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WaterShed

contents

Managing the ecological risks of water trading

by Professor Gary Jones

In the previous edition of *Watershed* I commented that many people in and around the water industry seem to have assumed that water trading will be either good for the river environment or, at worst, benign.

While the National Water Initiative (NWI) recognises that water trading arrangements must 'protect the needs of the environment', it also states the need to 'facilitate the operation of efficient water markets'[1]. Are these two policy aspirations compatible in a fully operating water market?

For example, will the market be able to function efficiently if individual trades need to go through an environmental assessment process that might take days or weeks? The risk is that governments and water traders alike will see environmental assessment as too restrictive and simply too hard.

Professor Gary Jones, Chief Executive of the CRC for Freshwater Ecology. Photo: L. Sealie

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The Cooperative Research Centre for Freshwater Ecology develops ecological understanding to improve and protect Australia's inland waters.

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Significant water trading up or down a river, or from one river valley to another, may change a river's flow regime. In some cases these changes could be ecologically beneficial (water trade may help reverse a previous flow impact); in other cases they may be adverse (water trade may exacerbate an existing flow impact).

For example, the Murray-Darling Basin Commission's Pilot Water Trading Project report[2] prepared by CSIRO concluded that:

> *from a salinity perspective and in the long-run, inter-state trading can be expected to have a negative impact on river salinity.*

And CSIRO's Mike Young and colleagues warn that the increased water-use efficiency expected to be achieved by water trading could ultimately reduce flows in rivers downstream (because there would be less excess water to drain into them).

Ecological effects of water trading could occur in some of the following ways.

- Increased dowstream releases from dams, due to the activation and trading of 'sleeper' and 'dozer' licences, could improve ecological conditions in rivers where unused water has previously been held in storage. On the other hand, it could cause problems by contributing to unseasonal (summer) flows and/or decreased downstream water temperatures, both of which impact on river biota.
- Net transfer of water-use licences upstream could lead to depleted flows downstream, with consequent negative impacts. Of course, the reverse situation — net transfer downstream — could, if the flow regime is well managed, benefit the river environment.
- Increased downstream usage could lead to greater pressure to run regulated rivers at constant and/or bankfull flow rates. High and/or constant flows cause erosion of river banks, and stimulate invasion of some exotic species that prefer relatively constant flow-levels.
- In unregulated rivers, accumulation of water-use licences by large irrigation properties could lead to excessive removal of water there during flow events. This also could adversely affect in-stream plants and animals locally and downstream.

Practically, the real challenge will be dealing with the cumulative effect of multiple water-trades. Individual trades will, in most cases, be tiny relative to annual river discharge, and it will be almost impossible to predict or detect an impact (whether positive or negative). This is the classic problem for environmental and catchment planners everywhere. And I can see no reason to assume that temporary trading is any less an ecological concern than permanent trade — it is the overall change in flow regime that should be considered.

Don't get me wrong. I agree that water trading offers a real opportunity to better manage Australia's water resources for the benefit of the environment and the economy. But if the trading process is solely driven by economic and financial concerns, the chances of positive outcomes for the river environment seem, at best, serendipitous. Surely in 2005 we can do better than this, without compromising our social and economic objectives?

The good news is that the answer is definitely yes.

First, we need to:

(i) publish guidelines to let traders know what volume and types of water trade in each river valley are fair and reasonable from an ecological perspective — probably to be updated every year based on prevailing climate conditions and feedback from monitoring data; and

(ii) develop the right assessment and monitoring tools that allow governments and market regulators to keep an eye on the progress of water trading and the resultant ecological outcomes.

Environmental decision support tools such as MFAT produced by our CRC (Murray Flow Assessment Tool, reported in *Watershed* December 2003), and RAP (River Analysis Package) produced by the CRC for Catchment Hydrology, allow rapid assessment of the environmental consequences of changes in river flow-regime, including those arising from water trading.

Second, we should consider other ways of managing the potential risks of water trading. One option might be to allow the environment to be become an active trader itself. I understand this is currently not possible, or at least very difficult, under existing state legislative and/or administrative arrangements.

How could it be put into practice? Special purpose environmental flow trusts could be established along a river, perhaps at key floodplain sites. 'Virtual environmental farms' notionally situated along the river, financed by public trusts, are another option.

Water access rights and usage licences could be bought and traded through the water market by the trusts, in exactly the same way as is done by irrigators. How the water right is called upon and how the water is used on-site, or downstream, would be up to the trust to decide — again just like it is in irrigation areas (with similar checks and balances as well). There would also need to be a process by which all environmental trusts along a river (if there were to be more than one) could coordinate their actions for an overall river benefit.

No doubt some will see serious 'problems' with this approach, and maybe the proposal is overly simplistic. Nevertheless I think it is worthy of more detailed analysis and consideration.

Whatever process is finally adopted, readers can be assured that the CRCFE and its successor, the eWater CRC (from July 2005), will make its resources available to support governments and industry in ensuring the best possible outcomes from water trading, for the environment and for the Australian economy.

To finish with a note about a related topic: the National Water Initiative will operate on the basis of sound information about water resources, their use, their quality and their value. Performance monitoring and data management are central to good management, and this applies as much to environmental water allocations as to managing the effects of traded water moving to new uses.

Monitoring and assessment can no longer be regarded as an optional extra or something that can be simply cut back if funds are short. I estimate that for every program of environmental water allocations, performance monitoring will require an investment of at least 10–15% of total capital and operating expenditure — its objectives being to confirm that the ecological targets of environmental flows have responded as expected.

To help stimulate performance monitoring, the CRCFE has just released a framework to guide the monitoring and assessment of the outcomes of programs of environmental flows[3]. It is outlined later in this issue of *Watershed*.

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eWater CRC gearing up

On 1 July 2005, eWater CRC begins operations, with Don Blackmore as Board Chairman and Professor Gary Jones as Chief Executive.

eWater CRC is a cooperative joint venture focusing on enterprise, environment and education in Australia's water industry. Its vision is to be a national and international leader in the development, application and commercialisation of products for integrated water-cycle management.

The eWater Cooperative Research Centre incorporates new participant organisations as well as those from the existing successful CRCs for Catchment Hydrology (CRCCH) and Freshwater Ecology (CRCFE). It combines the two water CRCs' and the new participants' partnerships, skill bases, end-user networks, intellectual property and business systems.

CRCCH and CRCFE will complete their current projects by 30 June 2005, after which they will cease to operate, but many of those two CRCs' existing products will continue to be supported and developed by eWater CRC.

For further information about eWater CRC and its operations, please visit www.ewatercrc.com.au, which lists the participant organisations, the proposed product areas and research programs, and the CRC's core business and expertise.

ewater CRC
enterprise environment education

Ecological effects of changing flows — clear but not simple

Being able to predict the ecological benefits that are likely to result from environmental flows — that is, from specific allocations of water for the environment — is an important part of managing flow in rivers.

Although few ecological studies have been made during environmental flows, there is strong evidence from around the world to show that both river ecology and river geomorphology are altered when river flows are changed from natural.

This strong evidence is summarised in a literature review titled *Does flow modification cause geomorphological and ecological response in rivers?*, published in 2004 by the CRC for Freshwater Ecology. The review focuses on change in river flow in 70 studies that examined responses in fish, birds, plants, trees, freshwater insects and crustaceans (macroinvertebrates), as well as geomorphology. The river flows examined in these studies had been altered in a range of ways: by drought, prolonged inundation, flood mitigation, augmentation, abstraction, or to satisfy irrigation needs.

large improvements in aspects of river ecology may follow relatively small environmental flows

Sixty-one of the 70 studies (87%) found that modifications to river flow were followed by responses in the ecology and/or geomorphology.

However, the relationship between flow change and ecological response is not simple. The most common responses to altered river flows were changes in the make-up or distribution of populations of freshwater plankton, macroinvertebrates, trees, submerged water plants, fish or birds. Whether the changes could be considered positive or negative depended on the circumstances of each study and the species involved.

