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contents

Time for a Decade of Landscapes

Thinking big

If the 1990s was the Decade of Landcare — recognised for its community empowerment and local natural resources management — I believe the 2000s must become the Decade of Landscapes — a time of thinking and acting at the whole-of-catchment or whole-of-basin scale.

It won't be easy. That statement may seem surprising because many scientists and managers have adopted a philosophy of integrated catchment research and management. However, not everyone has the capacity to act on that philosophy.

In practice, most scientists and managers focus on small-scale measurements, and on geographic scales that are amenable to traditional field-based investigations and management actions. 'Integration' has become code for 'reductionism' — that is, notionally breaking an ecosystem down to small bits that are easily examined and explained, and then attempting to piece back together the knowledge jigsaw or model that has been created.

There is a risk in relying solely on a reductionist approach. To use an example from the world of art, we may start by considering a classic Turner landscape, but end up reconstructing a surrealist Dali dreamscape! All the bits might be there in our model, but does it look or behave like the real world?

This is not to say that there is no place for reductionist science and management. Rather, managing and researching at a landscape scale requires a balance of reductionist and holistic approaches.

The holistic approach — looking at a whole catchment at once — is based on system thinking, recognising the complexity of natural ecosystems. Holistic approaches depend on innovative methods for undertaking large-scale measurement and analysis.

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

Learning to predict

The second R&D challenge for the 2000s will be to develop an ability to forecast the response of an ecosystem, whether it be a local wetland or an entire river system, to management actions proposed by governments or regional management groups.

As ecologists, most of our research focuses on the past — how ecosystems have changed over time — or the present — describing the current ecological condition, functional processes or major stressors on plant and animal communities. We are confident when it comes to explaining the wrongs of the past and problems of the present. But we are sometimes far more cautious, indeed hesitant, to discuss the actions and financial investments that are required to deliver the river ecosystems that communities may want in the future.

Nevertheless, the future is not a twilight zone of pseudo-science and ecological conjecture. Instead, freshwater ecologists will develop the types of predictive models that have long been essential in branches of the physical sciences such as meteorology, seismology and chemical engineering.

To do this, ecologists will need a strong base of known quantitative, cause-and-effect relationships: for example, the relationship between river flow rate and the availability of in-stream fish habitat. As well, we will need to develop a capacity to forecast and make predictive models, by learning from the techniques of terrestrial landscape ecology and disciplines such as economics and mathematics.

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

The new CRCFE research portfolio

To help guide the CRC for Freshwater Ecology (CRCFE) in its Stage 2 research portfolio (2003–2006), we have developed a knowledge-planning matrix (see figure) based on two themes: ecological scale and knowledge maturity. The small ecological scale focuses on point-scale measurements of forms or processes. The large scale considers whole landscapes. The stages of knowledge maturity begin at data collection, progress to identification of patterns and relationships, and finally reach mature knowledge. Ideally, with mature knowledge ecologists are able to make informed predictions about the future.

Depending on where we direct our research efforts across this matrix, four categories of knowledge 'product' are developed:

1. small-scale data and information, e.g. species life history, habitat requirements, water quality measurements;
2. large-scale data and information, e.g. GIS or National Audit maps, animal migration patterns, catchment flows, climate data;
3. small-scale predictions, e.g. river health models, reservoir management models, water sensitive urban design models and systems;
4. large-scale predictions, e.g. outcomes of environmental flow allocations, analysis of complex systems, scenarios and possible impacts of climate change.

If we are to address the water resources problems facing Australia now and into the future, we need to distribute our research efforts across all four of these knowledge-product categories, especially moving from small- to large-scale predictions.

I have asked the staff of the CRC for Freshwater Ecology to adopt the following strategic themes when developing our new research portfolio:

- encouraging thinking and understanding at both large (landscape) and small scales and over short and long time-frames;
- searching for measurable and predictable relationships between environmental stimuli and ecological condition, for eastern Australia and its climatic zones;
- increasing our ability to forecast the effects of human actions on ecosystems;
- ensuring that we have efficient turn-around times when analysing and synthesising data, and when publishing and communicating ecological knowledge;
- providing knowledge and practical advice on the issues that are emerging for water resources management, such as the effects of climate change on rivers and wetlands.

