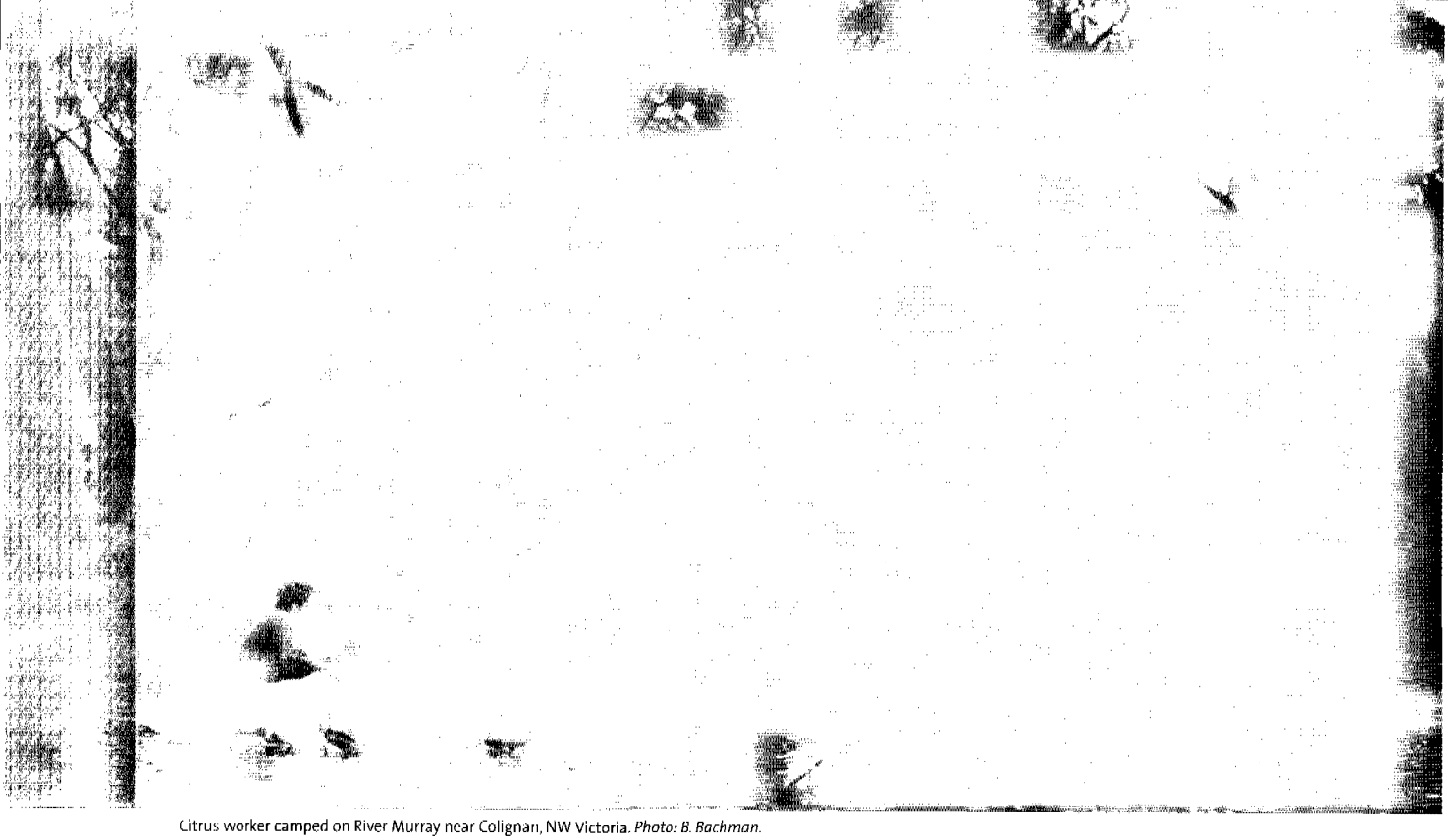
CONSERVING NATURAL RIVERS

A Guide for Catchment Managers

COOPERATIVE RESEARCH CENTRE FOR
FRESHWATER ECOLOGY

River Management Series Part 1



Citrus worker camped on River Murray near Colignan, NW Victoria. *Photo: B. Bachman.*

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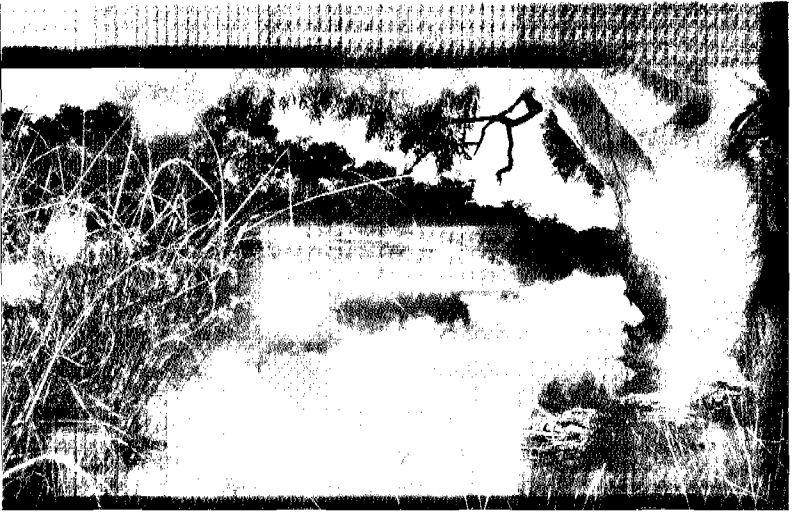
Table of Contents



Relatively undamaged rivers like the Paroo River provide important benchmarks to compare more modified rivers with. *Photo: A. Tatnell.*

Australia's rivers and wetland systems contain unique plants and animals that are adapted to the varied riverflows.

Undamaged reaches of rivers are now rare in the agricultural areas of Australia. Many people realise the importance of protecting the few undamaged rivers and wetland systems that remain.

But why should we maintain undamaged rivers and wetland systems? How do we identify ones worthy of protection and how do we manage them once we identify them?

It is far cheaper for society to prevent degradation in the first place, than it is to try and restore degraded systems.

Why Protect Undamaged River Systems?

