



WaterShed



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Recovering from the drought

By Gary Jones

Will land and water management practices during the drought worsen or lessen the stress of prolonged drought?

Drought is part of the natural climatic cycle experienced by the animals, plants and micro-organisms that live in and alongside Australia's rivers and wetlands. Natural low-flow and dry periods are as important as natural high flows and floods for maintaining biodiversity and healthy rivers. The abilities of organisms to survive prolonged dry conditions and drought (their resistance) and recover from it (their resilience) are 'hard-wired' into healthy aquatic ecosystems through eons of evolution.

Nevertheless, a one-in-a-hundred-year drought is a significant environmental stress. For native populations to survive and recover from a prolonged drought, all their built-in ecological resistance and resilience mechanisms need to be fully functional. That may not be the case in river ecosystems that are stressed by habitat destruction, reduced flows and poor water quality.

Organisms resist drought using a range of physiological, behavioural and life stage responses.

- Fish move downstream or retreat to isolated pools as headwaters dry.
- Plants reduce evapotranspiration losses from leaves, and set seed.
- Freshwater mussels and yabbies survive by burrowing deep into moist river sediments. Yabbies can remain safely buried for months or even years.
- Turtles migrate overland to find new water-bodies, while some species can survive for at least three months without water, by hibernation.
- Zooplankton and some benthic invertebrates produce desiccation-resistant eggs.
- Algae and bacteria produce resistant spores (cyanobacterial 'akinete' spores have been known to germinate after 50 years of drying!).

In spite of these resistance mechanisms, populations may suffer large losses during a drought and take many



years to recover. In extreme droughts, sensitive species of insects and other macroinvertebrates may die out.

When the drought breaks, the speed of recovery is variable and difficult to predict. The mixed community of organisms that existed prior to the drought may not fully reappear until there has been a progression through colonisers to species with longer life-cycles. Upon rewetting, zooplankton eggs in wetlands hatch rapidly, providing a food source for insects and juvenile fish. Water boatmen, backswimmers and beetles are among the first animals to re-colonise rivers and wetlands. Native fish populations may take many years to fully recover, but, at a scale of decades, there is little evidence that fish populations are affected by drought in healthy river systems.

Chemical changes also occur during drying and rewetting. As exposed lake and river sediments bake and micro-organisms die during droughts, nutrients become more available. When sediments are rewetted there will be an initial pulse of carbon, nitrogen and phosphorus into over-lying waters.

Just like humans, healthy populations of plants and animals are generally better able to cope with environmental stresses than the weak or sick. Their capacity to draw on natural survival mechanisms depends on the ecological condition of individuals or populations

before the drought. Where ecosystems are already degraded, the capacity to survive may be damaged, and the speed of recovery may be slowed. In severely degraded rivers and wetlands, a prolonged drought may be 'the straw that breaks the camel's back' for some sensitive or threatened species.

For all rivers, our ways of managing land and water during and following the drought are of critical importance. In particular, in-stream and floodplain drought-refuges, and the organisms they support, need to be protected. The following are some management actions that could help preserve aquatic communities during the drought.

- Environmental flows should continue to be released, to protect stream refuges and habitats downstream of dams. Large dams, especially those used solely for urban water, prolong the drought for the river downstream. The dams empty during the drought and it can take months or years until they fill and spill again. Periodic releases of water, as base flows and pulses, can help the downstream aquatic communities survive and recover from the drought. Although some people consider this a waste of precious drinking water, it is a small and very sound investment for sustaining healthy rivers. Bear in mind that up to half the water used in towns and cities in summer is for garden watering. Environmental flows are currently being released in the Cotter River system in the ACT (Canberra's main drinking water supply) to protect downstream habitats.
- Cart in water for livestock, where possible, rather than pumping it out of waterholes or drying creeks. Waterholes are refuges for freshwater fish, frogs, birds and invertebrates (such as yabbies and insects). They should not be pumped dry to provide water for livestock.
- Fence out or move livestock away from wetlands, waterholes and low rivers, so they will not damage the banks and beds and vegetation. Grazing, trampling and dung add severely to the stress these habitats are already bearing.



*Professor Gary Jones, Chief Executive
of the CRC for Freshwater Ecology.*

Photo: L Sealie

- Erect signs warning against over-fishing in waterholes and low rivers. Native fish, turtles and invertebrates such as yabbies congregating now in waterholes and low creeks are the breeding adults that will restock our rivers and wetlands after the drought.
- Where there is little waterside vegetation, dig shallow trenches as sediment traps now, parallel to and a suitable distance from the water's edge. The trenches and traps should reduce soil washing off adjacent paddocks and into the water in heavy rain.

Managers of drinking water supplies are aware that drought-breaking storms are likely to generate significantly dirty water. Storm run-off picks up fine sediment, nutrients and pathogens from the dry soil surface especially during the first flush of heavy rains. Where possible, it may be prudent to allow the first 24–48 hours of storm flow to bypass town water supplies.