The underlying message is: think big and think to the future.

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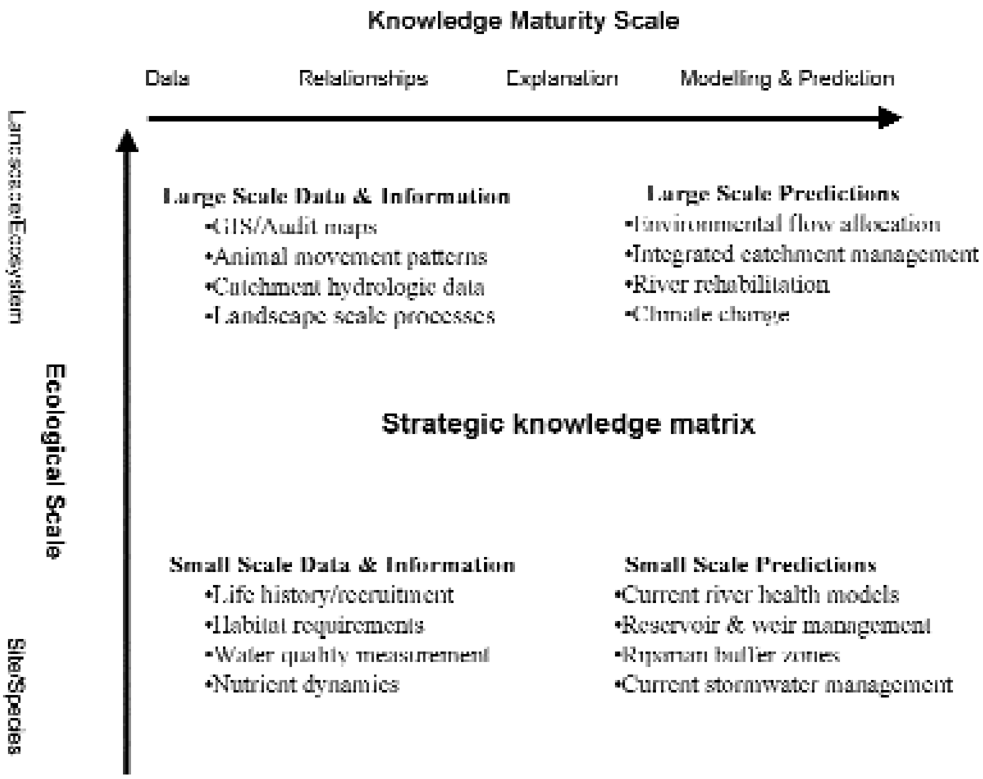


Avoiding Going Down the Drain

by Chris Walsh

It is not the imperviousness of the catchment but the path by which urban stormwater runoff is delivered to streams that determines their ecological health. This finding, by the CRC for Freshwater Ecology, disagrees with viewpoints accepted overseas.

In a catchment, impervious surfaces such as roads, concrete footpaths and roofs prevent rainfall from infiltrating into the soil. If an urban catchment has little land in gardens, agriculture or bushland, much of the rainfall stays above ground. It becomes surface runoff, flowing into drains and streams, where it increases the frequency and intensity of floods in the catchment.

The disturbance resulting from these floods and the pollutants associated with the runoff degrades in-stream communities of fauna and flora.

But how much of a catchment's surface can be impervious before stream degradation is inevitable?

A US report on the effects of urban design on freshwater ecosystems has recently attracted interest in Australia.

The report builds on the observation that, in the United States, streams that have hard surfaces covering more than 10% of their catchments are generally in poor ecological condition. Beach, the report's author[1], goes so far as to elevate the observation to a rule — 'the ten-percent rule'.

The report's strong message is that severe degradation is inevitable in a freshwater ecosystem when urban development covers more than 10% of the ecosystem's catchment with impervious surfaces.