There are four main reasons why we need to protect undamaged river systems:[4]

- To provide "seeding" sources to help re-colonise areas that have been damaged.
- To provide benchmark reference areas so we can assess how much our managed rivers have departed from the natural condition. Just as you would expect a doctor to compare a patient's blood pressure with normal levels, it's important to be able to compare damaged rivers with undamaged ones.
- To protect the freshwater species that live in these rivers. These organisms are of value in themselves, and the freshwater communities provide essential and often irreplaceable genetic material and ecosystem services.
- To meet our international biodiversity obligations (Australia signed the International Convention on Biological Diversity of 1992 in June 1993).

The Animal or the Community?

Are we trying to maintain icon species like Murray cod or silver perch, or are we trying to conserve whole communities of freshwater plants and animals? While it may be easier to gather community support for conserving icon species, it is not possible to maintain icon species in isolation, separate from their communities, food sources or habitat.

Focusing our conservation efforts on severely threatened organisms, and developing expensive recovery plans that may not work, could mean Australia has the best-documented extinctions in the world.

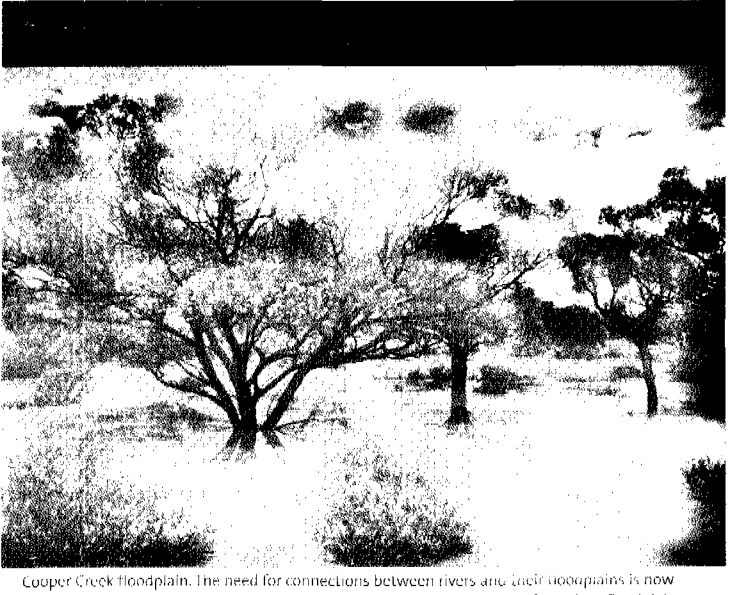
Rivers, their floodplains and their estuaries or terminal wetlands must be thought of and managed as a single system.

Assessing Change

As our community invests to improve catchment management, to restore more benign flow regimes to our rivers and to remove weirs and provide fish ladders and freshwater habitat, it is important that we develop clear aims for these investments. This will enable us to measure progress so as to ensure our investments are cost-effective, to learn from our experience and to develop best practice.

A central part of this assessment process requires us to have undamaged reference areas set aside and managed effectively so that we have something to compare treated areas with. There are very few such rivers left in the agricultural regions of Australia.

Black swans and yellow-billed spoonbills in a lower Murray wetland, Mannum, SA. The long-term survival of wetland bird populations depends on the timing and duration of floods. Some waterbirds may abandon their nests if floodwaters recede too quickly. *Photo: D. Eastburn.*



Cooper Creek floodplain. The need for connections between rivers and their floodplains is now appreciated. During high flows, rivers are seeded with biological material from their floodplains. *Photo: R. Ashdown.*

Connectivity and Seeding

Rivers are linear systems and to stay healthy, they need to be seeded with biological material from intact reaches and their floodplains. The need for connections, both up and downstream and cross-ways, is now appreciated.

Rivers need upstream areas that are connected with the downstream, and not isolated by weirs. The channel that carries dry weather flow needs to be connected with the floodplain during high flows. These connections are important to allow biological material to move up and downstream, to move between the river channel and the floodplain and to move between the channel and the groundwater below.

During high flows, the river and its floodplains are recharged and replenished. The floodplains are flushed with a fresh supply of water containing nutrients and sediment and fish move onto the floodplain to feed.

Protecting selected tributaries in highly modified systems may be important to provide material to colonise areas being rehabilitated.

Ecosystem Services

The environment provides a range of "ecosystem services". Healthy river-floodplain systems:

- provide habitat for species of commercial, aesthetic and recreational value;
- provide aesthetic and recreation services;
- provide fresh water, for domestic supply, irrigation and other purposes;
- mitigate floods, by holding back water on floodplains and in wetlands; and
- remove sediment, nutrients and other pollutants, through riparian filtering, sedimentation and other mechanisms.

The capacity of rivers and their wetlands to provide these ecosystem services depends on the biodiversity of the system. We have learned that when we simplify a freshwater system by transforming a flowing river into a series of weir pools we lose biodiversity, opening up the system for domination by exotic invasive species like carp or other undesirable organisms such as blue-green algae.

Conserving a wide suite of organisms in an ecosystem ensures there will always be some than can do well under any particular conditions of flow, nutrient status, temperature and light conditions. As our water management activities stabilise flows and limit the number of habitats, we lose species and create freshwater monocultures that may not contain any organisms to take advantage of particular conditions that later arise. This puts the system at risk of domination by undesirable species, and this may then be impossible to reverse.

Part of this problem is our ignorance of both the species we might lose, and how they contribute to the functioning of the entire ecosystem. Who would have thought that a simple fungus might be critical until penicillin was discovered? We just do not know what services many of the organisms at risk might be able to provide us with. Our ignorance is more profound at the ecological community level.

Paul Ehrlich provided an analogy between losing biodiversity and losing rivets in an aeroplane wing. Imagine you are about to board an aeroplane. As you are approaching the aeroplane, you see a worker removing rivets from the aircraft wing.....We can lose a certain number of rivets and the aircraft will keep flying; lose more and it may crash. Once

Healthy river systems provide a variety of 'ecosystem services', including fresh water for domestic supply, irrigation and other purposes. *Photo: MDBC.*

