CHAPTER TWELVE

The Murray flows the familiar Yangtse brown,
uniform of the Man river, worldwide.
It's a hundred years now,
nature and the cod have had mud in their eyes.

CHANGES TO RIVER FLOW

The coming of large-scale irrigation has brought new, artificial flow patterns to Murray-Darling rivers; patterns which bear little resemblance to natural flooding cycles. Under natural flow, winter and spring rain in the southern catchments delivered small or moderate floods to most rivers in most years; usually enough to spill out over the riverbanks, to wind through the maze of channels, billabongs and lakes and to inundate lower-lying areas of floodplain. Occasionally, perhaps one year in 10 or 12, a huge flood would roll down the rivers, spreading vast floods and wetting their entire floodplains.

But upstream water storages are now designed to capture water in wet months, when runoff is plentiful but downstream demand is low, and to release it again in dry months, when rivers would otherwise be low but when irrigators need most water. In summer, rivers are used as channels for delivering water to downstream users, often running bank-full, while in winter their natural high flow is diverted into storage.

TURNING OFF THE TAP

So where once the River Murray spilled out onto its floodplain three or four years out of every five, now the floodplain is thoroughly wetted perhaps only once a decade. Most other rivers in the Murray Basin have been similarly tamed. Small and moderate floods are mostly captured in reservoirs and stored for summer use; only very large floods have enough volume to overfill the storages and inundate downstream floodplains. In many places, particularly around towns, even such large floods are kept at bay by protective levees. In effect, much of the Murray-Darling system has been locked into a state of almost permanent drought.

Paradoxically though, and equally problematically, other areas of floodplain have been locked in a state of permanent flood. Long reaches of many rivers — such as the Murray and Murrumbidgee — have in-stream weirs and other storages, holding water levels high all year round, causing permanent inundation and raising groundwater levels for many kilometres upstream. Floodplains now are mostly either permanently wet or permanently dry: the crucial wetting-and-drying cycle that drives freshwater ecosystems has all-but ground to a halt. In some cases the natural flooding cycle is completely reversed, with high summer river levels spilling out over low-lying areas of floodplain. This is exacerbated when unseasonal summer rain falls in the southern Basin, causing river levels to rise as irrigators reject water already on its way downstream from storage. As well as being unseasonal, such summer 'rain rejection' floods are typically small, short-lived and infrequent.

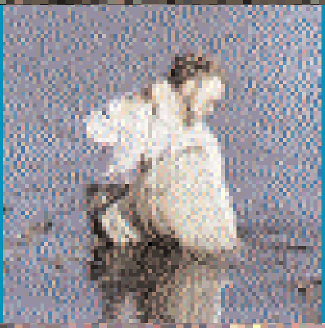
River regulation and the extraction of water for irrigation has had five main effects on river flood cycles, each of which has major, negative implications for floodplain health. First, it has greatly reduced the overall volume of flow in the middle and lower reaches of nearly all southern Murray-Darling rivers. Second, it has sharply reduced the frequency and size of small and moderate floods, halting them altogether in many streams. Third, in combination with alterations to floodplain waterways and vegetation, it has helped change the duration of floods, which in most (but not all) cases now drain away much faster than they once did. Fourth, it has changed the seasonality of flow in southern rivers, making floods less likely in winter and spring and high flows more likely at times of peak irrigation demand in late summer. Fifth, it has changed the long-term variability of flow.

Volume

The outright reduction in the amount of water now flowing through most inland waterways is perhaps the simplest problem to understand, and perhaps the hardest to address. Small and medium floods are now tapped from the system and put into storage, where once they would

Above: A giant centre-pivot spray applying water to maize and sorghum crops on the Hay Plain in south-western New South Wales.
Photos: *David Eastburn, MDBC*

Below: Flooding in the Barmah-Millewa Forests, the largest stand of river red gum in the world.