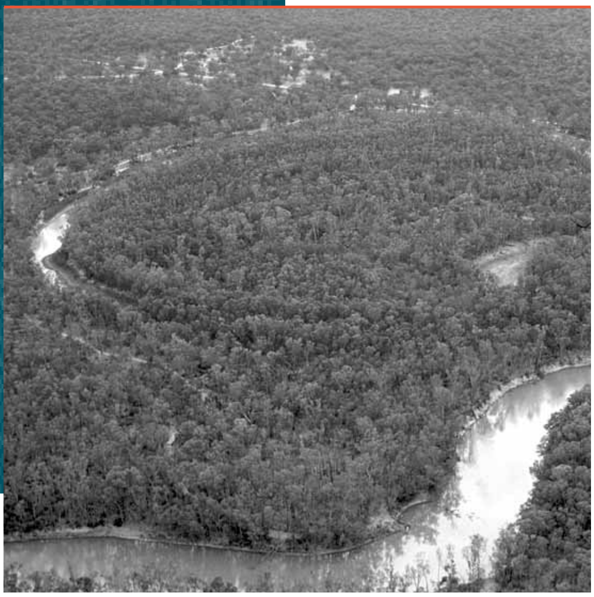
Although one might expect large ecological responses to be linked to large changes to flow, the review found that was not always the case. For example, the lowest proportional change in flow noted in the review was associated with a 67% loss of grassland in the Barmah Forest 'War Plain'[1]. Other relatively small flow changes were also associated with large percentage changes in ecological variables. There were 72% fewer birds-nests at Murrumbidgil Swamp and Lake Merrimajeel in years when the wetlands had not dried out, compared to years when they had[2], yet the proportional change in flow was very small.

It is highly probable that the factors driving the ecological function of one organism or habitat are quite different from those for an unrelated organism and habitat. For example, macroinvertebrate communities appear to need suitable physical habitat, such as in-channel benches that trap organic matter and provide flood refuge in flood events[3]. On the other hand, communities of single-celled plants depend more on water temperature and chemical conditions in the water.

Several of the reviewed studies supported the notion that populations can respond to 'thresholds' and triggers. Populations may decrease when conditions fall below a threshold level, or increase in response to a burst of water flow at a suitable point in their life cycle. However, the review did not find simple threshold relationships, possibly because of the wide range of variables studied.

The CRCFE team considered 657 studies for the literature review, but only 70 of the studies met the team's selection criteria — mainly that data were reported from which the team could assess a degree of change in some facet of ecology or geomorphology in relation to changed flows. In examining these 70 studies, the team

The River Murray running bankfull. Photo: A Tatnell



Floodplain forest along the River Murray. Photo: A Tatnell

looked for evidence for and against the following four hypotheses[4].

1. Flow largely determines the physical features of streams, the habitats available in them, and therefore the animals that can live there.
2. The life histories of freshwater species have evolved in response to the natural flow regimes in their waterbodies.
3. Many river species rely on natural patterns of connectivity, both along the channel and between channel and floodplain.
4. It is easier for exotic and introduced species to invade and succeed in rivers if the flow regimes have been modified from natural.

The studies contained evidence to support all four hypotheses.

Finding flow–ecology relationships or thresholds that managers can use to guide their environmental flow releases will require a larger dataset than was available in these studies. Many of the Australian studies in the review may have collected suitable data but the data may not have been relevant to the objective of the published papers. Also, data collected for national and state environmental surveys and audits may reveal flow–ecology relationships.

Until these or other data can be obtained and further analysed, and even after that, the future of environmental flows lies in adaptive management. It will be important to closely monitor the ecological and geomorphological consequences of the many environmental flow regimes being implemented across Australia.

The good news is that the studies overall imply that in some instances it may be possible to bring about large improvements in specific aspects of river ecology from relatively small environmental flows.

Although many studies record the degree or size of ecological change, it is much harder to see how important a change is in relation to the overall success of a population of organisms. For example, will a 20% rise or fall in yield of algae and plankton influence the ecology of a particular wetland, or is it within the natural range of variability? For how long can such a change be tolerated without marked effects on freshwater biota or the structure of the food web?

Understanding the significance of ecological responses, especially in terms of sustainability of populations, communities and ecosystems, is one of the most important research challenges for ecologists in the coming decade.

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Further reading

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A framework for monitoring and assessing the effects of environmental flows

A new framework for monitoring the effects of environmental flows has been prepared as a guide for all those who must deliver environmental flows and assess their effectiveness.

Environmental flow regimes exist or are planned for many regulated and unregulated streams across Australia. The regimes are devised with the aim of ensuring there is enough water, delivered with appropriate timing, to protect key environmental or ecological features of the streams or enhance their function. Implementation of an environmental flow regime is likely to mean a new operational strategy for river managers, as well as a large investment.

If stakeholders want to confirm that environmental flow regimes in streams do, in fact, result in ecological changes as predicted, it is essential that the streams be monitored during and after the flows. But while environmental flow recommendations have been developed for numerous rivers across Australia in recent years, relatively few of the actual flows and their ecological outcomes have been monitored and evaluated.

The following definition of 'environmental flow' was adopted by the team developing the monitoring and assessment framework:

> *An environmental flow results from a management intervention that protects or modifies the flow regime of a river to achieve an ecological or environmental outcome.*

This definition was kept in mind to ensure that the framework could apply to a wide range of flow manipulation projects. The framework can be applied equally to the monitoring of regulated streams — for example, those modified by large dams and weirs — and unregulated streams — for example, those where water is pumped directly from the stream. It can also guide the monitoring and assessment of environmental water allocations to specific locations, such as the ecological assets (mostly wetlands) being considered in the Living Murray Initiative.

Using the framework

The framework is based on seven main steps that lead users through the planning stages of the study, the operational stages, and finally the assessment stages (see flow chart).

The best time to start planning a monitoring and assessment program is when environmental flow recommendations are being developed. The teams developing both the specific environmental flow objectives and the management and scientific questions (hypotheses) to be answered by the monitoring program need to share a strong conceptual picture of stream function. Monitoring and assessment programs are most effective and informative when designed to answer clear and precise management and scientific questions about stream responses to flow regimes.

Framework steps 1 and 2 help the user to define:

1. the scope of the monitoring and assessment program and the objectives the program is intended to achieve; and
2. the conceptual relationship between river flow and riverine ecology for this environmental flow project, and the questions (hypotheses) that the monitoring will test.

The framework then leads users to define the detail of the monitoring program, put it into practice, and finally assess the outcomes, via steps 3–7:

3. Select variables (aspects of the river and its ecology) that are to be monitored.
4. Decide on a suitable and practical study design, accounting for the specific activities and location.

Learning how to measure river water characteristics. Photo: S Nichols

5. Optimise the study design (an iterative process) and identify how data are to be analysed.
6. Implement the study design.
7. Assess whether the environmental flows have met specific objectives, and review the conceptual understanding and hypotheses of this location's ecology in the light of the data.

The framework lists criteria that help users choose key variables to monitor, and gives examples of variables that have been used successfully in previous or existing environmental flow monitoring programs. The framework also refers users to other documents and resources that explain in detail how to measure environmental variables and manage the resulting data.

Study design is discussed at some length, because (along with setting objectives) it is crucial but often poses great difficulty in the planning of a monitoring program. The framework presents eight typical study designs and a decision tree to help users identify the study designs that best match their circumstances. For example, if there is no chance to collect comparative data from streams in the region before the environmental flows are begun, the monitoring program cannot apply some traditional study designs that are useful for showing cause and effect.

The size of the ecological or environmental response that is to be detected (the 'effect size') is a vital decision that users need to make when optimising the study design (framework step 5). The smaller the effect size to be detected, the greater the sampling intensity needed and therefore the greater the cost of the monitoring program. Step 5, therefore, is concerned with identifying the smallest effect size that can be detected with the resources available. Choice of effect size is slightly easier if users have access to data from pilot studies and advice from stakeholders and statisticians. Statisticians, who, in an ideal situation, are involved in all the study-design steps, can also give direction on how to analyse the data that will be collected, and the inferences that can be drawn from the results.

Getting the framework

The monitoring framework was devised by a CRC for Freshwater Ecology team drawn from agencies and universities across eastern Australia, all of whom have considerable experience in river assessment and environmental flows. The framework report is newly published on the website of the CRC for Freshwater Ecology at http://freshwater.canberra.edu.au > Publishing > Technical reports > 2005, and will be developed into a web-based tool shortly.

Reference

Cottingham P., Quinn G., Norris R., King A., Chessman B. and Marshall C. (2005) *Environmental Flows Monitoring and Assessment Framework*. Technical report. Cooperative Research Centre for Freshwater Ecology.