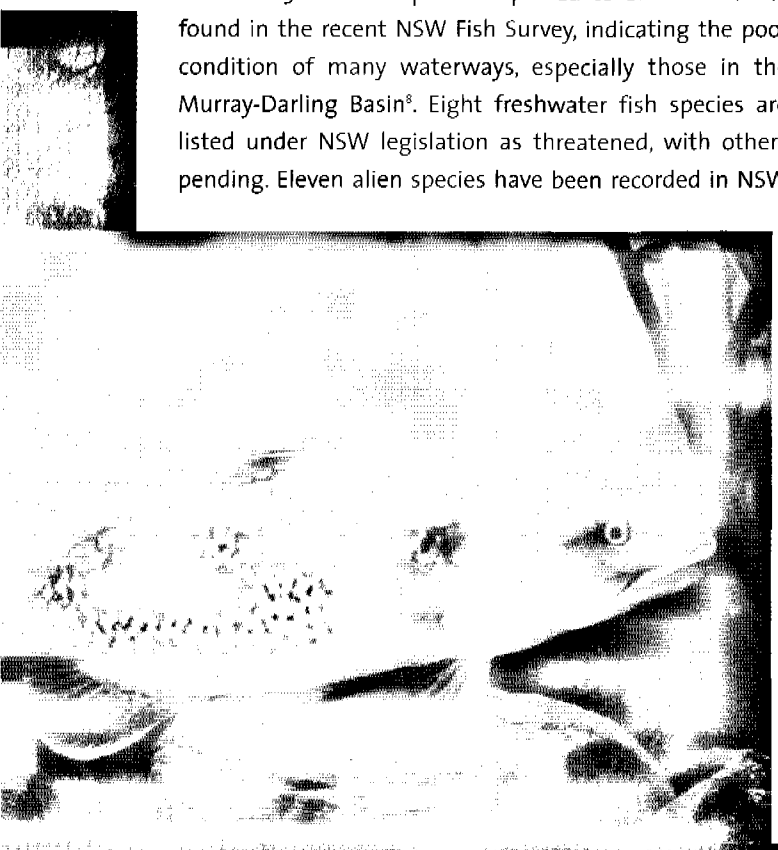
crashed it is not possible to put back together again. And just how many rivets can we lose and keep flying?

With biodiversity, we don't know how many species we can lose and still have a functioning river system, or which ones are the key species to keep.

The State of Freshwater Biodiversity

The Australia State of the Environment Report 2001 spells out what we have already lost[3]. Of the 208 frog species in Australia, 20 are considered endangered and seven are vulnerable. Of over 200 freshwater fish species in Australia, 11 are considered endangered and 10 are listed as vulnerable under the Environment Protection and Biodiversity Conservation Act. Thirty-five exotic fish species have become established in inland waters, with eight identified as having a significant adverse effect on biodiversity. Fifty seven species of freshwater Crustacea are regarded as threatened. Some of the larger freshwater crayfish species are under considerable pressure from habitat loss and overfishing, and appear to have been lost in the Lower Murray[5]. Numbers of platypus seem to have declined or disappeared in many catchments but reliable information is not available.

In NSW 25% of the species expected to occur were not found in the recent NSW Fish Survey, indicating the poor condition of many waterways, especially those in the Murray-Darling Basin[8]. Eight freshwater fish species are listed under NSW legislation as threatened, with others pending. Eleven alien species have been recorded in NSW



Australia's native fish species are endangered or vulnerable. *Photo: G. Schmida.*

The River Murray, a highly regulated river system.

inland waters, most again in the highly regulated Murray-Darling Basin.

Main Threats to Freshwater Biodiversity

- Habitat degradation, including loss of connectivity;
- Exotic species;
- Over-exploitation;
- Secondary extinctions; and
- Pollution.

Habitat Degradation

We have degraded freshwater habitats in a number of ways:

Desnagging – Large woody debris (snags) were removed to aid navigation and flood control and to provide recreational benefits, but snags provide critical habitat for a variety of organisms. Desnagging is rarely practiced nowadays, but the legacy of the past remains. Destruction of riverside (riparian) vegetation has removed the supply of woody material to many streams.

Loss of connectivity – Large dams fragment the essential connectivity of rivers and prevent the pulses of small to medium floods that stimulate fish and bird breeding and ensure wetting of riparian wetlands. The dams block fish movement, leading to fragmented populations vulnerable to disturbance. Dams also commonly lead to cold water plumes downstream if deep bottom water is released, and these plumes can impact the biota for hundreds of kilometers downstream. The dams trap sediment, nutrients and detritus that previously flowed to downstream sections.

Weirs – Weirs are placed across rivers to raise water levels to assist in extracting it by gravity, or for other purposes, but weirs block fish movements. Of the 53 native freshwater

Water release from Hume Dam. Cold water releases from the bottom of dams pose a major threat to native fish. In some rivers, the shock of the released cold water not only slows the fish's growth, but can stop fish breeding, leading to local extinctions. *Photo: J. Hawking.*

species in NSW, 28 undertake large-scale migrations and 16 migrate on local scales[x]. There are over 4,300 physical barriers to fish migration on NSW waterways, and some 26 effective fishways.

Weir pools provide ideal habitat for algal blooms and carp. They often maintain adjacent wetlands in a permanently wet condition, which can damage ecosystems adapted to wetting and drying. They raise local groundwater levels, increasing the risks of salinisation.

Alterations to flow regime – Water is stored in dams in wet periods so it can be released for human uses in dry periods. This can lead to flow reversal, where rivers run low in winter and run bankfull in summer. The extraction of water can greatly reduce overall flow.

Levee banks – Levees have been constructed to protect areas from flooding, but have served to disconnect the river from its floodplain with significant wetland loss and impacts on fish and bird breeding. We know that during floods fish move out onto the flooded floodplain for feeding and that floods stimulate high levels of production of plants and animals.

Poor riverbank vegetation and eroded banks. Goodradigbee River at Wee Jasper, NSW. *Photo: P. Sloane.*

Destruction of the riparian zone – Riverbank vegetation is a critical part of the river habitat, influencing light and temperature in the water, and providing organic matter as leaves fall. It also provides a filter for nutrients and sediment that might enter the stream from adjacent farmland or logged forestry areas. In many areas we have allowed grazing to destroy this vegetation altering the stream conditions and leaving banks exposed to erosion during high flow events.