Taking water samples from a billabong to examine the populations and make-up of the microscopic zooplankton that it contains.
Photo: *David Eastburn, MDBC*

have flowed downstream and wetted the floodplains. Average outflow of water to the sea at the Murray Mouth has been reduced by more than 75 percent, almost entirely due to water allocated to irrigation. In effect the Murray, and many of its tributaries, have become much smaller rivers for much of their lengths. Floodplains, where they are not permanently submerged, are mostly left high and dry.

Large, fast-moving volumes of water still flow through some sections of river systems, shunted from one storage to another and using the intervening channels as pipelines. But most of the water spends most of its time in storages until it is dissipated for irrigation; it doesn't roll lazily downstream toward the sea in wide, seasonal sheets as it once did. Compounding the problem, low flows are often combined with higher than natural water levels, with weirs and other impoundments ponding rivers for long stretches. By holding water levels artificially high for long sections, locks and weirs often disguise how little flow is moving through a river.

There are also a few sections of river where the overall volume of flow has been significantly increased by regulation. The most notable is the stretch of the River Murray between Hume Dam and Yarrawonga Weir, which carries extra water redirected by the Snowy Mountains Scheme from the Australian Alps. The upper sections of the Murrumbidgee River also now carry larger volumes of water from the Snowy Scheme.

Frequency

Scientists believe that many of the tiny invertebrates that form the bottom of the river food chain originate on floodplains, and are washed downstream by floodwaters. So a collapse in the population of river invertebrates, and of other species such as fish which depend on them, may be at least partly caused by floods happening less frequently tens or hundreds of kilometres upstream. Similarly, less-frequent flooding means river channels may be starved of carbon and other important materials, which under natural flows are fed into rivers from inundated floodplains (Chapter 6).

Outside of the large river red gum forests, there have been few attempts to ensure wetting and drying of floodplains continues at something approximating the natural frequency. Large areas of floodplain have not been wetted since the exceptional Murray-Darling flood of 1974. Some of the species which take refuge in dried floodplain mud will undoubtedly now have perished in such areas, although the more resilient creatures may be able to survive for decades (and even centuries, some scientists speculate) between floods. The many species of native vegetation which depend on frequent flooding and drying have doubtless also suffered from reduced flood frequency.

Regulated river levels can rise and fall very quickly, depending on how much water is demanded and released, and this creates major ecological problems on floodplains. Rising water triggers many native species into starting their breeding cycles and awakens dormant organisms from the soil. Sudden falls put an end to such 'false starts'. (43) When rapid rises and falls occur repeatedly, as with irrigation releases, they can seriously deplete the number of species in resting stages in the floodplain soil. Rapidly fluctuating river levels, combined with catchment erosion, have also changed the shape of riverbeds, filling in deep river holes with sand and scouring away natural riverbank 'benches'. In reaches of river without floodplains, riverbank benches, or steps, flood and dry much as floodplains do, and represent much of the river's interaction with its surrounding landscape. Carving away such benches may damage emergent vegetation and may trigger many other changes. The long-term effects are unknown.

