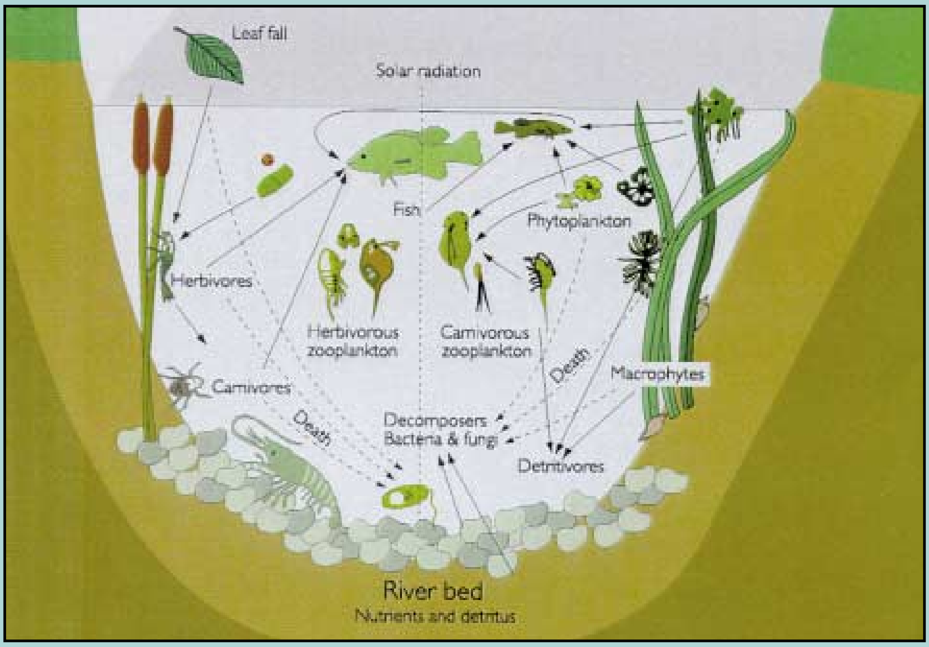
In rivers that flood, the major source of organic carbon is the floodplain. Large amounts of organic carbon move into and out of the channel during periods of high water in late winter and spring. In-stream algal production is low as a result of high turbidity, low temperatures and turbulent flows.

River regulation has substantially reduced the quantity of carbon entering lowland rivers. The regulated river connects only rarely with its floodplain, thereby reducing its supply of floodplain carbon sources and increasing the importance of instream sources such as algae.

The decline in macrophyte species also reduces carbon input to the river, as do dams and weirs that reduce the input of upstream organic material. High summer flows, however, have favoured in-stream algal production by increasing the amount of habitat available for their growth.

The second model **is built around six major types of organic carbon. It assumes that changes in the availability of any category of carbon will affect those organisms that rely on it for food or habitat. This will in turn affect predatory animals that feed on those consumer organisms.**

The six categories of organic carbon are: snags (coarse, woody debris), macrophytes, dead plants, floating algae, attached algae and dissolved organic matter.



Unravelling the **floodplain** foodweb

A TEAM of 17 scientists from the CRC for Freshwater Ecology is midway through a three-year quest to unravel the intricacies of carbon flows in Australia's lowland floodplains and rivers.

Organic carbon forms the base of the riverine food web, exerting a strong influence on the types and structures of animal, plant and microbial communities. So an understanding of how it enters the system, and how it is taken up by living organisms, is crucial to managing river flows for ecological outcomes.

Project leader, Dr Ben Gawne of the Murray-Darling Freshwater Research Centre at Mildura, says the study is investigating the relative contribution of major sources of carbon to the river system, and the factors that might cause them to vary over space and time.

Field research is being carried out at three locations along lowland sections of the River Murray, one near Albury, another in Barmah-Millewa Forest, and a third in Hattah National Park near Mildura.