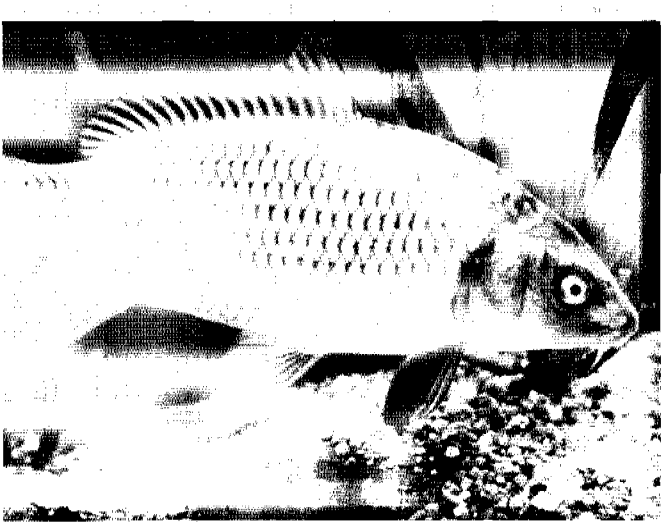
Loss of riverine wetlands – Terminal wetlands are lost when too much water is removed, as is happening with the Narran Lakes in NSW. In other cases, water level manipulations mean that wetlands no longer experience the wetting and drying cycles under which the organisms present have been selected. In other cases, grazing of the wetland by stock leads to a loss of freshwater plants which are replaced by algae, which might then seed algal blooms in the river downstream.

Exotic Species

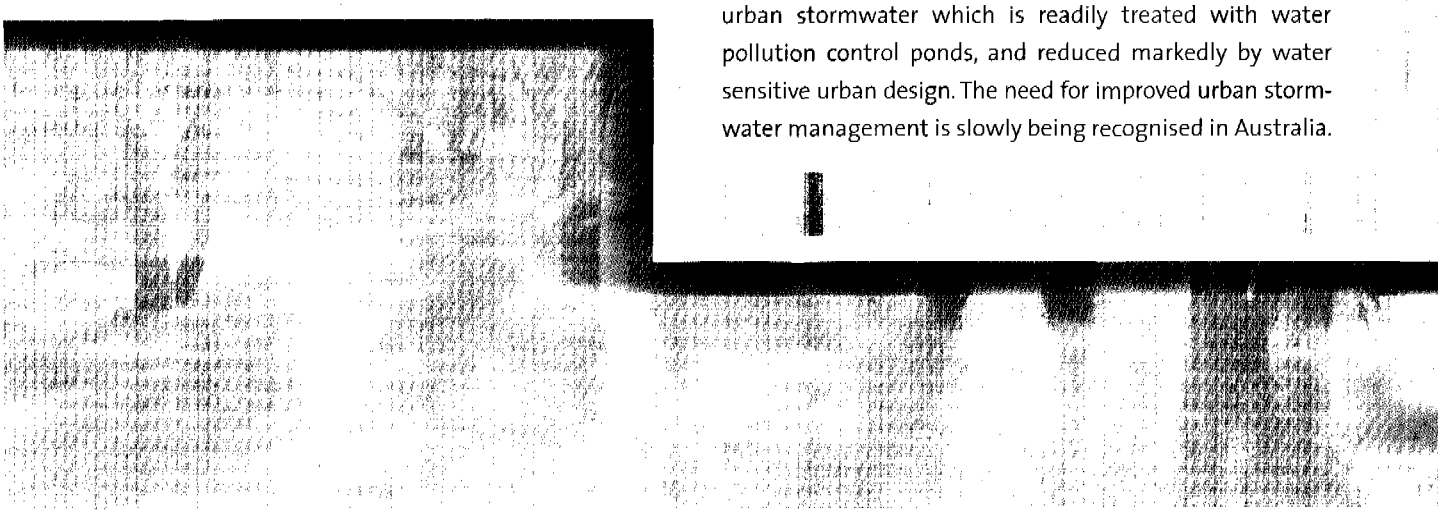
Australia has a long and disastrous history of accidental or deliberate introduction of exotic species that have displaced native species. We are still stocking trout to provide a recreational fishery. There is strong evidence that these exotics have had significant impacts. Similarly plants like water hyacinth, willows and blackberries have certainly had major impacts and are being removed in some catchments.

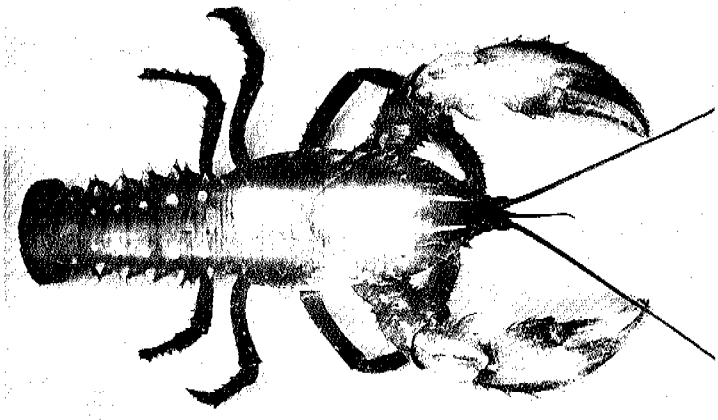
Carp have been a very successful invader and are favoured by constant water levels. They impact on native species and dominate the biomass in the highly regulated Murray-Darling system. They make water more turbid by stirring up sediment as they feed, and uproot freshwater plants.

Australia has inadequate controls over exotic aquarium fish. Many exotic species are imported from Asia and fish and plants used in aquaria are often released into waterways, and sometimes establish pest populations. The Oriental Weather-loach seems to have been introduced to streams around Sydney, Canberra and Melbourne in this fashion.



ed to Australia in the 1850s, are now our most abundant large freshwater fish.
ired by constant water levels. (*Cyprinus carpio*). *Photo: Bureau of Rural Sciences.*





Once abundant throughout the Murray and Murrumbidgee Rivers, the River Murray crayfish is now uncommon in the lower Murray system.

Over-exploitation

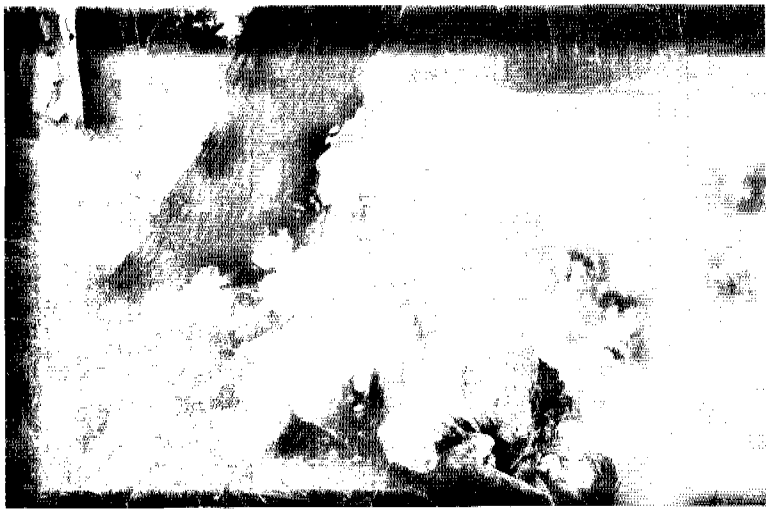
Commercial and recreational fishing exert a major pressure on certain species, and are one of a number of factors thought to have led to the marked reduction in Murray cod, Yabbies, River Murray crayfish and possibly Silver perch. Restocking of mostly native fish is undertaken in all eastern states and territories although with varying success. The loss of genetic diversity and introduction of diseases into wild fish populations have occurred as a result of restocking in some areas.