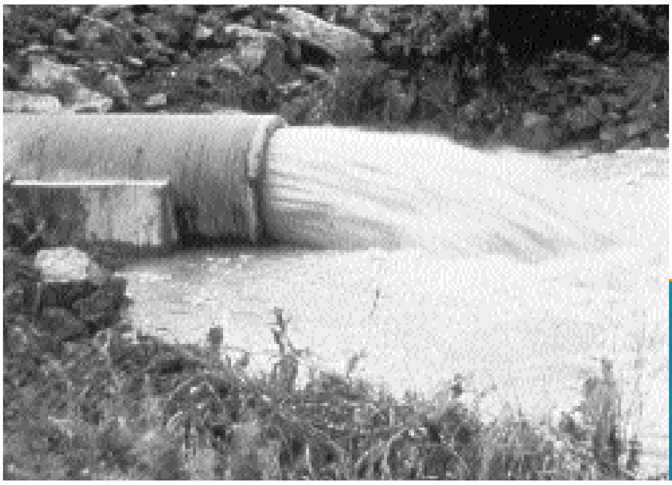
However, current research at the CRC for Freshwater Ecology (CRCFE) suggests that the ten-percent rule is not universally applicable. That is, measuring imperviousness is not a sensitive way of predicting stream degradation. In fact, many studies, both in Australia and overseas, have reported a wide range of stream conditions in catchments that have similar percentages of imperviousness.

A CRCFE project, called 'Urbanisation and the ecological function of streams', is testing other factors associated with urban land use that might contribute to stream degradation. One factor that is under focus is the degree to which impervious surfaces are directly connected to the catchment's streams by stormwater drains and pipes.

We have developed a simple index of drainage connection,

Drainage Connection = the proportion of impervious areas in a catchment that are directly connected to a stream by a stormwater pipe or sealed drain,

and are testing the relationship between it and stream health in the Dandenong Ranges on the eastern fringe of Melbourne. We selected this area because it is characterised by an unusual mosaic of urban settlements scattered among forested reserves.



Streams that receive piped stormwater are likely to be severely degraded.
Photo Tim Fletcher

The settlements vary widely in the extent to which they are drained by stormwater pipes. In the catchments, impervious surfaces cover anything from zero to 12% of the area, but Drainage Connection ranges from zero to 60%.

The study is finding that the ecological condition of streams in the Dandenong catchment is more highly correlated with Drainage Connection than with imperviousness. Connection explains variations in the abundance and types of in-stream algae, the communities of macroinvertebrates, the electrical conductivity of the water, and the concentrations and loads of phosphorus and heavy metals. The more efficiently a catchment is connected by stormwater pipes to its stream, the more degraded the stream.

There is one exception to this strong trend. Concentrations of nitrate and nitrite, the dominant forms of dissolved nitrogen in these streams, are more strongly correlated with the density of septic tanks in each catchment than with Drainage Connection. Imperviousness is only weakly correlated with nitrogen concentration.

So how does this study, working mainly in catchments of less than 10% imperviousness, throw doubt on the validity of the 'ten-percent rule'?

By demonstrating that stream condition is more strongly correlated with Drainage Connection than it is with imperviousness, the study suggests it is the path by which runoff is delivered to streams that is critical.

Now, in most cities of the world, developed areas with greater than 10% imperviousness are well serviced by efficient piped stormwater drainage. It is therefore not surprising that most streams draining such catchments are severely degraded — apparently supporting the 'ten-percent rule'.

But this need not be the case. 'Water sensitive urban design' is increasingly being applied to new developments. Well-designed urban catchments are beginning to be drained by stormwater systems that allow much of the stormwater to infiltrate into the soil or to be retained in wetlands. These catchments therefore have less Drainage Connection. Because more of the stormwater reaches the streams slowly via a belowground path rather than quickly as runoff, it is likely that those streams could remain in good ecological condition even if perhaps 40–50% of the catchment surface was impervious.

Grassed swales allow stormwater to infiltrate the soil and travel slowly to streams. Photo Tim Fletcher

As more and more municipalities around Australia embrace water sensitive urban design, the condition of waters downstream looks likely to improve.

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1 Beach, D. (2001) *Coastal Sprawl. The Effects of Urban Design on Aquatic Ecosystems in the United States.* Pews Ocean Commission, Arlington, Virginia.