'We're measuring factors such as the growth of macrophytes, algal production in open water and on snags, and litter infall from river red gums,' Gawne says. 'We're also looking at how different carbon sources are processed by bacteria and bugs in different locations.'

These data will be used to develop carbon budgets at two different scales. The first will evaluate the total carbon balance over extended river reaches, and the second will focus on carbon production and processing in specific habitats (see diagrams). The models will offer clues to the quantity and quality of food available to invertebrates and fish.

Gawne says the study has already yielded some clues to carbon sources in the Murray River. It seems that algae may generate the 'fast food' of the river system, while organic debris may act as long-term energy storage. 'We've found that most biological activity can be attributed to algae floating in the water column,' he says.

'This has been a surprise because we thought terrestrial inputs would have been just as important, particularly at Barmah where trees drop their leaves straight into the river. But the rates of litter decomposition are slow. So we suspect leaf material may act as an important store of carbon in the river system.'

Gawne says understanding carbon flows in the river and floodplain is key to deciphering the impacts of flooding on river ecology.

'Small to medium floods have disappeared due to river regulation,' he says. 'If we're going to use environmental flows as a means of rehabilitation, we need to know what benefits to expect.

'We also need to know the structure of food webs so we know where to concentrate rehabilitation efforts. Should it be on snags, riparian vegetation, or controlling algae in the water column?'

Data gathered during the study will be incorporated in a model for predicting the effect of different flow-management initiatives on the supply of carbon in its various forms to riverine food webs.

The team also hopes to identify key indicators – processes such as water column production or decomposition of leaves – that can be used to characterise a particular river reach and determine its status, enabling more rapid evaluation of river management strategies.

Issues such as the optimum volume and timing of environmental releases, and the setting of protocols for water sharing between the environment and consumptive uses, are subject to ongoing debate. As part of this process committee members are weighing up technical information relating to the effects of proposed water management strategies on both irrigation supplies and the forest ecosystem.

An important source of ecological evidence is David Leslie's research into relationships between river flows, wetland flooding and the breeding success of colonially-nesting waterbirds. When these relationships are combined with historical flow records and modelled river flows, the effects of water management on waterbird breeding can be predicted. They also provide a basis for understanding how river regulation has affected the reproductive performance of waterbirds.

To see how the technique evolved, let's go back to Reed Beds Swamp . . .

When we visited the swamp in November, a handful of ibises had nested, but were leaving their eggs due to a rapid fall in water levels. But nature would have produced a different outcome had the floodwaters not receded. Rather than 50 or so birds, Leslie would have expected to see some 600 pairs of ibis tending nests, 100-plus pairs of royal spoonbills getting down to nest construction, and perhaps a sprinkling of black swans, great crested grebes, little bitterns and brown bitterns. A flood large enough to inundate the wetland until mid-summer would have triggered a breeding bonanza, attracting more birds and more species.

Such relationships between water depth conditions in nesting and foraging habitats, and the ability of waterbirds to lay eggs and fledge their young, are fairly well documented by ecologists. Leslie used this knowledge to define the kind of habitat conditions contributing to four levels of breeding success: excellent, poor, abandon and nil. These were field-tested at nesting and foraging sites in the forest. November's attempted breeding event at Reed Beds Swamp, for example, would have been ranked as 'abandon'.

The next step was to determine what shape of river flow 'pulse' would create each set of habitat conditions. Once the timing, peak and duration of flow pulse has been associated with a level of breeding success, it's possible through computer modelling to see how many times each breeding outcome would be triggered over time.

Above: A belt of dead and dying river red gums lining the edge of Moira Lake, a response to near-permanent inundation.

Right: Permanent summer inundation has killed some 2000 hectares of river red gums at Millewa Forest, mostly in low-lying areas adjacent to the Edward River and Gulpa Creek. Because several trees in this area contain nesting hollows for the endangered superb parrot, special efforts are being made to protect them from the drowning.