Secondary Extinctions

Removing a species can have impacts on other species'. We are not aware of any documented examples for freshwater in Australia, although there are terrestrial examples. It is likely that the changes to biofilms in the Lower Murray may have contributed to the widespread decline of freshwater snails. We expect the loss of native fish in the Murray to have secondary impacts on some mussels, which are dependent on fish for part of their life cycle.

Pollution

Environment protection agencies in Australia have helped to raise the standard of sewage treatment and replace septic tanks with sewage systems in towns. This reduces organic, nutrient and microbial pollution. Catchment management is starting to address the issue of sediment management through land management and riparian vegetation. Similar attention is now needed to manage urban stormwater which is readily treated with water pollution control ponds, and reduced markedly by water sensitive urban design. The need for improved urban stormwater management is slowly being recognised in Australia.



The Lindsay River, a healthy anabranch of the Murray, west of Mildura. *Photo: B. Bachmann*

Today, the big challenge for pollution control agencies is the non-point pollution of materials washing off farmland, and they have been surprisingly reticent to engage in this massive problem. While most farmers are keen to use sustainable land use practices, some farmers still dump massive amounts of nutrients, organic matter, agricultural chemicals, sediment and salt into waterways. These pollutants are a major cause of algal blooms, stream degradation and the loss of biodiversity.

Salinisation has now been recognised as a major national problem. Increasing salinisation of waterways will lead to a loss of freshwater plants with significant flow on to many organisms that depend on wetlands. Our knowledge of the effect of various levels of salinity at different life stages of freshwater organisms is poor. This knowledge is needed to set realistic salinity targets to guide catchment actions. The degradation to freshwater ecosystems from out-of-control salinisation is evident in many Western Australian streams.

Decisions for Regional Catchment Authorities

Regional catchment authorities are being established in most States, and they have very differing financial and knowledge-based resources, and differing powers to manage their catchments.

These catchment authorities provide a forum for the diverse interests that seek to use our waterways for extractive and other uses. In many situations they are the conduit by which State and Federal funding is being delivered to provide for on-ground works to improve catchment and river health. Given the variety of factors that lead to a loss in freshwater biodiversity, these organisations face a range of ways they can intervene if they wish to achieve some positive biodiversity outcomes.

Do you have a River of Regional or National Value?

Relatively undamaged river systems are unusual in the settled parts of Australia, making them especially important and warranting protection. This is clearly something in the national interest that regional community groups could take on board and make happen. One of the reasons taxpayers funds are available for catchment management is to invest in such issues of national priority. This is recognised in the priority activities for funding under the Rivercare program in the Natural Heritage Trust.

There are four approaches to decide whether you have a river worthy of protection:

- Check the assessments of waterway condition in the National Land and Water Resources Audit, which will give you a measure of the biota and an assessment of the physical health (National Land and Water Resources Audit Office, Phone: 02 6257 9516; Email: atlas@nlwra.gov.au; Web Site: http://www.nlwra.gov.au.
- Check any state agency water plans or other reports that might have assessed the quality of waterways. For instance, in Victoria the Victorian River Health Strategy spells out the State interests in protecting undamaged rivers and restoring mildly damaged rivers.
- Get some ecologists to conduct a reconnaissance survey to give you a direct assessment.
- Look at the river yourselves to see how apparent the major threatening processes are. The common ones are listed in Table 1. A river is not excluded from protection if it has some of these activities, but they may be causing damage and warrant management attention.

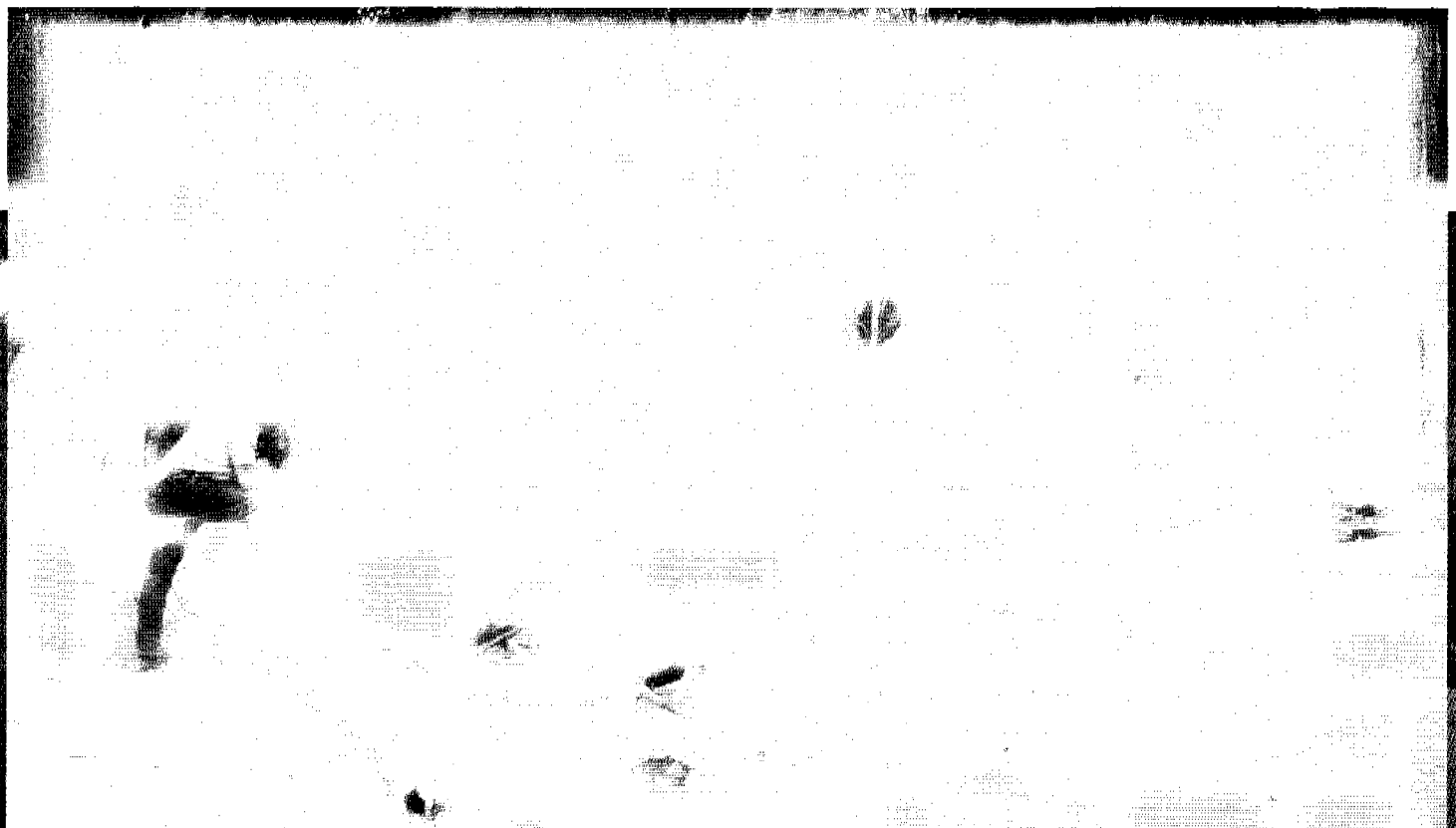
Table 1. Catchment Activities that Threaten Natural River Systems