Consider the Benefits and Drawbacks before Restocking Fish

by John Harris

There have been some excellent outcomes from restocking waterbodies with native fish from hatcheries. For example when rivers are dammed they can become incapable of supporting self-sustaining fish populations. Using hatcheries to break through the ecological barriers to fish breeding, migration and population recruitment in water storages has often been the key to ongoing, good-quality fisheries.

Artificially propagated native fish have also been used to rehabilitate damaged fish populations. Two such programs were the restocking of the endangered eastern cod in the Clarence and Richmond rivers, and Manning bass in the Manning River. The community was made aware of the importance of the sustainable use and conservation of native fish, and this awareness program, together with fishing restrictions and the restocking program, has been able to reverse the declines of both fish species.

Some stocking projects have no effect, particularly when fish are released into waters that are ecologically unsuitable. In waterbodies that have already reached their fish-carrying capacity, stockfish are either eaten by the larger residents or migrate elsewhere.

In other cases, stocking with native fish can actually damage the fishery that it is intended to boost. Fisheries departments have designed hatchery procedures to prevent adverse genetic effects, but the rules are time-consuming, costly, and hard to implement. As a result, many thousands of genetically similar young fish are sometimes bred in private hatcheries from only one or two pairs of broodstock and then released into the wild. This affects the genetic diversity that helps to ensure populations remain adaptable under conditions of large-scale environmental change. Genetic diversity can be grossly damaged if restocking programs are not implemented carefully, especially where the existing wild population is small in number.

Releasing trout cod into the Murrumbidgee River, Angle Crossing, ACT.
Photo: Karen Markwort

When large numbers of hatchery fish are added to a small residual wild population of the same species, they can out-compete the wild fish for food and habitat. This can eliminate the wild fish, and then the hatchery fish may in turn decline and die out if they have poor fitness and low long-term viability.

Another adverse effect occurs when one species is built up by over-stocking to such an extent that it disturbs the ecological balance among the other fish species in the area. The resident species are likely to suffer as a result of this ecological imbalance.

There are numerous examples of unintended species being introduced to waterbodies because they were lurking in hatchery shipments. When they compete successfully with the preferred species, their invasion poses serious threats to the future of wild native fish.

Disease is an ever-present risk in stocking programs and we know far too little about it. It is extremely difficult to prevent the spread of some diseases from infected hatcheries. Many infectious diseases can be spread before symptoms appear. The EHN virus for example, fatal for native fish such as Macquarie perch and silver perch, may be carried, and therefore spread through the water, by redfin perch and trout that have recovered from the virus.

It is important to consider the reasons for the supposed need for stocking. What is the environmental stressor that has affected the fish population? If it is overfishing, then stocking might help, but possibly some sort of change in fisheries management would be equally effective. If it is poor water quality, then stocking is unlikely to be effective.

Thus, stocking is not necessarily a long-term answer (apart, perhaps, in fisheries based in lakes or impoundments). It is only one step towards rehabilitation. We must not see stocking as the complete solution, because it rarely is. It is a bandaid, interim measure and should only be used as a prelude to longer-term, sustainable measures.

In summary, we cannot rely on fish stocking to solve the problem of declining stocks of native fish. However, the technique can be very useful, in conjunction with other management tools, for rehabilitating and managing our fish stocks.

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Eastern swamphen Porphyrio porphyrio melanotus.
Photo: Environment ACT

The fauna feature for this issue is the eastern swamphen:

Family: Rallidae

The eastern swamphen (*Porphyrio porphyrio melanotus*) is often seen walking near or in reedbeds on lowland rivers, lakes and wetlands throughout the Murray-Darling Basin and Tasmania and around the east coast. It is a large bird, about 43 cm tall, with long legs, a red bill and patch on the forehead, a deep purple breast and throat and a black back. The swamphen feeds on reeds and other plants, but also preys on frogs and insects and even other birds' eggs.