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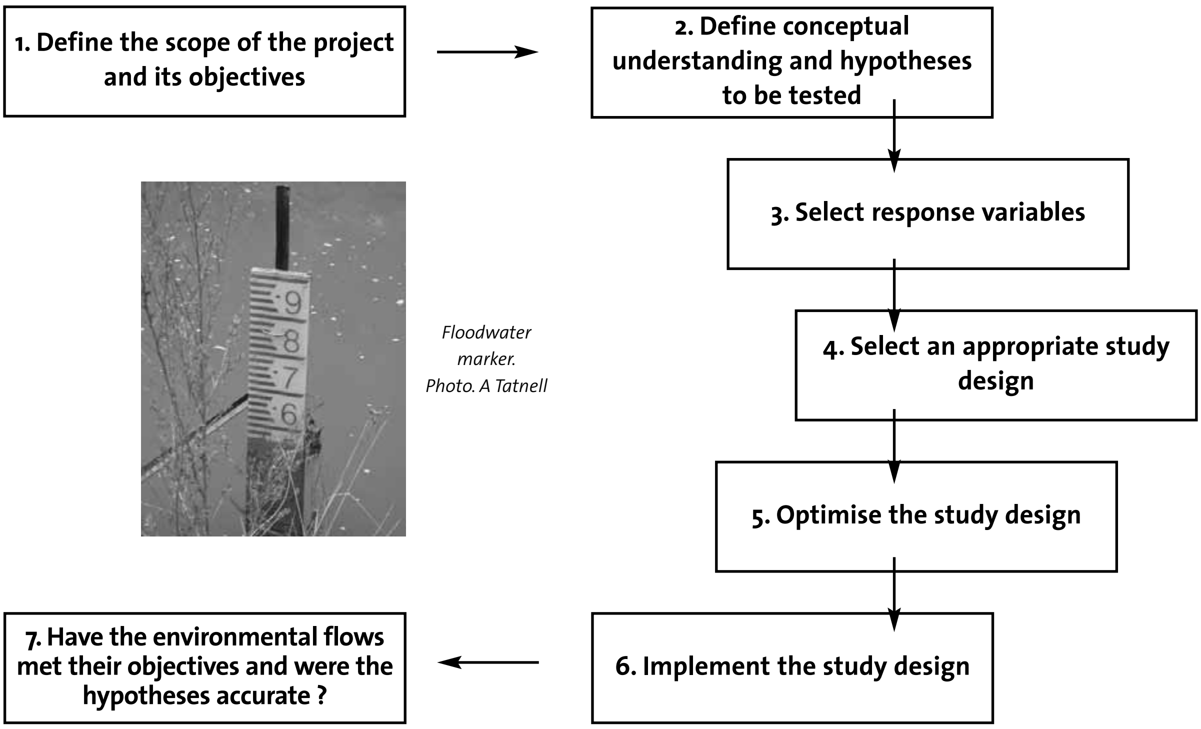
Simplified flowchart for use in monitoring environmental flows



Floodwater marker. Photo. A Tatnell

Case study: Monitoring the effects of Wimmera–Glenelg environmental flows

A program designed for monitoring the effects of an environmental flow regime in the Wimmera–Glenelg river systems closely follows the CRC for Freshwater Ecology framework for monitoring environmental flows (see previous article).

In semi-arid western Victoria, the Wimmera River flows north-west, ending in a series of terminal lakes including Lake Hindmarsh which overflows into Lake Albacutya. In the next catchment to the south, in a wetter climatic zone, the Glenelg River flows south-west, from the Grampians National Park to the ocean. The Wimmera Mallee Stock and Domestic System (WMSDS) harvests water from both the Wimmera and Glenelg catchments for distribution across the Wimmera and Mallee. As a result, environmental flows and environmental monitoring are considered for both the Wimmera and Glenelg catchments. Salinity and sediment loads have increased in both rivers over the last fifty years or more, and the waters have become nutrient-rich and oxygen-poor, causing ecological problems such as algal blooms. In natural circumstances, flow in both rivers would be highly variable, and intermittent in some reaches.

Working with a range of partners and institutions, including Monash University and Sinclair Knight Merz consultants, the CRC for Freshwater Ecology has been involved since the late 1990s in, first, assessing river condition in the Wimmera and Glenelg systems, then devising recommendations for environmental flows, and, in 2004, designing the program to monitor the effects of the flows. The Victorian Government has recently made provision for environmental flows in these river systems through water savings associated with the northern Mallee pipeline. The pipeline has replaced open channels used for the delivery of stock and domestic water supplies. The pipelining project is expected to continue through the Wimmera–Mallee region, with pipelines replacing all channels and the majority of the water saved being used for environmental flows.* Monitoring of the 2004–2005 environmental flows began in the Wimmera in November 2004 (see box).

Scope and objectives of the flow regime and monitoring

The environmental flow recommendations were based on conceptual pictures ('models') of the way the Wimmera and Glenelg Rivers function. These models have also provided the basis for designing the monitoring program.

The Wimmera River upstream of Antwerp.
Photo: F Dyer

The environmental flow objectives are to:

- maintain or improve stream habitat condition;
- manage flow conditions for 24 threatened flow-dependent flora species;
- maintain conditions suitable for self-sustaining populations of endemic native fish including river blackfish, southern pygmy perch and mountain galaxias; and
- minimise algal blooms and the development of mats of azolla;

and the monitoring program has been designed to check if those objectives are achieved by the environmental flow regimes, when implemented.

The monitoring program had to be adaptable because the recommended flow regimes comprise a bundle of flow types — low-flows, no-flows, flushing, channel-forming and bankfull flows, to be delivered at various times. Flow recommendations are also specific to individual reaches and seasons. The flow regime is likely to be delivered reach by reach as water becomes available, and the scope and performance of the monitoring program therefore had to be flexible to suit the flows delivered.

Monitoring variables

When recommending riverine features to be monitored, the design team ensured that the variables were known to be sensitive to the changes that were expected to be caused by the proposed environmental flow regime. The recommended variables also had to:

- matter to the human community, but be important in the ecological system and function of the rivers;
- be cost-effective to sample; and
- have been sampled previously so the earlier measurements could be used as a baseline for comparison.

In its design, the team described appropriate methods for measuring the recommended variables, the parts of the channel or habitat to be measured and the time-frame for measurements (see table).

Example. Recommended monitoring for a key site: Glynwylln VWQMN site 415206

Variable to be measured, and methods	Monitoring frequency
Water quality: in pools. DO, EC, pH, temperature at the surface and at depth. Use a portable meter.	Monthly Additional event monitoring to assess changes after freshes.
Hydrology: Discharge and water levels. Visually assess flow and habitat inundation.	During flow events Only needs to be done once for each flow type, not repeated each year.
Geomorphology: in pools. Dimensions, sediment deposition, distribution of debris.	Short-term responses measured before and after specific flow events. Only needs to be done once for each flow event. Use photopoints and/or direct measurement.
Geomorphology: in channels Cross-sections and longitudinal sections, vegetation extent and vegetation composition.	Every 3–5 years but should always be done in summer to accurately measure vegetation.
Macroinvertebrates: Standard EPA rapid bioassessment techniques.	Autumn and spring every 3–5 years.
Fish: at three replicate pools per site. Use electrofishing by qualified person; fyke nets set overnight, one end out to avoid drowning mammals and turtles; bait traps set overnight.	Early summer every 3–5 years but will need to be done more frequently if trying to detect responses to specific flow releases such as spring freshes.

EPA = Environmental Protection Authority; DO = dissolved oxygen; EC = Electricity conductivity.

The monitoring program in practice

by Fiona Dyer

Environmental flows in the Wimmera River were released as 'freshes' between early December 2004 and mid-February 2005, separated by a constant baseflow. The releases are being monitored in a program based on the recommendations of Andrew Sharpe (SKM) and Gerry Quinn (CRCFE, Monash University).

The monitoring has already tracked the December fresh to Jeparit Weir. A significant reduction in salinity levels has been observed in some pools, and is considered to be a positive outcome of the releases. Monitoring is expected to continue until mid-April.

Storage capacity in the Wimmera Mallee Stock and Domestic Water Supply System hovered around 15% during 2004, so only a limited volume of water has been allocated from the system to the environment.