Below right: A range of engineering solutions, has been used since the 1930s to try and control water movement through the floodplain. In some areas this has succeeded in protecting the timber resource, but rejuvenating the floodplain ecosystem will also require the reintroduction of more frequent flooding at a landscape scale.

This was done for a 101-year sequence of waterbird breeding at Millewa Forests – under current (1994 level of storage and diversions) and natural (no dams or diversions) flow conditions – using a computer model that simulates monthly Murray River flows.

Results of the modelling showed that under natural conditions breeding would have occurred in the forest almost every year. There were 20 'excellent' breeding episodes in the 101-year flow sequence.

Under current conditions, breeding occurred only four times a decade on average, with three excellent breeding events per century (see graphs on page 27).

Below: The yellow-billed spoonbill. Historically, the Millewa wetlands supported large colonies of waterbirds such as egrets, terns, ibises and herons. Some species, such as whiskered tern, intermediate egrets and little egrets, no longer breed there, and others such as great crested grebes nest in one or two remnant colonies. For wading species such as egrets, herons and spoonbills, the premature drying of shallow wetlands, particularly in late spring and early summer, has diminished food availability during critical breeding periods. The waterbirds may return to traditional nesting grounds near Moira Lakes if a suitable flooding regime is reinstated. A return to high, stable spring water levels during October and November, followed by gradual recession in December and January, are likely to satisfy their needs.

Bottom: Great egrets nest in large, spreading trees adjacent to Duck Lagoon, the most significant waterbird breeding site at Millewa Forest. Egrets need at least a four-month inundation of nesting and feeding areas to gain body fat, construct nests, mate and fledge young. All but two egret colonies in the forest have been abandoned.

In addition, the period between excellent breeding was more than double the 'natural' outcome.

Leslie's conclusion from the modelling is that river regulation can reduce the frequency of successful waterbird breeding episodes by 80% from the natural precedent, primarily due to the reduced occurrence of sufficiently high and suitably timed flood peaks, and reduced flood durations.

Using this knowledge, conservation targets can be set to ensure the persistence of waterbird breeding in the forest. For example, breeding should occur in four years out of 10, excellent breeding should occur twice a decade, and nil or abandoned breeding should never occur for more than four consecutive years. These targets can then be linked to guidelines, or 'river flow rules' that specify how much water to release, and when, subject to seasonal factors such as waterbird breeding history, river flows, and the needs of irrigators.

In quantifying the relationships between water flows and waterbird survival, Leslie has provided the Murray-Lower Darling Community Reference Committee with a means of assessing the ecological benefits of environmental flows against potential water losses to consumptive users.

Although the status of waterbirds is only one of many components of the river system that need to be considered in managing environmental flows, it provides a useful biological indicator because waterbird conservation can only be achieved by maintaining healthy and productive floodplain environments.

'Without firm evidence on which to support a call for the water, the needs of irrigators, who have no trouble demonstrating the economic benefit of their allocation, tend to win out when there are competing demands, such as during periods of water shortage,' Leslie says.

Pumping up the volume

The research also yielded a means of testing the capacity of the 100-GL Barmah-Millewa Forest water allocation to meet conservation targets for waterbird breeding, and the outlook is not promising. Leslie suggests 150 GL is a more realistic figure, with provision for its accumulation over time.

This finding is supported by the results of separate hydrological modelling in Victoria, and by the mediocre ecological response that followed release of the 100-GL allocation in 1998.

Leslie says the 1998 release was triggered by a large natural fresh that emanated from the Ovens River in September. The plan was to maintain a flow of 16 000 megalitres a day down-stream of Yarrawonga until the allocation was exhausted. Environmental releases were maintained for three weeks, inundating a quarter of the forest (15 500 ha) with water depths varying from 2.5 m in ephemeral creeks to 0.5 m in higher, forested areas.

'But the flood duration was only about four weeks and little waterbird breeding was recorded (it would have ranked as nil),' Leslie says. 'Another 300 GL would have been needed to sustain habitat conditions suitable for waterbird breeding.'