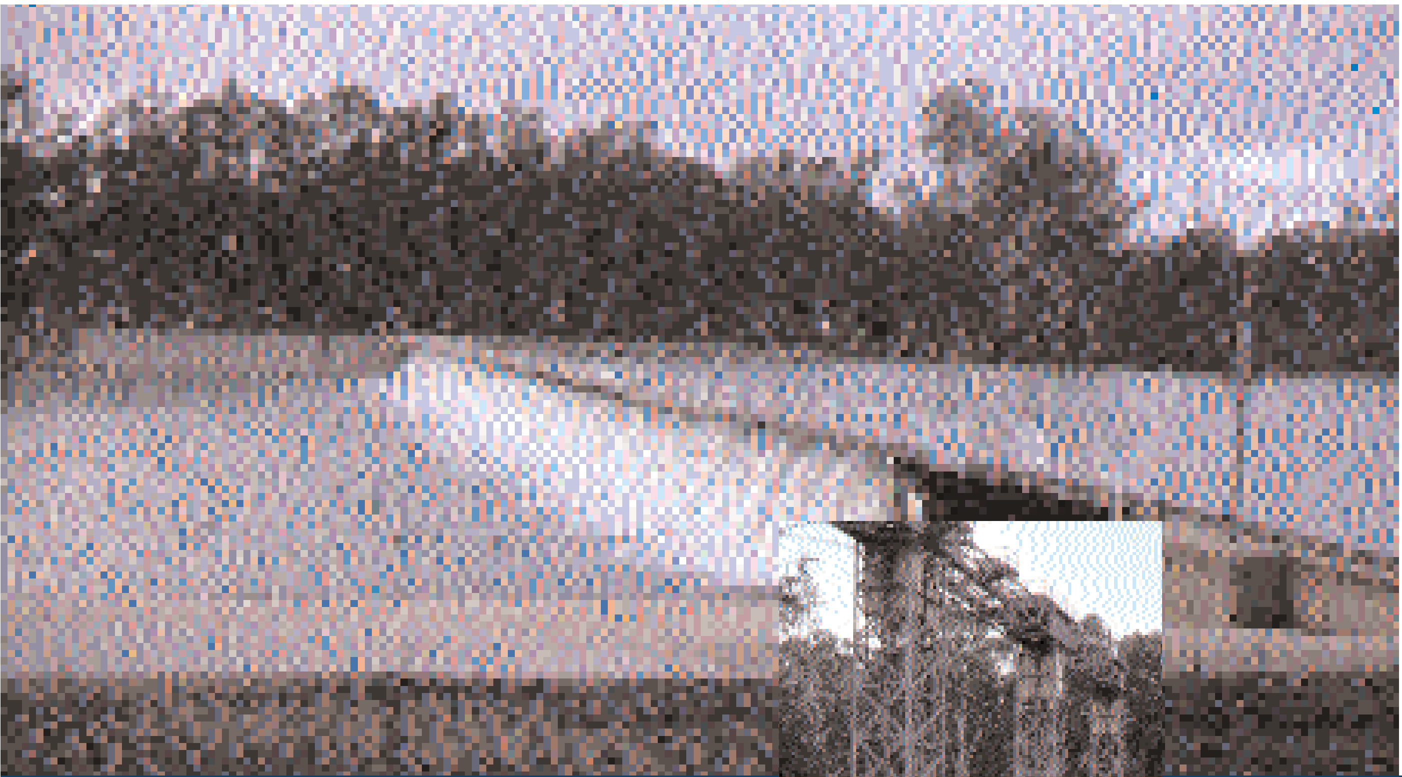
Large areas of Australia's inland floodplains have been deliberately excluded from frequent flooding by the construction of levee banks. When used extensively, levees can be self-defeating as flood control measures. They can raise the height of floods and redirect water, rather than prevent floods. In the past there have been few controls on levee banks, and in some areas their construction has been heavily subsidised by local, State and Federal governments. The annual, Australia-wide bill from flood damage now runs at between $250 and $350 million a year, mostly from over-bank floods. Until now the term 'floodplain management' has been largely a euphemism for building levees to protect urban and rural property, and to reduce the frequency of floods. Between 1970 and 1990, across the whole of Australia, the Federal Government spent about $145 million on such efforts. (44)

Duration

The problem of shorter-than-natural floods is little recognised, but may be one of the greatest challenges facing managers of Australia's inland river systems. Floods that once spread out over wide fronts and took many months to recede now drain away in just a few days or weeks. There are many reasons for the faster drainage. For example, many wetlands which once slowed receding floodwaters have been cleared or grazed, or have dried out and vanished.

Largest recorded floods (in terms of river height).