The objectives of environmental flows in the Wimmera River over the 2004–2005 spring and summer period revolve around restoring water quality within pools along the river. Consequently, the monitoring program is focusing on the weekly measurement of surface water quality (DO, salinity, pH and turbidity) and observations of river levels and the inundation of in-channel features, at 26 sites along the MacKenzie and the Wimmera Rivers.

Study design

Neither the reference-condition approach nor the traditional Before–After Control–Impact (BACI) designs were applicable to monitoring the Wimmera and Glenelg river systems. Reference-condition monitoring does not easily identify causal links between the predicted environmental or ecological response and the flow regime, and it was not possible to define the 'before' and 'control' elements that are essential parts of BACI designs.

The study design that was ultimately recommended was based on detecting trends at key locations over time and then assessing the changes in comparison to the flow regime's environmental objectives. Some upstream-reach versus downstream-reach comparisons would also be possible, from which to infer causal links between flow changes and observed ecological responses, thus contributing to a levels-of-evidence approach for assessing flow–ecology responses.

The report

The report, *Monitoring Environmental Flows in the Wimmera and Glenelg Rivers,* by A. Sharpe and G. Quinn (2004) (Sinclair Knight Merz and CRC for Freshwater Ecology) was prepared for the Department of Sustainability and Environment, Victoria, and the Wimmera and Glenelg-Hopkins CMAs, and is available from CRCFE on request. It is summarised as an appendix to the CRCFE monitoring framework described on p.6 above.

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* As at early March 2005, State Government funding for the remainder of the pipeline project has just been announced, potentially freeing up considerably more water for environmental flows in this region.

A monitoring site on the Wimmera River.
Photo: F Dyer

Progress in understanding dry rivers

> *'On the outer Barcoo* [or a little sou-west of there], *where the churches are few and men of religion are scanty, on a road never cross'd 'cept by folk that are lost, ...'**

... the Dryland River Refugia team have been periodically surveying, setting fishing nets and turtle-traps, weighing, measuring and releasing fish and turtles, collecting molluscs, macroinvertebrates (largely prawns and insect larvae) and benthic algae, trawling waterholes for plankton, measuring algal production and collecting water-quality samples, since April 2001.

The team has been examining and comparing the ecology and hydrology of in-channel waterholes on four reaches of each of the Cooper Creek around Windorah, the Warrego River around Cunnamulla, and the Border Rivers around Goondiwindi, during the months when they are separated by stretches of dry river bed.

The latest significant finding is that the water in waterholes that comprise the Cooper Creek when it is dry has all come from the surface water when the Cooper Creek is flowing. There are no significant inputs from groundwater. The team has analysed the concentrations of sodium, chloride and oxygen-18 (a stable isotope of oxygen) in the waterhole water to identify where it has come from. Comparing the waterholes when isolated, the river channels when flowing and the groundwater accessed via bores, they find that the waterhole water resembles the waters of the Barcoo and Thomson Rivers much more closely than it resembles the groundwater.

The change in the concentrations of these elements, over time, indicates the rate at which the water is evaporating — and the result is 2.1 metres per year on average during 2002. Since evaporative water loss is the main control on water levels in the fifteen sampled waterholes between flows, the team estimates that these waterholes would be only 10% full by 6 to 23 months after the river inflow stops.

Although Cooper Creek and the Warrego River are both dryland rivers, it is surprising how different the Cooper waterholes and their biota are from the waterholes and biota of the Warrego, 400 km to the east. For example,

- seven of the 14 species of fishes in the Cooper Creek are not found in the Warrego River; and six of the 13 species in the Warrego are not found in the Cooper (see box); and there are fewer exotic species in the Cooper Creek than the Warrego (and fewer in the Warrego than the Border Rivers);
- in the Cooper, three fyke nets set for an average time of 19 hours often catch more than 500 fish but the same nets catch generally fewer than 150 fish in the Warrego over the same length of time;

Cooper Creek: September 2001, catches range from about 100 to 1100, with most catches averaging about 250 fishes. After flooding (April 2002), there were over 1000 fishes in many waterholes, maximum 46,000. Photo: J Marshall

Warrego River: October 2001, catches range from 10 to about 120, with most around 60. After flooding, (April 2001), there were still fewer than 100 fishes per catch in most holes, but four holes produced catches of 100–300 fishes. Photo: J Marshall

- the biomass of algae (an indicator of primary productivity in freshwater systems) is much larger in the Cooper than the Warrego;
- primary production and respiration (processes that control the relative use and release of carbon, oxygen, energy and carbon dioxide) by benthic algae are higher in Cooper than in Warrego waterholes. Benthic algae are the algae attached to the banks of the waterholes near the water surface. Cooper waterholes produce an average of 0.4–0.9 grams of carbon per square metre per day ($g.C.m^2/d$) and respire 0.4–0.7 $g.C.m^2/d$, whereas Warrego waterholes average 0.2–0.3 $g.C.m^2/d$ in production and 0.3 $g.C.m^2/d$ in respiration;
- molluscs and prawns live in the Cooper waterholes, but only the freshwater prawn lives in the Warrego waterholes; molluscs are mostly absent;
- the Cooper Creek turtle (*Emydura macquarii emmotti*), the species that is abundant in the Cooper Creek waterholes, is less diverse genetically than the turtle populations in the Warrego;
- in the Cooper region, the waterholes seem to differ from each other in physical character, whereas the Warrego waterholes are physically quite similar to each other.

Cooper Creek is in the Lake Eyre Basin and the Warrego River is part of the Murray-Darling Basin. Land-use is also not quite the same around the two river systems, with land in the Cooper Creek area being mainly used for pastoralism, while water resources development and farming are beginning to appear along the Warrego River.

On the other hand, there are also some similarities between the river systems.

- Water plants were found in only one fifth of waterholes sampled in either the Warrego River or Cooper Creek.
- Few species of phytoplankton (single-celled floating algae) were found in either river system. One waterhole on Cooper Creek was rich in phytoplankton species, but that may have been associated with a large waterbird community there.
- In contrast, there are numerous (over 250) species of benthic diatoms (algae attached to underwater surfaces such as wood or sediment) in the waterholes of both systems, with generally 10–20 species per waterhole.

The outcomes of sampling in the Border Rivers region will be reported in the team's next newsletter.

The next stage

Beginning in 2004, stage II of this project has been
(i) examining the patterns of diversity in all the species that have been observed so far, and their relationships to water quality, and
(ii) studying the production of benthic algae in the waterholes, in the presence or absence of carp, and in relation to the slopes of the waterhole banks (shallower slopes can support larger quantities of productive benthic algae).

Ultimately the team wants to be able to predict how the ecology of waterholes would be affected if management strategies for water resources and floodplains were to change, in semi-arid and arid regions of Australia.

Glen Murken waterhole on the Cooper Creek. Photo: J Marshall

The Dryland River Refugia project is being carried out by researchers from the Centre for Riverine Landscapes (Griffith University), the Department of Natural Resources and Mines (Queensland), the University of Canberra, the Murray-Darling Freshwater Research Centre Northern Basin Laboratory at Goondiwindi, and the Department of Infrastructure, Planning and Natural Resources (NSW), all partners in the CRC for Freshwater Ecology.

This article is drawn from *Dryland River Refugia Newsletter* No. 2, prepared by Fran Sheldon of Griffith University. Both newsletters 1 and 2 are available at http://freshwater.canberra.edu.au, or from:

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* Opening lines of *Bush Christening*, by Banjo Paterson.

Fishes of the Cooper Creek and Warrego River waterholes

Cooper Creek only

northwest ambassis (*Ambassis* sp.)
Cooper Ck tandan (*Neosiluroides cooperensis*)
silver tandan (*Porochilus argenteus*)
Barcoo grunter (*Scortum barcoo*)
desert rainbowfish (*Melanotaenia splendida tatei*)
Lake Eyre yellowbelly (*Macquaria* sp.)
Welch's grunter (*Bidyanus welchii*)

Lake Eyre yellowbelly.
Photo: J Fawcett

Cooper & Warrego

carp gudgeon (*Hypseleotris* spp.)
Hyrtl's tandan (*Neosilurus hyrtlii*)
Australian smelt (*Retropinna semoni*)
spangled perch (*Leiopotherapon unicolor*)
*goldfish (*Carassius auratus*)
*mosquitofish (*Gambusia holbrooki*)
*bony bream (*Nematolosa erebi*)
(= exotic species)*

Hyrtl's tandan.
Photo: J Fawcett

Warrego only

silver perch (*B. bidyanus*)
yellowbelly (*Macquaria ambigua*)
eel-tailed catfish (*Tandanus tandanus*)
olive perchlet (*A. agassizii*)
crimson-spotted rainbowfish (*Melanotaenia fluviatilis*)
*common carp (*Cyprinus carpio*)
(* = exotic species)

Crimson spotted rainbowfish
Photo: B Gawne

BILLABONGS: REFUGES OR FISH TRAPS?