Victoria's Murray Water Entitlement Committee began tackling the provision of environmental flows, and the tightening up of Murray River diversions to meet the Murray-Darling Basin Cap, in 1996. Rules for diverters and the environment have since been written into Bulk Water Entitlements for Victorian Rural Water Authorities.

Freshwater ecologist Julia Reed was employed to develop environmental flow recommendations for the major Victorian Murray wetlands. She set broad ecological objectives for the forests based on processes such as fish passage, bird breeding, nutrient exchange and plant germination, and proposed various flooding scenarios to meet these targets. These were modelled along with the needs of other water users during the Bulk Water Entitlement process.

Her conclusion was that three, four-month floods were needed every 10 years, and no more than five years should pass without a four-month, low to medium level flood.

'The 100 GL allocation only keeps the flood up for a few weeks,' Reed says. 'The water level needs to be maintained at about 500-550 GL/m for three months, then tailed off to around 400 GL for another month.

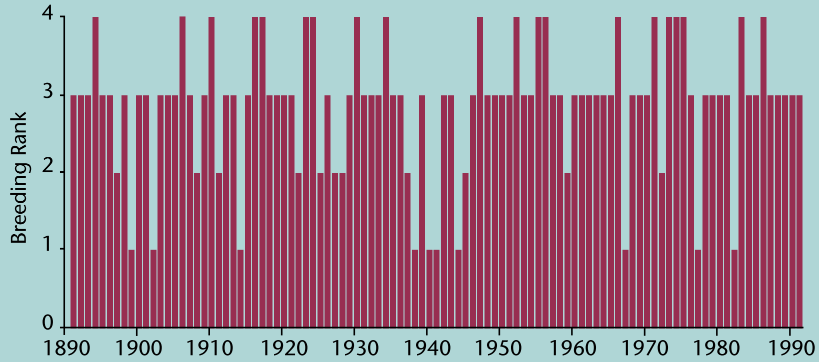
'We really need to save up the annual allocation in storage. When we modelled this, we found that if we saved up the 100 GL every year, and released it when conditions were right to top up a flood, we got fairly close, but we needed an extra 50 GL a year to break a couple of long, dry periods.'

Irrigators in Victoria have agreed to an extra 50 GL allocation in about eight out of 10 years, and to allow the allocation to be stored in Dartmouth and Hume dams in years when it isn't triggered. In return, they can borrow the saved up environmental water in dry periods, as long as they 'pay it back' in the years when the allocation is triggered.

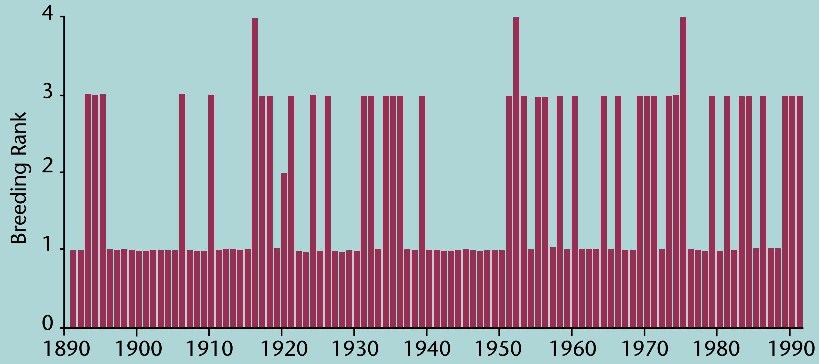
Right: The frequency of breeding under natural and current conditions was modelled for a 101-year period using established relationships between flow characteristics and breeding success. Results of the modelling showed that under natural conditions breeding would have occurred in the forest almost every year. There were 20 'excellent' breeding episodes in the 101-year flow sequence. Under current conditions, breeding occurred only four times a decade on average, with three excellent breeding events per century. The period between excellent breeding was more than double the 'natural' outcome.