River	Location	Order of floods (largest first)				
Murray	Albury	1870	1917	1975	1974	1931
Murray	Mildura	1870	1956	1931	1917	1975
Darling	Bourke	1864	1890	1976	1974	1950
Murray	Morgan	1956	1870	1931	1917	1974



A run of dry years from 1895, culminating in a record drought in 1902, prompted the signing of the River Murray Waters agreement in 1915 by the Commonwealth and State governments. This provided for the construction of storages, weirs and locks to increase the security of water supply. Mildura (above) and Maude weirs. Photos: *David Eastburn, MDBC*

Similarly, floodplain levees, channels and other earthworks often funnel water more rapidly back to the river. However, probably the single largest factor making floods briefer is river regulation and the extraction of water. The floods, which under natural flow conditions would once have given floodplains a thorough, long-lasting wetting, are mostly held in reserve and released only as needed by irrigators.

How long floodwater lies on the ground before it recedes can have a profound effect on what species can take advantage of it. For example: many researchers believe floodplains are important breeding sites for fish (Chapter 10). However, the first flush of water flowing through the leaf litter on the floor of a red gum forest can carry so many toxins leached from the eucalyptus leaves that it is actually lethal to fish. (45) It is possible fish must wait for the toxins to be broken down and diluted before the floodwater is suitable for their young to live and feed in. And perhaps water must lie on the floodplain long enough for young fish to reach a suitable size to survive in the river channel.

Similarly, birds breeding in floodplain wetlands need time to raise their young before the waters recede. Most Australian waterbird species are opportunists: highly adapted to breeding in temporary water. It means they are well able to find new water-bodies and nest near them, but that they are also cued to abandon their nests and move on when the floodwater they have colonised begins to dry. Similarly invertebrate resting stages may revive from the dried mud, seeds may germinate and animals may begin to breed, only to have their cycles cut short by the untimely disappearance of floodwaters.

It is very difficult to be precise about how much more quickly floodwaters now recede, because no two floods are alike. However, what evidence there is points to a dramatic acceleration. For example, a daily 50,000 megalitre flow in the River Murray as it enters South Australia is sufficient to inundate some 30 percent of the Chowilla floodplain. Before regulation a flow that size or bigger happened about every second year, and took three months to recede. But in the modern river a 50,000 megalitre flow happens only about one year in three, and takes just six weeks to recede. Similarly, a 100,000 megalitre flow happened about once every three years at Chowilla under natural conditions, and took three months to recede. Under regulated flow a 100,000 megalitre flow happens only once every 10 years, and takes two months to recede. (46) Similar trends have been noted in the

Barmah-Millewa forests, along the Darling River, and elsewhere.

With duration, as with so many other aspects of regulated flow, there is a further paradox. In some river sections water managers have lengthened the duration, but lowered the height, of inundation by pre-releasing water from storages in anticipation of coming flood peaks. Such pre-releases are usually aimed at reducing the damage caused by high floods to downstream floodplain users. They can cause floods to lie longer over low-lying areas, while leaving higher sections of floodplain dry.

Artificial weir pools and storage reservoirs are very different environments from natural, flowing rivers, and support a different mix of species. Weir pools and low-flow rivers also promote cyanobacterial (blue-green algal) blooms, which thrive in slow-moving, warm water. Water held in storages in summer promotes cyanobacterial growth by forming into layers of different temperature, with a warm layer on top and cooler water beneath (Chapter 17).

Seasonality

Most of the native species of inland Australia are part seasonal in their breeding behaviour, and part opportunistic (Chapters 7, 9 and 10). Some lean more toward opportunism, and can take advantage of floods at any time of the year, while others are more strictly seasonal and depend on floods in late winter and spring. The modern pattern of unseasonal water releases from upstream storages, along with in-stream impoundments, has sharply reduced the frequency of winter and spring floods, and has subjected some areas of floodplain to prolonged, or even permanent, summer and autumn flooding.