Billabongs and waterholes provide refuge for fresh-water biota in unregulated dryland rivers throughout inland Australia — even in the relatively wet temperate regions of southern Australia. In these floodplain rivers, when flow ceases during the dry, often hot, conditions between floods, the fish, insects, crustaceans and turtles survive in the residual waterholes or billabongs. But are these habitats really refuges or are they traps?

Dale McNeil studied the structure of fish communities in 51 floodplain billabongs or waterholes along the Ovens River in Victoria, an almost unregulated tributary of the River Murray, to gain his PhD with La Trobe University (at Wodonga) and the CRC for Freshwater Ecology (CRCFE).

He found that the relative abundance of fish species changed significantly over the course of the summer dry season. Fish were affected by the physical and chemical conditions within waterholes over the summer, including the effects of high temperatures and low concentrations of dissolved oxygen, particularly in the smaller billabongs.

Dale measured changes in the water chemistry, and the responses of the resident fish communities, in waterholes of various sizes. He also ran laboratory trials so he could estimate the fishes' relative tolerance to hypoxia (lack of oxygen) in warm water (25°C).

Lab trials grouped the fish species according to tolerance

Most tolerant to low oxygen:
oriental weatherloach (*Misgurnus anguillicaudatus*).

Highly tolerant to low oxygen:
carp gudgeon (*Hypseleotris* spp.),
pygmy perch (*Nannoperca australis*),
flatheaded gudgeon (*Phylipnodon grandiceps*),
carp (*Cyprinus carpio*),
goldfish (*Carrassius auratus*),
mosquitofish (*Gambusia holbrooki*).

Least tolerant to low oxygen:
redfin perch (*Perca fluviatilis*),
Austalian smelt (*Retropinna semoni*),
flat-headed galaxias (*Galaxias rostratus*).

A young redfin, about 12 cm long. Dale McNeil caught redfin up to 43 cm long in his study. Photo: courtesy of MDBC.

The lab tests showed that while fish species found in floodplain billabongs all had physiological adaptations for surviving hypoxia, their tolerances varied. Redfin perch, Australian smelt and flat-headed galaxias were least tolerant: they 'panicked' when the oxygen concentration reached 1–1.5 mg O_2/L, and then died. Five other species were highly tolerant to hypoxia (see box). These species reacted to falling oxygen concentrations by moving higher in the water column, adapting their gill respiration rates, and breathing at the water surface. The most tolerant of the tested species was the relatively new pest-fish, oriental weatherloach, which can breathe out of water, and can migrate overland to new habitats.

Dale then compared the lab tolerance measurements with the actual distributions of fish species in the waterholes, before and after summer drying.

After spring flooding, most of the floodplain fish species were to be found in all 51 billabongs. However, by late summer the fishes had sorted themselves into distinct communities in the various billabong types (floodplain or anabranch; ephemeral or permanent (that is, not drying out before reflooding)).

In small, warm, hypoxic, ephemeral billabongs, the fish communities were dominated by small-bodied species such as carp gudgeons, mosquitofish, goldfish and pygmy perch.

In billabongs that were relatively large and deep, with moderately low oxygen concentrations, pygmy perch, flat-headed galaxias and smelt were present in large numbers. However, mosquitofish were numerically dominant.

In the biggest, deepest and most environmentally benign billabongs, where there was almost no risk that oxygen would be depleted, the fish communities were dominated by redfin perch, smelt and carp gudgeons.

The results of the late summer field sampling largely reflected the results of the lab trials: the very tolerant species occupied the harsh habitats; and two of the most intolerant species (redfin perch and smelt) were restricted to the most environmentally benign habitats. The equally intolerant flat-headed galaxias (the biggest of the prey fishes and a target for the redfin perch) were restricted to intermediate habitats where the large predatory redfin perch could not survive. Mosquitofish (high tolerance) outnumbered all other species in the harsh and intermediate habitats.

Surprisingly, mosquitofish were exceeded in the most benign habitats by carp gudgeons (a native species that showed high tolerance of warm deoxygenated waters in the lab). Mosquitofish numbers may have been kept under control by the redfin perch in these habitats, corroborating a suggestion, made in previous CRCFE work by Rick Stoffels and Paul Humphries*, that redfin perch are likely to prey upon mosquitofish in preference to carp gudgeons.

In the harsh habitats, as dissolved oxygen concentrations fall, it is likely to be the relatively intolerant species that are the first to move out of shelter and up to the water surface to breathe. That makes them very susceptible to being eaten by birds and by aquatic predators. For the remaining fishes, the

Flat-headed galaxias. Photo: Courtesy of MDBC

Dale used fyke nets to sample fish in the billabongs. Photo: John Hawkins, Albury City Council.

downside of their strong tolerance to harsh conditions occurs when those habitats dry out entirely and they perish.

Dale concluded that under natural flow conditions, the majority of habitats dominated by mosquitofish and goldfish dry out before re-flooding, providing some control on those populations of introduced species. (Trapped!) Meanwhile, the natives — carp gudgeon, pygmy perch, smelt and flat-headed galaxias survive in the permanent waterhole refuges. Those refuges give the native species a potentially strong advantage in dispersal and recruitment once the floods come again the next season.

For further information, please contact:
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* Stoffels R.J. and Humphries P. (2003). Ontogenetic variation in the diurnal food and habitat associations of an endemic and an exotic fish in floodplain ponds: consequences for niche partitioning. *Environmental Biology of Fishes* **66**, 293–305.

New hope for the southern corroboree frog

Pro-active management, combined with a program of captive-rearing and re-release, are reducing the field mortality of the tiny endangered corroboree frog, from about 80% to 20%.

Renowned for its spectacular yellow and black colouring, the southern corroboree frog (*Pseudophryne corroboree*) occurs naturally only in the subalpine bog habitats of the Snowy Mountains, New South Wales, and Brindabella Range, ACT. In winter these frogs survive beneath the snow by sheltering deep within protective vegetation and leaf litter. Then in summer they go hunting for food (primarily ants) in the subalpine woodlands. Each year, the species relies on shallow water-filled mossy pools to complete its breeding cycle. Adults only reach breeding age when 3–4 years old and they can live for up to 7 years.

Young corroboree frog. Photo: M Paterson

A frozen bog pool in the Snowy Mountains. Photo: M Paterson

The southern corroboree frog was once quite common within its restricted subalpine habitats. It could readily be found in and around the sphagnum bog breeding areas during the summer breeding season. The populations have experienced huge decline over the past couple of decades, leaving the species now confined to only a few localities. David Hunter and Will Osborne (of the University of Canberra and the CRC for Freshwater Ecology), have been monitoring the species since 1986. They estimate that the number remaining now is less than 0.05% of the total population three decades ago.

The decline is most likely due to a combination of factors:

- excessive exposure of tadpoles to UV-B as a consequence of declining ozone in the atmosphere,
- loss of breeding pools because of the now generally warmer and drier climate in the mountains. The species has entirely disappeared from the drier part of its original range.
- the deadly chytrid fungus, which is known to be present in the corroboree frog population. The disease apparently arrived in eastern Australia in the early 1980s and its origin is unknown though it may have been introduced from overseas.
- human-induced impacts, such as:
  - illegal collecting of frogs,
  - feral pigs and brumbies, which disturb vegetation and soil, damaging frog habitat,
  - contamination of breeding sites by materials eroded from walking tracks, roads and resort developments.

There is strong scientific evidence that the weakest link in the life-cycle of corroboree frogs is the development of eggs into young frogs. Corroboree frogs pair up in late summer and lay their eggs. Tadpoles hatch in late autumn, and turn into frogs in early summer. However, not enough young have been completing this cycle.