Under a flow-sequence designed to balance consumptive water use and forest conservation targets, the frequency of excellent breeding events improves from three (under the current regime) to 19 per century. The maximum time between breeding events is reduced from more than 10 years to no more than five. Achieving this outcome, however, requires a larger environmental water allocation, and the facility to 'bank' unused flows from year to year.

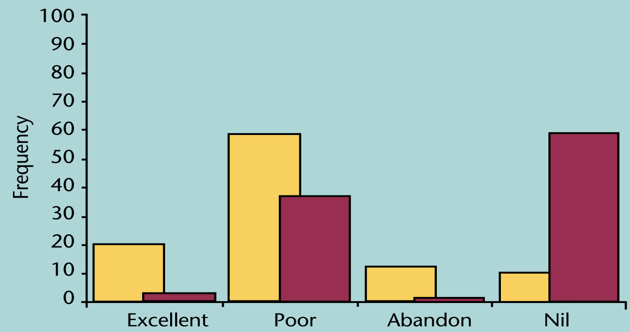
Waterbird breeding level predictions from the natural flow sequence (no dams or diversions)



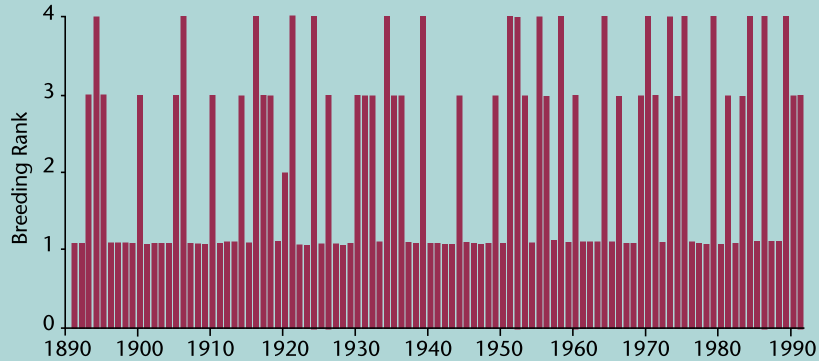
Waterbird breeding level predictions from the current flow sequence (1994 level of storage and diversions)



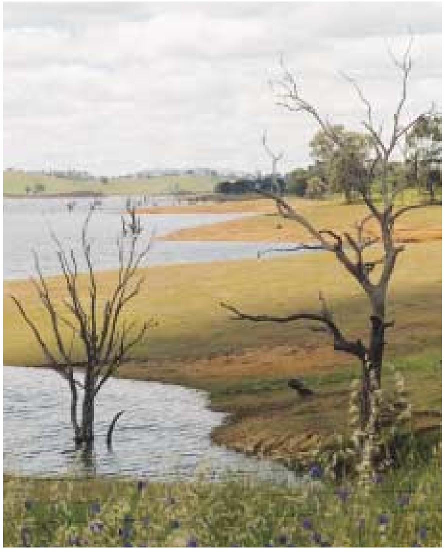
Waterbird breeding level frequencies obtained from the modelled natural and current flow sequences (101 years)



Breeding level predictions from the proposed managed flow sequence



NSW irrigators have also recently agreed to the extra allocation, according to a recommendation by the Murray-Lower Darling Community Reference Committee. Now it's up to an interstate forum hosted by the Murray Darling Basin Commission to arbitrate on the rules that govern water release.



Drying out

Just as important as boosting floods at Barmah-Millewa Forest is the need to reinstate periodic drying cycles. According to Leslie, wetting and drying go hand in hand.

'It doesn't serve much purpose to dry a wetland if it doesn't flood again,' he says. 'Similarly, it doesn't serve much good to inundate an intermittently flooded wetland if it doesn't dry.'