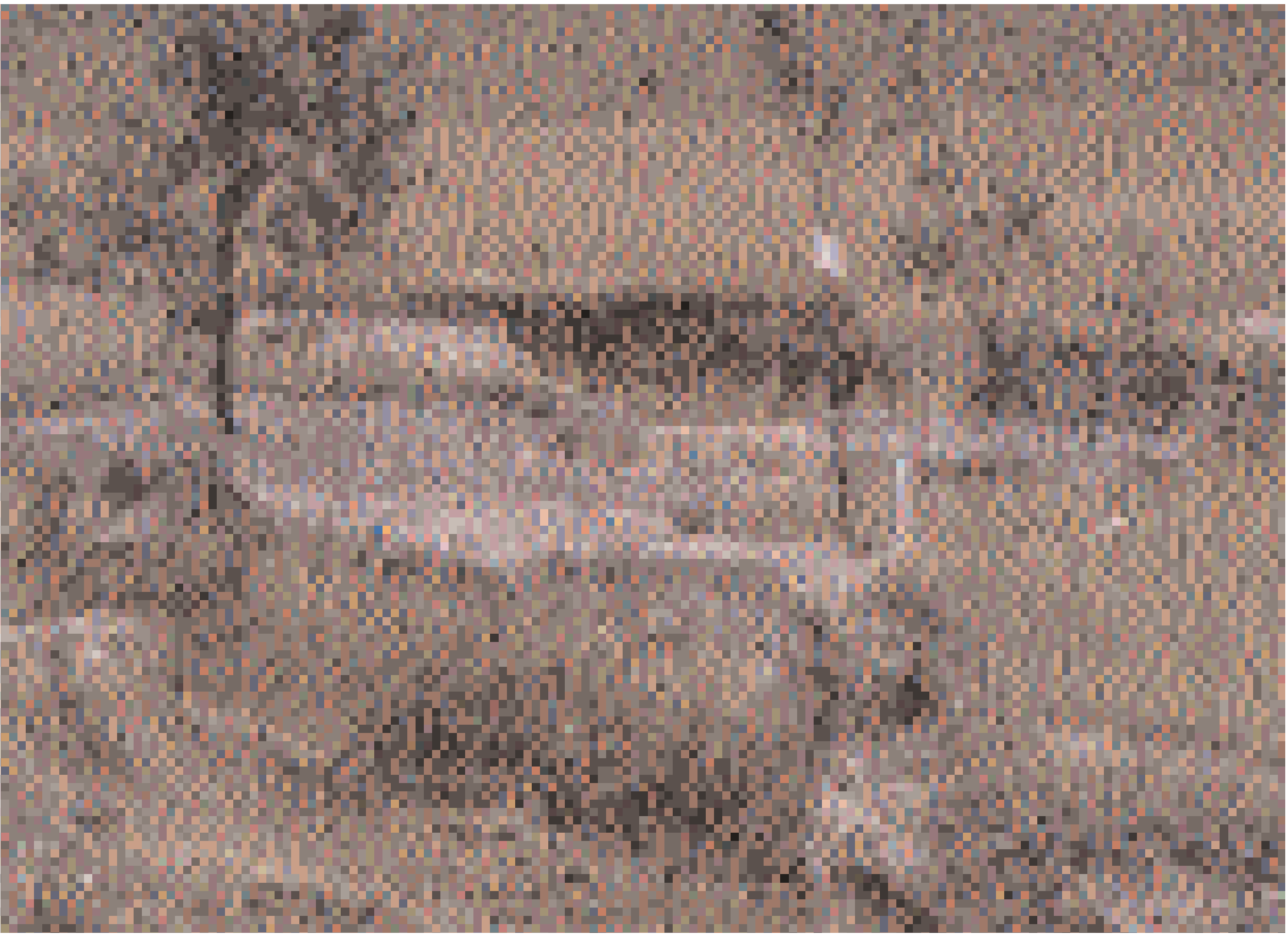
The cumulative impacts are extremely complicated, and they affect different stretches of river quite differently. For example: all native fish produce sperm and eggs every spring; but some will not go on to spawn unless conditions are right. Inflowing floodwaters trigger upstream migration to breeding areas by golden perch. So for many native fish to breed, floods need to come at the right time of the year. A mid-summer flood may not help a species that is geared to spawn in early spring. Introduced fish such as carp, by contrast, need no such flooding signal to begin their seasonal breeding. They produce young every spring, regardless of the level of flooding, and — as with native fish — their larvae are able to take advantage of floods when they do occur.