This is where the captive-rearing program comes in. Amphibian breeding expert Gerry Marantelli from the Amphibian Research Centre in Melbourne maintains over 2000 corroboree frogs in captivity. Of these about 30 are of breeding age, but in five years only one pair has bred in captivity. This is because corroboree frogs need very specific climatic conditions and particular natural cues, so the captive-rearers have had much to learn. In the meantime the program focuses on captive-rearing of tadpoles collected earlier as eggs, and their release back into the wild in the NSW Snowy Mountains.

The recovery team, led by Will Osborne, is now very hopeful that soon this translocation of human-raised frogs to potential or existing habitats will help the natural populations overcome the factors causing their loss.

*A Snowy Mountains bog pool in summer.
Photo: M Paterson*

Adult corroboree frog with eggs. Adults' bodies are about 2.5 cm long. Photo: D. Hunter.

Land-managers are taking other steps to help the frogs. For instance:

- artificially filling the bog pools if they begin to dry before the breeding cycle is complete,
- controlling feral pigs,
- preventing people from trampling frog habitat,
- continuing the ban on livestock access to the area (in place since the 1960s),
- raising public awareness of the frogs.

Corroboree frogs are highly susceptible to natural disturbances such as drought and fire: the December 2002 – January 2003 fires burnt almost all the corroboree frog habitat. The leaf-litter, rotten logs and understorey the frogs rely on during winter were destroyed. Very small patches of the breeding sites were not burnt, but it is feared that 50% of the population died in the fires. On the positive side, however, the fires opened up many new breeding pools in the wetland vegetation. The surviving frogs have readily moved to these pools. Monitoring in the years ahead will determine whether they are good breeding sites.

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Northern Basin Freshwater Forum 2004

By Janey Adams

The 'Northern Basin Freshwater Forum' in Goondiwindi, southern Queensland, on 16–17 November 2004, brought together a wide range of people from the catchment to talk about what they are doing and planning to do in the future.

With so many organisations researching and managing the river systems around the Border Rivers region, it is often hard to keep track of everyone's activities. At this forum, catchment managers and researchers, as well as educators and social scientists, gathered to share their expertise and discuss ways to improve the connections between researchers, managers and the community of the Northern Basin region. Representatives from most of the organisations in attendance gave presentations on the primary aims of their organisation or on their research work in the region.

The forum identified opportunities for collaboration as well as several issues of concern and importance in this region. For instance, a workshop facilitated by Bruce McCollum (of Border Rivers Food & Fibre) found that many groups want to know how decisions will be made regarding the future management of the northern Murray-Darling Basin. Participants felt that the planning of the future Basin management priorities should be discussed as a matter of urgency, via very strong networking and collaboration between the various groups involved.

Steps needed to achieve that strong interaction were also addressed at the forum. A framework (Communications Plan) for sharing information and enhancing collaboration was developed in a workshop facilitated by Letitia Cross of Border Rivers/Gwydir CMA. One highlight of the framework is a proposal to appoint a jointly-funded Knowledge Facilitator/Communications Officer to maintain the flow of information between the research and management groups in the northern Basin. Also, to assist further communication, a discussion group has been set up at http://www.smartgroups.com/groups/NorthernMDB/.

The following topics for research and management were of prime importance to forum participants:

a) understanding how our riverine systems work,
b) understanding, managing, and allocating flows,
c) building capacity and improving inter-agency coordination in management and research,
d) finding a balance between exploiting and conserving resources.

Representatives of the several groups that are already focusing on aspects of these topics spoke about them. For example, staff and students from the CRC for Freshwater Ecology described their work on:

- fish habitat associations and habitat availability in the Barwon-Darling (Craig Boys)
- predicting the ecological response of aquatic salinity (Daryl Neilsen and Margaret Brock)
- inland river floodplains: the role of sediment and nutrient exchanges (Mark Southwell)
- diversity of riverine landscapes: the role of patches and connectivity (Mike Reid, Martin Thoms and colleagues)
- the Narran lake system — extensive research into numerous aspects of hydrology and biota.

The workshop was run by the Murray-Darling Freshwater Research Centre Northern Basin Laboratory in Goondiwindi, with support from the CRC for Freshwater Ecology.

For further information, or a copy of the proceedings, please contact:
Janey Adams (workshop organiser)
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or via
http://www.smartgroups.com/groups/NorthernMDB/.

The Condamine River, northern Murray-Darling Basin. Photo: CRCFE

Coming to grips with the science of stream restoration

by Shane Brooks

In a huge project that spans the USA as well as Victoria (Australia), information describing stream restoration projects is being marshalled. The goal of this National Riverine Restoration Science Synthesis Project (NRRSS) is to analyse the extent, nature, scientific basis and success of stream and river restoration projects, and to present this information in a form that is useful to scientists, restoration practitioners and those making policy decisions for funding and implementation.

The restoration of streams and rivers has become a multi-billion dollar industry worldwide; yet in surprisingly few cases has the performance of completed restoration works been assessed. Of the thousands of restoration activities that take place each year, it appears that only a few are catalogued or monitored. Any analysis is typically done at local scale, often by visual survey, and few restoration projects' outcomes are evaluated, particularly in terms of ecological values. Whatever the reasons for this lack of recording and evaluation, it has meant that ecologists involved in stream restoration are rarely able to use observations from successful past projects to provide sound scientific guidance to current and future projects.

In a determined effort to change this situation, the NRRSS has developed a database framework in which to store data and metadata about completed restoration projects. Most contributors to the database, and most of the restoration works incorporated in it, are in the USA, but there is also a south-eastern Australian node, run by Shane Brooks and Sam Lake of Monash University and the CRC for Freshwater Ecology.

A key feature of the NRRSS database is that it does not restrict the types of activities that can be called 'restoration'. However, to sort the wide range of data being provided, the NRRSS team has identified 12 categories:

- riparian restoration
- educational activities
- channel reconstruction
- fishways
- stormwater control
- instream habitat enhancement
- bank stabilisation
- water quality
- flow manipulation
- dam removal
- land acquisition
- floodplain reconnection.

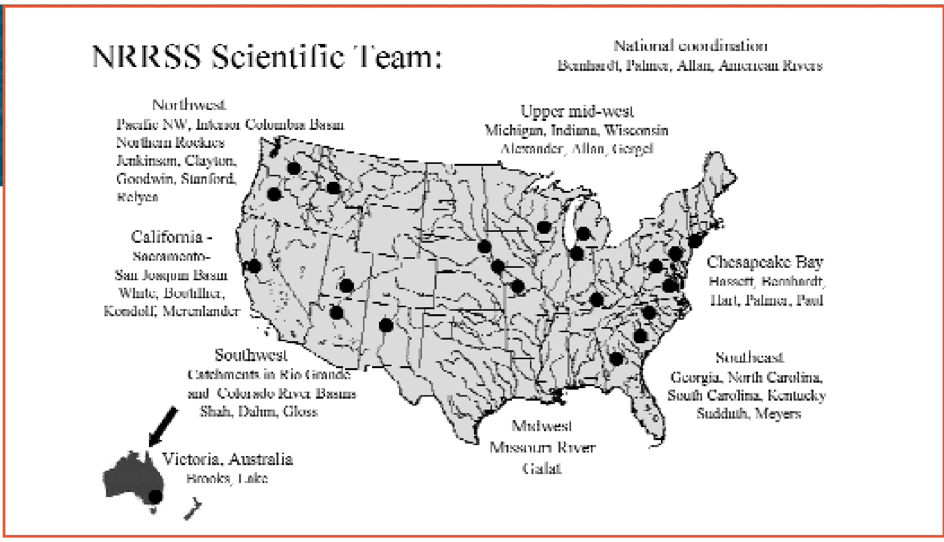
As there was little guidance on what constituted a successful stream restoration project, its definition became an NRRSS project in itself, and the outcome is published as 'Standards for ecologically successful river restoration' in the *Journal of Applied Ecology**.