Unexpected results of flooding at Barmah Forest

As reported recently by ABC Online, one PhD project supported by the CRCFE has had unexpected results. Andrea Ballinger is studying the response of forest-floor invertebrates (insects and spiders) to changes in flood patterns and amounts of woody debris in the river red gum forest on the River Murray. After a trial flood in spring 2000, she was amazed to find numerous large spiders and beetles that have never been recorded in the area before.

Andrea's project is taking place in the Barmah State Forest, on the River Murray in northern Victoria. The forest is managed so as to balance its ecological needs and the economic and cultural interests of its users. Its understorey of grasses, sedges and rushes is grazed. The forest is also a source of timber, besides containing rare plants and animals and internationally important wetlands. In natural conditions, river gum forests used to be often flooded, and would have had plenty of woody debris on the ground. River regulation has greatly reduced flooding and wood collection has greatly depleted floodplain woody debris.

In 2000, a flood was generated by the cooperation of water regulators in the area. It was equivalent to a 1-in 20-year flood, and inundated more than 25 000 ha of forest for several months, until January 2001. Some areas were extensively flooded, others were moderately flooded or not flooded at all. The previous flood had been eight years earlier, in 1992–93.

When the floodwaters receded, Andrea found that the beetle and spider species at sites that had been extensively flooded were very different from the species at drier sites. The fauna at extensively flooded sites was dominated by large numbers of wolf spiders and carabid beetles that hunt freshwater species stranded along the receding edge of floodwaters. Among the largest carabid beetles was *Catadromus lacordairei* Boisd, which is even known to prey on frogs.

The Barmah (Victoria) and Millewa (NSW) forests fringe the Murray for about 50 km.
Photo: D. Eastburn, courtesy of MDBC

Not only were there more beetles and spiders at extensively flooded sites, but the species trapped were also, on average, much larger than species from drier sites. For instance, there was 1000 times more total mass of beetles at flooded sites than at the drier sites. This dramatic increase in invertebrates is likely to have cascade effects through the food web.

There was no flood in spring 2001, so Andrea was able to compare flooded and non-flooded conditions. In 2001, while ants increased in numbers and diversity under the dry conditions, the flood-adapted beetles and spiders were almost absent.

Catadromus lacordairei, *the frog-eating beetle, shown life size. Photo: Adrian Dyer*

The project, which is being supervised by Professor Sam Lake of the CRC for Freshwater Ecology and Dr Ralph MacNally, has a second focus as well. It is examining the invertebrates that use forest-floor logs as habitat. Andrea has caught invertebrates in pitfall traps and found that there are different species in areas with much or little coarse woody debris on the ground. Pitfall traps are open cups, containing a small volume of preservative solution. The traps are set into the ground so that insects and spiders walking along the ground surface just fall in. Andrea removed her traps between sampling periods, to avoid injuring livestock in the area, and because otherwise the traps would have floated away during flooding. However, she says: 'Digging in 250 pitfall traps every three months was a lot of hard work and has certainly put me off gardening'.

To supplement the collections from pitfall traps, Andrea has developed techniques for extracting unwilling bugs from pieces of wood in the laboratory, using mallets, chisels, band saws and a lot of patience. She emptied 68 logs of all extractable creatures. Although she found that few invertebrate species use river red gum logs directly as habitat, she noted that the richness and abundance of invertebrates was greatest in old logs.

The most commonly collected beetle, *Nargomorphus* sp., lives on decaying organic matter, which tends to accumulate in areas with woody debris and little human or grazing disturbance. However, woody debris on the ground probably also modifies air movement at ground level, helping to keep the humidity and temperature more constant than in bare areas, slowing the drying of the soil and providing shelter from predators.

Coarse woody debris on the ground may partly determine which invertebrate species are present. However, flooding, which also affects the species composition of insects and spiders in old fallen logs, dramatically changes the structure of the food chain at ground level.

'Invertebrates are not usually considered when hydrological management policy is formulated', Andrea says, 'yet these findings suggest that flooding may play a key role in sustaining invertebrate biodiversity in river red gum floodplain forests'.

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A Passion for Freshwater Education

Education is fundamental to the aims of the CRC for Freshwater Ecology (CRCFE).