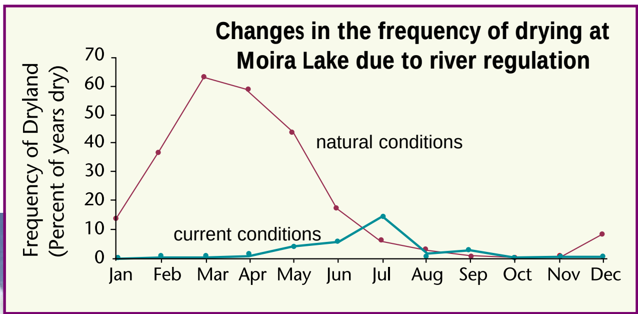
For example, wetland plants depend on wetting and drying cycles to germinate, grow and reproduce. When natural flow regimes are altered, water levels generally become less variable and some plant communities disappear while others prosper.

'At Moira Lake – where artificially high water levels have been maintained during summer since the 1930s – plants such as giant rush that "tolerate" water level fluctuations have been most advantaged, while others such as milfoil and wavy marshwort have been unable to reproduce without a drying period,' Leslie says.

The domination of giant rush may have contributed to the decline of some waterbirds by removing feeding opportunities along shallow fringes of the lake in spring and summer. And waterplants such as wavy marshwort used to provide nesting habitat for grebes and whiskered terns.

A natural drying phase is being reinstated at Moira Lakes under a rehabilitation plan developed by the NSW Murray Wetlands Working Group, NSW State Forests and the NSW Department of Land and Water Conservation. Regulators constructed along inlet channels to the lake enabled it to dry completely in the summers of 1997/98 and 1998/99, for the first time in several decades.

Significant vegetation changes have occurred in response to the drying. Terrestrial and semi-aquatic plant species have established on the lake bed from seed blown or washed in from the surrounding



What's 'natural' anyway? After 60 years of river regulation, local communities have grown accustomed to seeing high water levels and flooded wetlands in summer. In 1999, NSW Murray Valley irrigators received a fraction of their water entitlements due to a run of dry years and a subsequent lack of water in storage. While water levels at Hume Lake (above left) offered some clue to the prevailing climate, irrigation channels were full to the brim.

forest. Leslie says these will play an important role during the wetting phase as they are provide substrate for biofilms (slimy layers of fungi, algae and detritus) and a source of carbon (energy) for consumers. He says the re-establishment of aquatic plants will take longer because the seed bank has been depleted. An added challenge for forest managers is to manage the distribution of giant rush.

The response among waterbirds has also been positive, with a substantial improvement in abundance and diversity noted in recent times. This has been attributed to not only the 1998 and 1999 drying phases, but to the first release of the 100-GL water allocation in October 1998. The exclusion of cattle from the area, and the commercial harvesting of 10 tonnes of carp, have also helped.

Project officer with the Murray Wetlands Working Group, Paul Lloyd, says the idea of drying Moira Lake met considerable community opposition. While some negotiable concerns surrounded the maintenance of water supply to nearby landholders, others reflected the fact that people had grown familiar with the character of the regulated river.

'Because the river has been regulated for 60 years, an astounding number of people think that the lakes and swamps along the Murray River should always be full,' Lloyd says. 'It's a fundamental misconception of what is a natural state for a lake in inland Australia.

'I've been called an environmental vandal for trying to dry it (Moira Lake). It's been a long battle. I think it will take at least another 10 years of education before this concept is widely accepted and understood.'