The authors (members of the NRRSS team) first point out that restoration can be undertaken for multiple reasons (e.g. to protect infrastructure; to build social capital), only one of which may be to restore systems ecologically. Further, they emphasise that there is no universally applicable endpoint for ecological restoration projects. Local geology, climate, vegetation, land use, and species distribution must all be considered. However, they propose five criteria for identifying an ecologically successful stream restoration project:

- The project has had a guiding image from the start, describing the dynamic, ecologically healthy river that could exist at the site to be restored.
- The ecological conditions of the stream are measurably enhanced.
- The stream ecosystem is more self-sustaining than before the restoration.
- The restoration project has not itself harmed the stream.
- On completion, the ecological outcomes have been assessed in comparison to ecological conditions pre-restoration, and the results have been made available.

For applying the criteria, the team gives guidelines, and examples of suitable indicators.

And they propose that while restoration can be a success on many levels, it should not be labelled 'ecological restoration' unless it meets their five criteria.



Nodes included in the National Riverine Restoration Science Synthesis project in USA and Australia.
Map: NRRSS project

This list was developed during several workshops and after examining a number of existing and complementary databases. Projects are catalogued according to their stated goals. Later, detailed analysis will identify any mismatches between goals and actual outcomes.

The NRRSS team comprises widely respected research scientists — ecologists, engineers, geomorphologists — and stakeholders who are or have been closely involved in restoration practice and policy. They are grouped geographically into eight nodes (see map).

The Australian node is focusing only on Victoria. Shane and Sam have been working closely with the regional catchment management authorities (CMAs), which have supplied data from their restoration activities. So far, the information collected since July 2003 describes more than 2000 restoration projects initiated during 1999–2002 in Victoria by the Corangamite CMA, Goulburn/Broken CMA, Port Phillip CMA, and North Central CMA.

Records and data for restoration projects in Victoria before 1999 are hard to obtain. On the other hand, since being set up in 2001, a voluntary reporting and management system called CAMS (Catchment Activity Management System), run by the Dept of Natural Resources and Environment (now Sustainability and Environment), is proving a very useful source of data on restoration works in the last three years. Being Web-based, CAMS forms a central repository for information about on-ground activities, supplied by organisations all over Victoria.

At the moment, the NRRSS team as a whole is in Stage II of the project, evaluating the state of the practice of stream restoration and identifying completed projects that have been demonstrably successful and the reasons for that. This stage is going to take another six months to complete, since the database already contains information about 27,000 projects, assembled from 188 data sources and more than 200 personal contacts.

Catchment regions of Victoria: N-C = North Central, G-B = Goulburn-Broken, C = Corangamite, P-P = Port Phillip.
Map: Dept of Sustainability and Environment, Victoria

One of the benefits of the huge NRRSS project database is that it does not duplicate regional databases such as CAMS, though it may mine them for particular types of data.

Following, or partly concurrent with, the evaluation stage, the team plans to identify and report on the links between ecological theory and stream restoration (for example, the roles of refuges for freshwater biota, connectivity and natural processes). That process should highlight unanswered questions, which could stimulate new research.

By the end of the project, scientists and restoration practitioners hope to have access to specific recommendations that they can use as a basis for future stream restoration research and activities. And ultimately, the knowledge and experience currently being stored by the NRRSS project should help communities and river management groups to practise restoration works that achieve their objectives efficiently and at minimum cost.

The general momentum being generated by systems such as the NRRSS database and CAMS must surely eventually lead to more individual restoration works being reported, monitored and evaluated.

An example of stream restoration by installing wooden structure. Photo: CRCFE

For further details, see the NRRSS web site at http://nrrss.nbii.gov/, or contact:

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or
Professor Sam Lake
Phone: 03 9905 5653
Email: sam.lake@sci.monash.edu.au

Reference

* Palmer M.A., Bernhardt E.S., Allan J.D., Lake P.S., Alexander G., Brooks S., *et al.* (2005) Standards for ecologically successful river restoration. *Journal of Applied Ecology* (in press); posted at http://www.blackwellpublishing. com/.

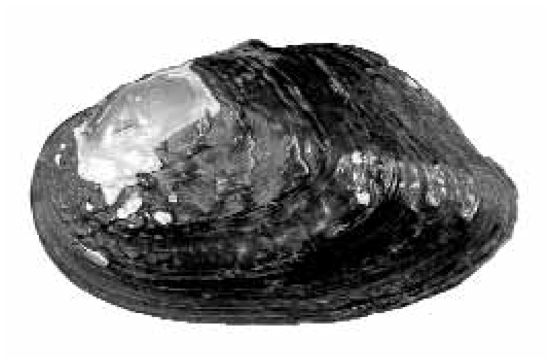
The National River Restoration Science Synthesis Project is run by a working group of the US National Center for Ecological Analysis and Synthesis (NCEAS). NCEAS is a research centre funded by the US National Science Foundation to be a catalyst for collaborative ecological research on major fundamental and applied problems in ecology. The centre is administered through the University of California at Santa Barbara and provides logistic and technical support to individuals and working groups as well as being a repository for the outcomes of synthesis projects.

The creature feature for this issue is the Glenelg River mussel.

Family: Hyriidae

Species: *Hyridella glenelgensis*

The Glenelg River mussel (*Hyridella glenelgensis*) is the smallest of the freshwater mussels of Australia, reaching a maximum recorded size of 52 mm. Its most distinguishing feature is the pattern of ridges or 'sculpture' on its shell. This mussel is most often found in areas of stream with significant amounts of riparian vegetation and it prefers sandy sediment where the water flow is relatively strong. Like all other mussels, the Glenelg River mussel is a filter feeder and lives off plankton that it removes from the water column through a siphon. This rarest of the Australian freshwater mussels is listed under the *Victorian Flora and Fauna Guarantee Act (1988)* and was once known throughout the Glenelg River system. Its range has contracted and it now lives only in one small tributary of the Glenelg River in south-western Victoria. Recent surveys have found several new populations in this tributary, some containing over 100 individuals.



Hyridella glenelgensis. Photo: Museum Victoria

This information was provided by:
Tim Playford formerly of
School of Earth & Environmental Sciences
The University of Adelaide
Email: tim@picknowl.com.au

SideStream

eWater CRC bid successful

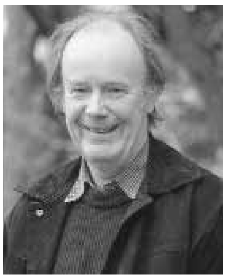
As you will all know by now, the eWater CRC bid was successful. The Federal Government has allocated the new CRC a little over $40 million over 7 years. Thank you to everyone who contributed to this successful eWater CRC bid.

Moving on

Paul Humphries, after almost 10 years with the MDFRC in Albury, Monash University and the CRCFE, has taken up a lectureship in Environmental and Applied Statistics at Charles Sturt University. However, Paul continues to contribute to research in river and fish ecology. He was been awarded one of six 2005 Harold White Fellowships at the National Library of Australia, and is using it to search the Library's collections of diaries, scientific reports, newspapers, photographs and other historical sources to identify the species, abundance and distribution of fishes in the River Murray in earlier times.

Congratulations to Gerry Quinn, who has accepted the Chair of Marine Biology at Deakin University, starting in May. Gerry, who has been with CRCFE since it began, based at Monash University, has been leader of program A: Flow-related Ecosystem Processes.

Senior Research Fellowship to Sam Lake



Congratulations to Professor Sam Lake (Monash University and CRCFE) who was awarded one of three inaugural Land and Water Australia Senior Research Fellowships, in December 2004. The research fellowship allows Sam to review ways in which drought affects freshwater ecosystems.

Input to the Global Water Systems Project

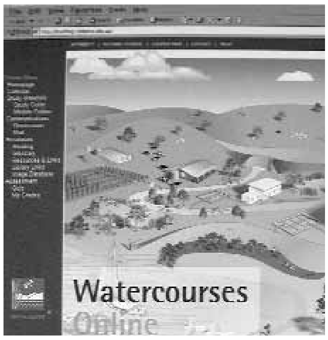
Professor Stuart Bunn (Griffith University and CRCFE) has accepted an invitation to join the inaugural Scientific Steering Committee of the Global Water Systems Project (GWSP). The GSWP is a joint project between DIVERSITAS, the International Geosphere-Biosphere Program, the International Human Dimensions Program and the World Climate Research Program. The project is supported by the Earth System Science Partnership.

Heading the Australian Society of Limnology

Congratulations to Sabine Schreiber (Arthur Rylah Institute and CRCFE) and Stuart Bunn (Griffith University and CRCFE) who were appointed President and Vice President (respectively) of the Australian Society of Limnology at its last annual general meeting.