Studies in river red gum forests have shown that populations of the small invertebrates which feed on wetted leaf litter boom just as spectacularly during summer floods as they do during winter and spring floods, but that the order in which different species appear is different. Similarly, wetting will always cause a swarm of tiny creatures to awaken from eggs and other dormant stages in dried floodplain mud, but experiments have found that cooler floodwaters hatch a different mix of species, and in a different order, than warmer waters. The ecological effects are unknown, but may be important.

Similarly, floodplain plants flower seasonally, and some species depend on floods to distribute their seeds or to water their seedlings. Floods coming at the wrong time of year may not suffice. Although adult river red gum trees can thrive with short summer floods, much of the rest of the floodplain ecosystem probably depends on earlier seasonal wetting. For example, some scientists believe it may be very important for fallen eucalyptus leaves to lie on the dry floodplain and be 'conditioned' for several months, with rainfall leaching out the toxins they contain, before they are wetted. Summer flooding cuts short this conditioning — with unknown effects up the food chain.

Researchers on the Bogan River surveying to determine the genetic variability in native fish populations. Photo: *David Eastburn, MDBC*

Studies of sediment cores in billabongs indicate that erosion in the Murray-Darling Basin has increased markedly since European setlement. Photo: *David Eastburn, MDBC*



Reservoirs are deeper than rivers, and the water they hold tends to be colder and, especially when it is released from the bottom, less oxygen-rich. Reservoir water also develops a different chemistry from river water, and supports different microinvertebrates. Rapid rises and falls of oxygen-starved, cool water downstream of storages can have quite dramatic effects on the ecology of river channels. Native fish shun such areas, and floodplain species, such as yabbies and floodplain mussels, move into areas formerly inhabited by their river-channel 'pairs' (Chapter 5). In general, summer floodwaters are higher in toxins and lower in oxygen than winter and spring floods.

Variability

Although water levels in many river reaches may now rise and fall very swiftly, over the longer-term flow in most Murray-Darling rivers is now much less variable than it once was. Weirs and other impoundments hold water levels high in summer, and in southern Basin rivers water held in storage is released to maintain a minimum flow during droughts. In most cases the overall volume of flow has been sharply reduced, but what remains is managed so that the rivers never dry into chains of ponds as once happened.

Regulation has not choked off variability altogether. Occasionally very large floods still surge through the system, swamping storages with far more water than they can contain or control. But aside from such rare events, floodplain species are now confronted with something that was entirely absent in the natural system: certainty. And for species adapted to conditions of constant uncertainty, certainty may be deadly.

In the short-term, certainty removes the competitive advantage held by native floodplain species. Native species have evolved to thrive on the boom-and-bust variability of natural flow. With that variability removed, Australian rivers have become very much like rivers elsewhere in the world — so the same species that dominate rivers elsewhere have also begun to dominate in Australia. Regulation has turned the Murray and its tributaries into their kind of river system (Chapter 7).

In the long-term, some scientists are worried that a less variable flow could undermine the genetic diversity of even those native species which survive the new regime. They argue that a highly variable environment breeds high diversity among its inhabitants — to survive, a species must be genetically equipped to cope with just about any eventuality. A variable environment, they say, is reflected in variable genes; a uniform environment in uniform genes. Precious genetic diversity could be lost over successive generations if variability is lessened. Recent research findings that golden perch populations in different Murray-Darling tributaries are genetically distinct lend weight to such fears.

Total Murray-Darling Basin annual diversions (excl. Queensland), 1930–31 to 1990–91