Activities
Removal of snags
Building bank stabilization works
Building dams or weirs
Extracting water that changes flow patterns
Isolating river from floodplain with levees
Grazing of riparian vegetation and wetlands
Introduction of exotic plants and animals
Excessive fishing pressure
Urban stormwater or sewage contamination
Contaminated agricultural runoff

The National Land and Water Audit has given us a national survey of waterway condition throughout most of the agricultural and urban areas of Australia. It shows widespread damage to our river systems[3]. Most States have now identified some rivers that are relatively undamaged, and recognised the importance of protecting them from further development, but at this stage the legislative means for giving ongoing protection is weak.

Salinisation is a major national problem. *Photo: D. Eastburn.*

Regional catchment organisations could initiate working with State and Federal agencies to identify their freshwater ecosystems that are still relatively natural and intact. They need to ensure that at least a representative sample of such rivers is protected. In view of the degradation, this really means identifying any remaining undamaged rivers and ensuring appropriate management of the entire upstream catchment protects them. If this is not done adequately such plans may not achieve accreditation for funding.



Overlooking a branch of the Edward River, Millewa Forest. *Photo: A. Tatnell.*

The relatively unregulated Broken River, Victoria. A healthy river maintains the connections between the river, floodplain and Wetlands. *Photo: P. Humphries.*

Characteristics of an Ecologically Healthy River (from Victorian River Health Strategy, 2002)

An ecologically healthy river will have flow regimes, water quality and channel characteristics such that:

- in the river and riparian zones, the majority of plants and animal species are native, and no exotic species dominate the system;
- natural ecosystem processes are maintained;
- major natural habitat features are represented and are maintained over time;
- native riparian vegetation communities exist sustainably for the majority of its length;
- native fish and other fauna can move and migrate up and down the river;
- linkages between river and floodplain and associated wetlands are able to maintain ecological processes;
- natural linkages with the sea or terminal lakes are maintained; and
- associated estuaries and terminal lakes systems are productive ecosystems.

How Should a Natural River be Managed?

If catchment planning groups believe they have a fairly natural system, with good populations of native fish or other biota recognised as important, the planning challenge becomes how to retain such a system. This requires an understanding of the various processes that might threaten the existing community, and planning interventions to minimize such possible impacts. Table 1 (page 8) lists a range of actions that may lead to degradation of natural freshwater ecosystems, and therefore proposals to introduce any of these into a catchment may pose real risks. In other catchments, removal or reduction of these processes may lead to an improvement in ecosystem health.

Of course protecting a river system from stress of one particular kind, while allowing other stresses to continue or expand, will negate any benefits that may have been generated. An understanding of the possible impacts of a variety of actions needs to be undertaken, to understand what is, and what is not possible in a particular catchment without causing degradation. One needs to assess the variety of interventions that managers may make, and assess the ecological benefits and costs of each possible intervention[12]. This sort of analysis is river specific, and requires ecological understanding.

Reducing the Threat to Natural Rivers

Even our relatively undamaged river systems have suffered a variety of impacts, even if these have not led to widespread degradation. Catchment managers may choose to identify what threatening processes are occurring in a catchment, and reduce them. Table 2 gives a checklist of what might be examined in the context of a particular river.

Table 2. Management Activities to Maintain or Restore Biodiversity in Rivers and Wetland Systems

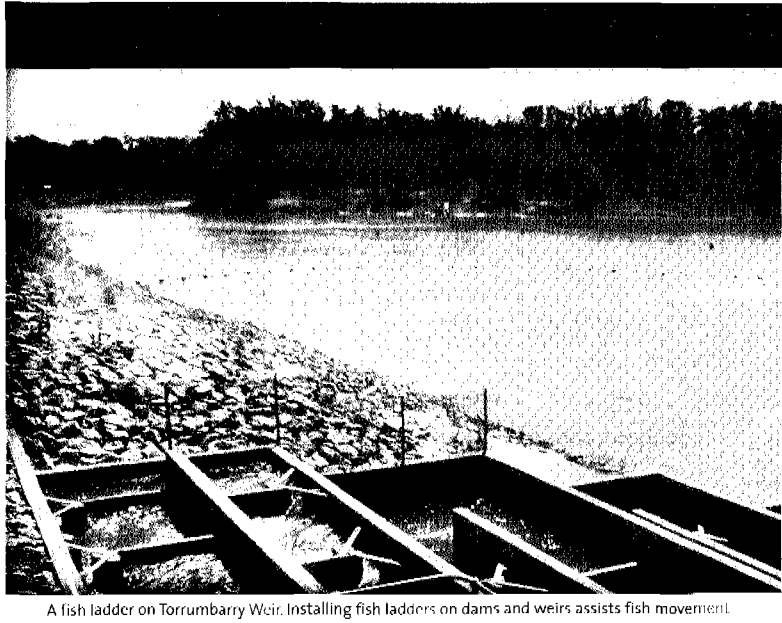
Possible Intervention	*Physical extent of benefit*	*Chance of beneficial outcome*	*Cost*
Do not remove snags or build bank stabilisation works	Local-Regional	High	None
Replace snags	Local	High	Low
Install fish ladders on large dams	Regional	Moderate	High
Install multi-level offtakes on large dams	Several hundred km	High	Very High
Remove weirs	Extent of weir pool at least	High	Low
Install fish ladders on weirs	Length of weir pool	Moderate to high	Medium
Introduce environmental flows, possibly through *purchase of entitlements*	Whole river downstream	High	High
Remove levee banks	Regional	High if floodplain not degraded	Low
Protect riparian vegetation	Local to whole system	High	Low to medium
Prevent stock grazing wetlands	Local	High	Low
Prevent introduction of exotics	Whole river	Moderate	Medium
Remove exotic species	Regional	Low	High
Reduce fishing pressure	Local to whole river	High	Low
Manage urban stormwater	Regional	Depends on relative contribution	Medium
Impose best management practice on farmland to reduce pollution	Regional	High	Medium
Restocking with native species	Local to whole river	Medium	Low
Education to develop a water literate community	Regional	Medium	Low