More about birds and floodplains

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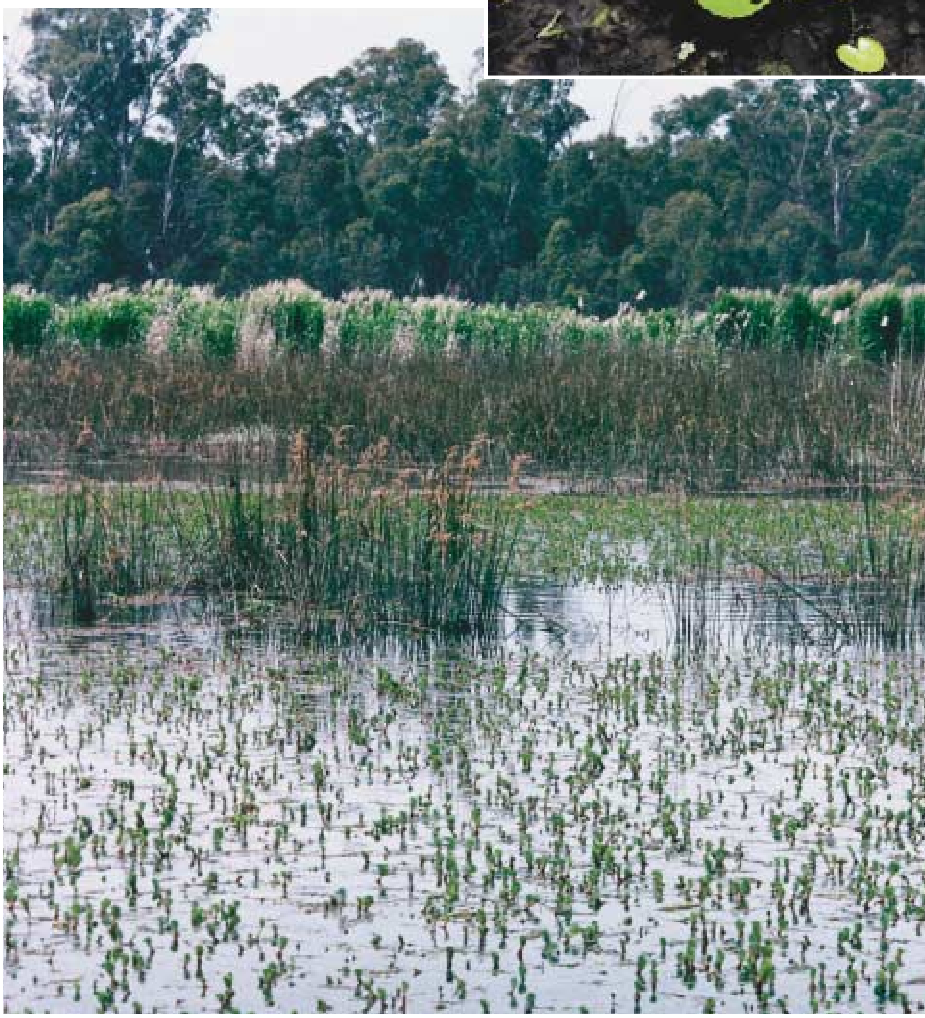
The permanent inundation of Moira Lake has disadvantaged water plants such as milfoil (bottom foreground) and wavy marshwort (below) which have been unable to reproduce without a drying period. These species once provided nesting habitat for swans, grebes and whiskered terns.



Abstract: Water flows to Barmah-Millewa Forest have for the past 60 years been attuned to the demands of irrigated agriculture and only partially to the natural rise and fall of the Murray River. This has reduced the frequency, depth and extent of natural winter/spring flooding, while increasing the duration of non-flood periods and unnatural flooding in summer. Initial efforts to temper the effects of river regulation aimed to protect the timber resource, but now it is recognised that the entire ecology of the floodplain is inextricably linked to river flows. A 100-GL water allocation for Barmah-Millewa Forest was agreed to in principle by the Murray-Darling Basin Ministerial Council in 1993, but research into the habitat needs of waterbirds suggests a larger allocation is required. River management committees in Victoria and NSW are considering how the extra water might be made available, and how to mange water releases for the best ecological outcome. The introduction of a drying phase at Moira Lake in the Millewa Forest has yielded positive results, despite the initial misgivings of the local community.

Keywords: Murray wetlands, wetlands, wetland ecology, river management, waterbirds, flooding, river flow, Murray floodplain, environmental management,irrigation, Barmah-Millewa Forest, NSW, Moira Lakes, NSW, Reed Beds Swamp, NSW.