The CRCFE's Education Program trains the water scientists and managers of the future to be able to understand, improve and protect Australia's inland waters. The program also aims to make the community aware of water health and related environmental issues.

Ms Debbie Heck is the new leader of the Education Program. Therefore, she is responsible both for community education and for managing all 47 PhD and Masters students attached to the CRCFE or working on topics of interest to it. Debbie is based at Griffith University in Brisbane, but the students work at any of the five university partners in the CRCFE — Monash, La Trobe, Griffith, Adelaide and the University of Canberra — with their own research supervisors.

Three of Debbie's passions are teaching, environmental education and research. 'I have wanted to teach since I was ten years old', she says. While employed as a teacher of geography and science in a high school, Debbie became dedicated to teaching about the environment as well. One group of Debbie's students was curious to know whether the plastic carry-bags developed by a major supermarket chain were as biodegradable as was being claimed. They were concerned that the green image the supermarket was promoting would lead shoppers to use many more bags than usual, believing they would gradually turn to dust. On testing the bags, the students found that they did not in fact disintegrate into harmless dust upon exposure to sunlight. The students wrote to the company and a national television current affairs program. Within a week the students were on national television and the company had withdrawn the bags from the market.

'I'm passionate about education because I see it as a way of achieving a sustainable world,' says Debbie. 'Education is one of the most effective ways of bringing about change that will address current and future environmental problems.

'Students need to have the skills and abilities to engage in the education process and to communicate their ideas to others so that changes can be made. Therefore, it is important that students are able to develop skills in problem solving, communication and critical thinking. It is these skills and abilities that transform our students into environmental professionals who are well respected in the community, as well as people who contribute to the improvement of our environment,' she says.

Leadership and experience in environmental education, as well as ideas, enthusiasm, administrative skills and drive — these abilities of Debbie's can only benefit the CRCFE Education Program in its community and student activities. With her at the helm, the program looks set to go from strength to strength.

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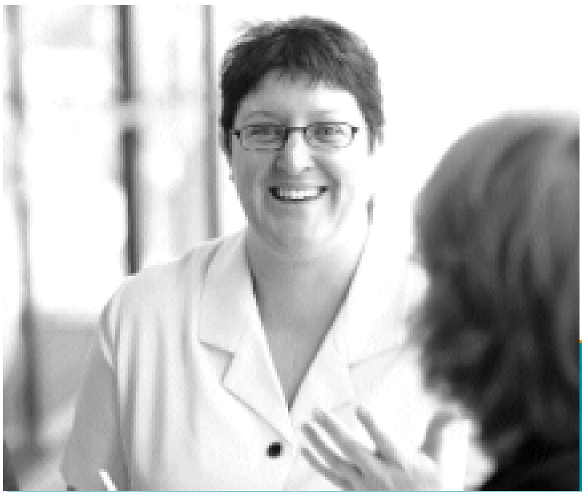


Debbie Heck has a passion for education. Photo: Tony Bee.

SideStream

Community Scientists for the CRC

Mark Southwell recently began working as the first Community Scientist in the CRC for Freshwater Ecology. He is based at the Murray-Darling Freshwater Research Centre Northern Laboratory in Goondiwindi, Queensland. Most of Mark's time is spent liaising with the community, and informing individuals and resource management groups about the CRC's work in the region and any relevant research findings.

During his Honours year at the University of Canberra, Mark mapped and studied the flow-structure of anabranch channels along a 150-kilometre reach of the Macintyre River. As he worked and communicated with the landholders along the Macintyre River, Mark was encouraged by their desire for sound ecological knowledge and reliable information on 'their river'. Now, as the CRCFE's Community Scientist for the region, he is keen to discuss ecological information with them and learn from their local knowledge. Mark can be contacted by phoning 07 4671 6131 or emailing <Mark.Southwell@nrm.qld.gov.au>.

Sylvia Zukowski has also recently started work part-time as a Community Scientist, at the Lower Basin Laboratory at Mildura, Victoria. Sylvia's Honours year at University of Adelaide was spent studying interactions between native and exotic water snails. Sylvia is working with Michelle Bald, and can be contacted by phoning 03 5023 3870 or emailing <Sylvia.Zukowski@csiro.au>.