Many catchments have a variety of degrading processes occurring, so it may be necessary to have a suite of targeted interventions. Continuing investment in one intervention may be ineffective if it is some other factor degrading the system. In these situations, an adaptive management framework is recommended where outcomes are predicted and then measured through adequately designed monitoring. Using adaptive management means the mix of interventions can be changed if the desired outcome is not being obtained.

At this stage objectives like maintaining populations of certain native fish are probably the best surrogates we have for general biodiversity measures. The assumption is that if we are able to maintain conditions suitable for these natives we will probably have suitable conditions for a wide range of other organisms.

Avoiding Degradation in the First Place

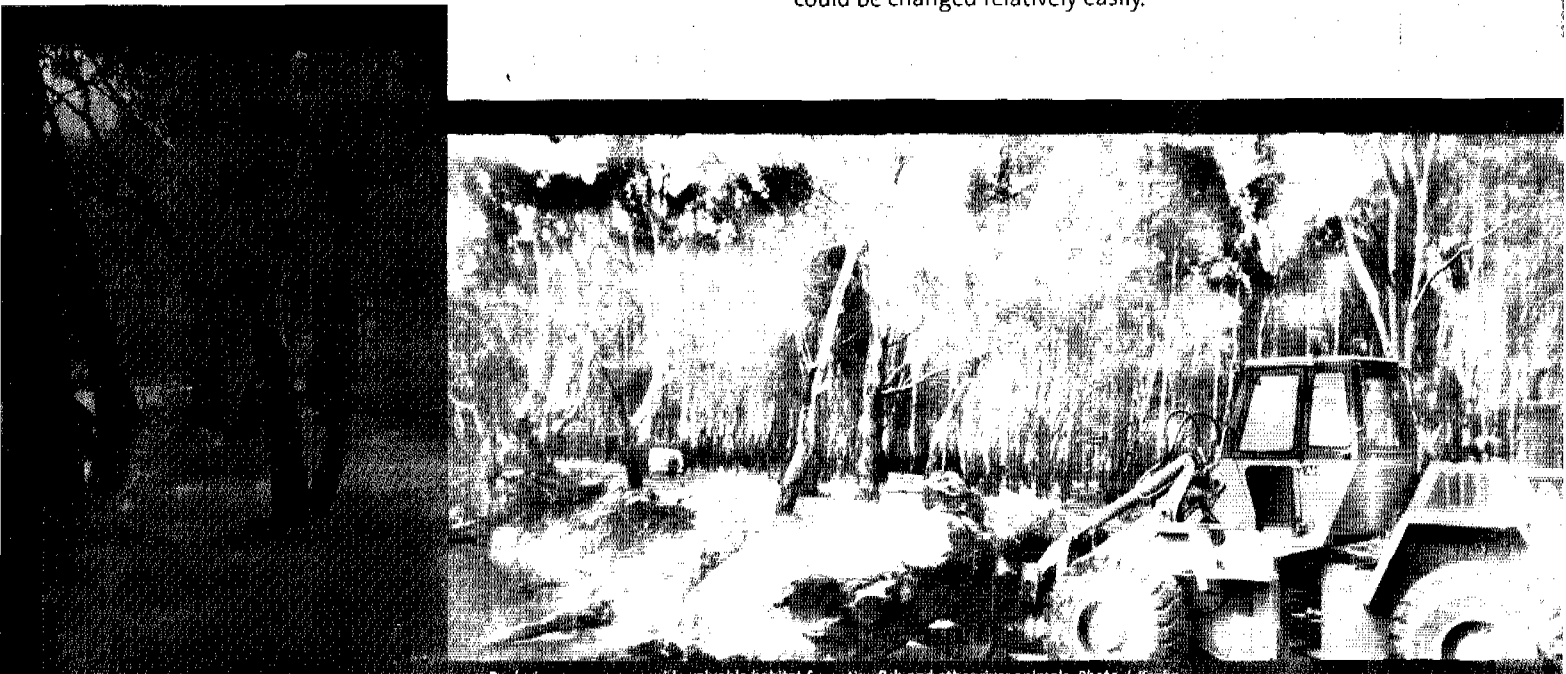
There has been no comprehensive effort to identify important freshwater areas and to establish reserves to ensure their survival[11]. Even the streams that happen to be in protected land areas are not protected from all threatening processes. Sewage effluent is discharged into streams in our alpine national parks, salt may be applied to roads, water is extracted for resort use and for activities such as snow making. Introduced fish are treated as a major recreational resource rather than a threat to native biota. In Kosciusko National Park all but one river is dammed or has water diverted by aquaducts.



A fish ladder on Torrumbarry Weir. Installing fish ladders on dams and weirs assists fish movement along a river system.

We do not have large park systems that protect lowland freshwater ecosystems, except in the Northern Territory. Even internationally recognised wetland sites that are designated under the RAMSAR Convention, may be ineffectively managed. It seems fairly obvious that you cannot protect a major wetland if you allow most of its water to be extracted for irrigation, and yet this is what we have done to many of our wetland systems with significant contraction in their size and extent. Narran Lakes is an important example of where an important wetland has been identified and designated, but we have not been able to restrict water extraction which is at a level that may destroy the lakes[4]. National Parks agencies often lack the knowledge or the powers to effectively manage freshwater ecosystems.