Online courses currently enrolling

NEW! Watercourses Online is a set of self-paced online training courses, designed primarily to support personnel in water management, natural resources management, environmental education and ecological consulting. The three courses currently available are called: (i) Ecology and river function; (ii) Catchments: their character, waters and chemical composition; and (iii) Waterway assessment. These three new online courses, as well as the four existing AUSRIVAS Online modules, are run by CRCFE and University of Canberra. All seven online modules will be run in semester 2, 2005, provided there are sufficient enrolments. Fliers about them are included with this issue of Watershed.



For Watercourses Online, please register your interest via http://freshwater/canberra.edu.au/watercoursesonline.nsf, or ask for further details from Professor Richard Norris (phone 02 6201 2543, norris@freshwater.canberra.edu.au), Sue Nichols (phone 02 6201 5408, nichols@freshwater.canberra.edu.au), or Professor William Maher (Catchments module only), (phone 02 6201 2531, bill.maher@canberra.edu.au).

For AUSRIVAS Online, please register your interest at http://ausrivas.canberra.edu.au/Bioassessment/Macroinvertebrates/Training/ or contact Sue Nichols at nichols@freshwater.canberra.edu.au, **particularly if you would like the practical face-to-face workshop run for a group in your home state or territory.**

New technical reports available via CRCFE website, http://freshwater. canberra. edu. au > publications > technical reports

(i) *Urban Stormwater and the Ecology of Streams*: a report by Chris Walsh (Monash University and CRCFE) and coworkers Anthony Ladson and Tim Fletcher from CRC for Catchment Hydrology. The report explains why urban stormwater degrades the ecological condition of urban streams, during dry and very wet conditions, and, most importantly, following just a little rain. It shows how reducing the effective imperviousness of an urban catchment, using water sensitive urban design, can lessen the damaging effect of urban stormwater. The report should help readers manage rainfall and stormwater within their own areas of responsibility, whether that area is a house-block or a suburb. Please contact amilligan@freshwater.canberra.edu.au for printed copies.

SideStream

(ii) *Environmental Flows Monitoring and Assessment Framework*: a report presenting a framework that guides the design of monitoring programs for assessing the performance of environmental flows (see the article about it in this issue of *Watershed*). The framework, which can be applied to regulated and unregulated streams, was developed in a collaborative project between Monash University, Dept of Sustainability and Environment (Vic.), Dept of Infrastructure, Planning and Natural Resources (NSW), Dept of Natural Resources and Mines (Qld) and University of Canberra.

For both reports, see http://freshwater.canberra.edu.au and follow the link from the home page, or click Publications > technical reports.

Catchment Modelling School, CRC for Catchment Hydrology

The 2005 CRCCH Catchment Modelling School in Brisbane and Sydney during July is a unique opportunity to understand and apply a new generation of software tools designed to underpin catchment management. The 11 workshop themes are: understanding catchment modelling; climate variability and data analysis tools; environmental flows; modelling frameworks; salinity; rainfall–runoff modelling; river engineering; river system and water allocation modelling; urban hydrology; water quality modelling; water trading. See http://www.toolkit.net.au/school for details, costs and registration.

Inside MFAT

The Murray Darling Basin Commission has released a new component of the Murray Flows Assessment Tool (MFAT) website, called 'Inside MFAT'. 'Inside MFAT' provides an insight into scientific information and results that reside within the MFAT. See www.mdbc.gov.au/livingmurray/mfat/.

Northern Basin Freshwater Forum

A Northern Basin Freshwater Forum was held on 16–17 November 2004 in Goondiwindi, Queensland, organised by Janey Adams of CRCFE and the Murray-Darling Freshwater Research Centre. See the report in this issue of *Watershed*.

MDFRC moves at Albury-Wodonga

The Albury-Wodonga lab of the Murray-Darling Freshwater Research Centre has moved onto the Wodonga campus of La Trobe University. All phone numbers and email addresses are unchanged, but the new fax number is 02 6059 7531 and the mailing address is PO Box 991, Wodonga, Vic 3689.

Business trip to South Korea

Professor Gary Jones (CRCFE), Dr Rob Vertessy (CSIRO), Dave Perry and Geoff Podger (CRCCH) and several industry representatives visited South Korea late last year. The purpose was to strengthen relations with the South Korean National Water Management Authority (KOWACO), and the Sustainable Water Resources Research Centre (SWRRC). The hosts were particularly interested in our river ecological assessment and environmental flows work.

Presentation to the Yellow River Conservancy Commission

Professor Gary Jones joined the Chief Executive of the Murray-Darling Basin Commission, Dr Wendy Craik, and her staff in a presentation to the Director and staff of China's Yellow River Conservancy Commission, in November 2004. The topics, which included water trading and water resources management in the Murray-Darling Basin, as well as CRCFE work on environmental flows assessment, were of great interest to the guests.

International editorial board appointments

Congratulations to Professor Angela Arthington (Griffith University and CRCFE) who has been appointed an Advisory Editor of the journal *Environmental Biology of Fishes*; and to Associate Professor Martin Thoms (University of Canberra and CRCFE) who has been appointed to the editorial board of the journal *Geomorphology*.

Science meets Parliament

'Science meets Parliament' 2005 was recently held in Canberra. Several CRCFE scientists attended to talk to Parliamentarians about the science behind the national water initiative and other water related issues. The scientists included: Gary Jones, Ralph Ogden, Richard Norris, Shaun Meredith, Scott Rayburg and Nadine Kelly. The scientists found it an enjoyable and productive event.

CRCFE web site:
http://freshwater.canberra.edu.au

Photo: Haley White

Feature plant
by David Williams

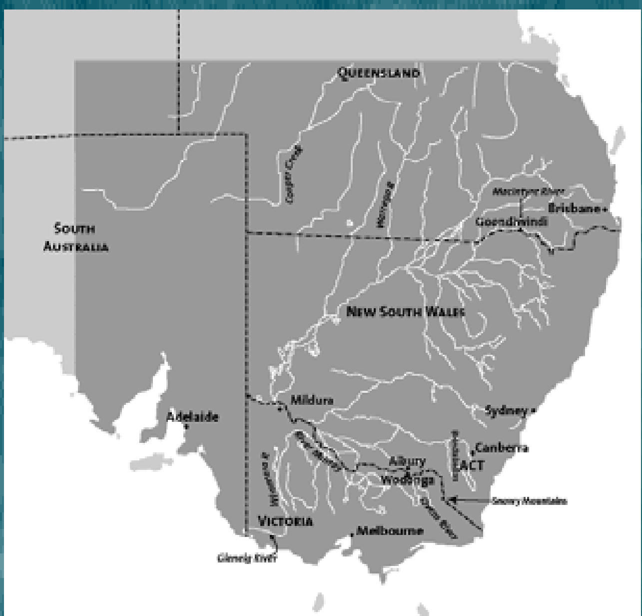
Alligator weed

Family: Amaranthaceae
Species: *Alternanthera philoxeroides*

Alligator weed is a summer-growing perennial found both in freshwater and on wet land. It establishes on land and in shallow water, but it also floats, forming mats that can cover entire water surfaces. In the latter situation it has long hollow stems and thin stringy roots, with opposite leaves 20–70 mm long. The flowers are small (12–14 mm wide) and silvery-white. Alligator weed is spread by plant fragments floating in a water body, or by being moved by animals, machinery and boats. So far, no viable seed has been found in Australia.

This 'Weed of National Significance' was introduced from South America and is now found in all Australian states. Although it is highly invasive and causes heavy environmental and economic impacts, it is also sometimes cultivated as a garden herb. If found, alligator weed should be reported to a state/territory management agency (because attempting to remove the weed can cause it to spread downstream). Herbicides, harvesting and biological control can then be used to help control the plant.

For more information please refer to the web site of the CRC for Australian Weed Management, http://www.weeds.crc.org.au/documents/wmg_alligator_weed.pdf, from which some of the information here has been sourced.



Areas mentioned in this issue.

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Opinions expressed in *Watershed* are not necessarily shared by all members of the CRC for Freshwater Ecology.

Watershed is produced by the CRC for Freshwater Ecology Knowledge Exchange Team. Unless otherwise stated, all articles are written by Ann Milligan, Bronwyn Rennie and Hayley White.

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