Griffith University Wins the Allen Strom Eureka Prize for Environmental Education

Debbie Heck, leader of the CRCFE's Education Program, was part of the team from Griffith University that won the $10,000 Allen Strom Eureka Prize for Environmental Education at the Australian Museum's Eureka Prize Dinner in August. Working with UNESCO, the team has created a comprehensive multimedia teacher education resource with 100 hours of professional development. Thousands of teachers across the world are using the program to enable their students to develop their own visions of a sustainable world.

Hydrology Symposium in Alice Springs

Associate Professor Martin Thoms and Dr Fiona Dyer of the CRCFE were part of the committee that organised the recent successful symposium of the International Association of Hydrological Sciences (IAHS). The symposium, held in Alice Springs, was attended by over 70 participants from six countries.

Of the ten staff or students of the CRCFE who presented papers, two won awards. Heather McGinnes won the best poster presentation for her paper called 'Connectivity and fragmentation of floodplain-river exchanges in a semi-arid anabranching river system'. Neil Sims won the prize for the best oral presentation, 'What happens when floodplains wet themselves'.

Student Success at BIOGEOMON 2002

The focus of the recent BIOGEOMON 2002 symposium on ecosystem behaviour, which was held at The University of Reading, was on biogeochemical responses to global change. Alison Mitchell, a PhD student in the CRCFE, based at Albury, received an award for presenting one of the best student oral presentations at the conference. Alison's paper was called 'The interactions of anaerobic nutrient cycling processes and phosphorus release from freshwater sediments', and it was highly commended by an international panel of judges for its content and presentation.

BIOGEOMON 2002 was attended by over 260 delegates from 25 countries. There were 43 invited speakers, 96 contributed talks and over 150 poster presentations.

Moving On

Two key members of CRCFE staff have decided to move to new billabongs. Dr John Whittington, Knowledge Broker and, recently, acting Director of Knowledge Exchange, and Ms Lynne Sealie, the centre's Communication Manager, have both left to take up new jobs elsewhere. We wish them well.

Lynne Sealie and John Whittington will be missed by the CRCFE. Photo: Heath Chester

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

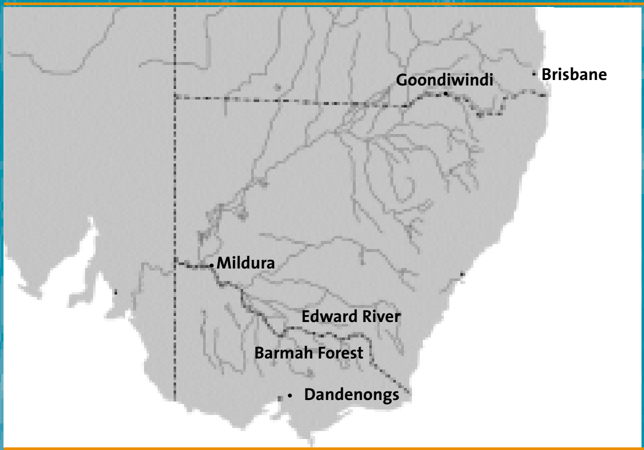
Feature Plant

by David Williams

The common reed is the feature plant for this issue of Watershed.

Family: Poaceae

The common reed (*Phragmites australis*) grows in freshwaters. It is the most widespread and common water grass in Australia and around the rivers, lakes and wetlands of the temperate world. Using its extensive rhizome system, the reed can grow in water up to 2 m deep, but also occurs in areas that are seasonally flooded, as well as in estuaries. Not surprisingly, it is a weed of irrigation channels, but it is also famous for its capacity to stabilise the beds and banks of rivers (and polders). It is one of the most productive of water plants, probably second only to papyrus (*Cyperus papyrus*). In a nutrient-enriched swamp in the Murrumbidgee Irrigation Area, the annual above-ground production of common reed was more than 12 kg m^{-2} (120 t ha^{-1}). The annual shoots can grow to over 5 m tall in 7 months. The stand pictured here is forming an island in the channel of the Edward River near Deniliquin.



Areas mentioned in this issue.

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