Victoria does have a Heritage River Act (1992) but has so far largely failed to implement it[11]. New South Wales also has a capacity to establish freshwater freshwater reserves under its Fisheries Management Act (1994), but has chosen not to do so[9]. The other States can identify undamaged rivers in their water plans and can designate them not to be developed, but this protection is currently limited and could be changed relatively easily.



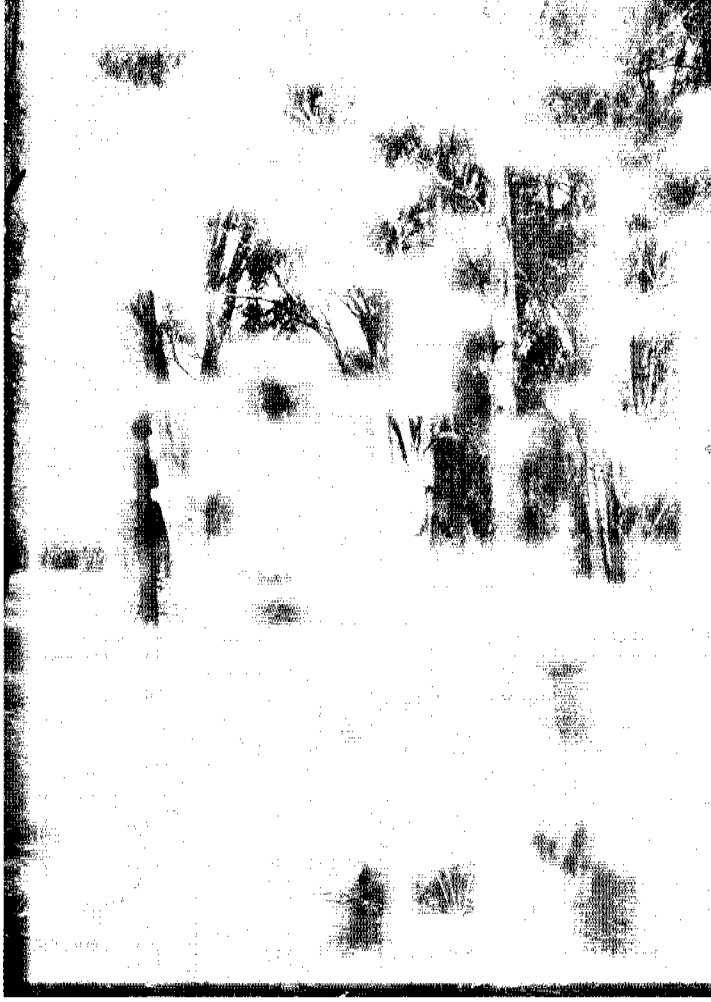
Replacing snags can provide valuable habitat for native fish and other river animals. *Photo: J. Koehn.*

A National Heritage River System

There is a clear case for a National Heritage River System, and this requires leadership from the Federal Government. In agreeing to formally designate rivers as Heritage Rivers under proposed amendment to the EPBC Act, Catchment Authorities should be eligible for two years of Federal funding to undertake reconnaissance and planning studies. These should report on the ecological assets and the ecological services provided by the river, identify important threatening processes and make plans for appropriate interventions.

If the Catchment Authority and the State agrees to heritage designation, and commits to no further extraction of water from the system, Federal funding should be available to support implementation of the management plans. This might include funding of weir removal, riparian repair and fencing, introduction of best management farming practices in the catchment and other management activities as appropriate.

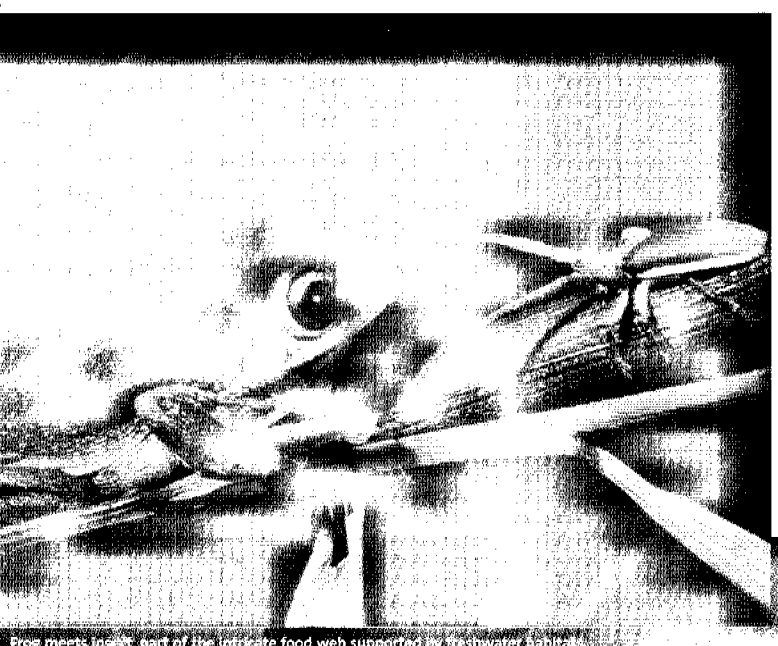
Each jurisdiction in its water planning has identified rivers of conservation value, and they are seeking to protect them from further development. The Paroo River and Coopers Creek are examples in Queensland; the Ovens and Mitchell in Victoria. Other important and relatively undamaged rivers worthy of attention include the East Alligator in Northern Territory, the Clarence in New South Wales and the Fitzroy in Western Australia. The Barmah-Millewa wetlands are also recognised as priority conservation areas.



The Barmah Millewa Redgum Forest in flood, a priority conservation area. *Photo: K. Markwort.*

This sort of integrated treatment of an intact river is only possible through some form of Integrated Catchment Management strategy and organisation. States have generally failed to appoint a "river manager" responsible for the health of the rivers, and we have a variety of agencies in competition with each other to sell irrigation water, to reduce pollution, to promote agriculture and to manage fisheries. Integration of these various interests has largely been impossible, even in the conglomerate natural resource agencies that have been established in some States.

A Heritage River System to protect the few undamaged rivers is necessary, but is no substitute for smarter and more sustainable management of land and water across the entire landscape.



Frog meets insect, part of the intricate food web supported by freshwater habitats.

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