And a final word ... drought can benefit river ecosystems by thinning out populations of non-native species poorly adapted to drought conditions. For instance, in normal conditions, introduced trout prey heavily on

small native fish such as mountain galaxiids. But droughts are known to selectively reduce trout populations allowing threatened galaxiid populations to recover.

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Further reading :

Lake, P.S. (2003) On the ecology of perturbation by drought in flowing waters. *Freshwater Biology*, Volume 48 (in press).

Proceedings of the 'Symposium on the Role of Drought in Aquatic Ecosystems' (2001). Published jointly by CRC for Freshwater Ecology, Murray-Darling Freshwater Research Centre, and Land & Water Australia, 68 pp. See <http://freshwater.canberra.edu.au> > Publications > technical reports.



Victoria River red-faced turtle, *Emydura victoriae*.
Photo: A Georges

The fauna feature for this issue is the Victoria River red-faced turtle, *Emydura victoriae*.

Family: Chelidae

Genus: *Emydura*

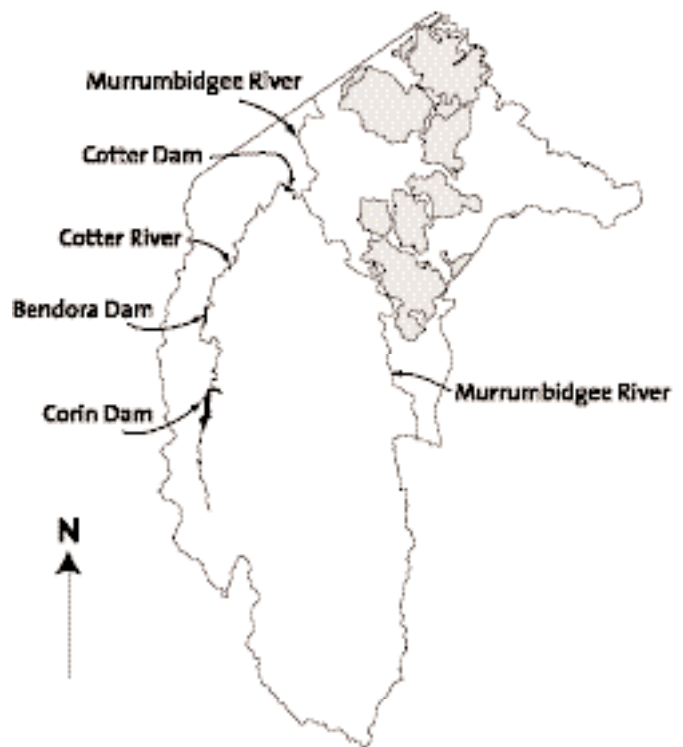
The Victoria River red-faced turtle (*Emydura victoriae*) is a freshwater species that lives in the north-western Northern Territory. For example, it is found in the Victoria River, the Daly River and the Bullo River. This turtle inhabits large rivers and the relatively large waterholes and billabongs on their floodplains. It feeds on both plant and animal material, depending on what is available. Females can reach sizes of 25–30 cm (shell length); males are slightly smaller.

Can Environmental Flows Compensate for Upstream Dams?

Two years of research on the environmental flows and consequent ecology of the Cotter River, ACT, are drawing to a close. The indications are that the results will enrich our understanding of the way stream organisms respond to differing flows.

For many years, the flows in regulated rivers and streams were arranged chiefly to suit human uses. Since the early 1990s, rivers throughout Australia have been required to allow 'environmental flows' as well. 'Environmental flows' are volumes of flow retained in a river system or released from a dam or weir with the intention of maintaining healthy river ecosystems. They are an explicit recognition of the need to balance care for the environment and water uses for other purposes, such as urban and agricultural water supplies

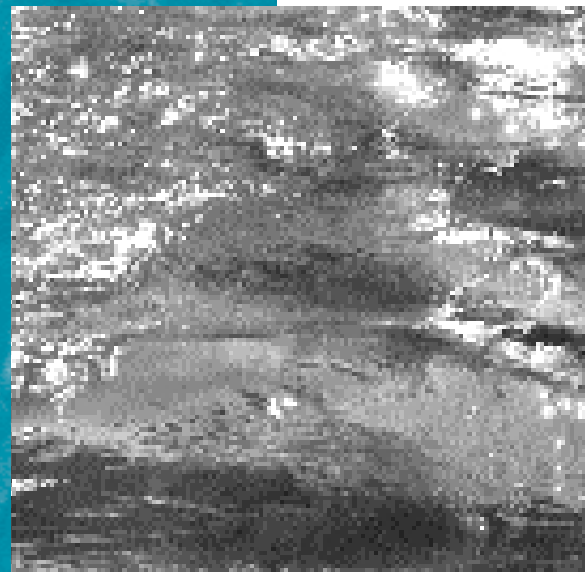
Environmental flows are required in all rivers and streams within the jurisdiction of the Australian Capital Territory (ACT), including the Cotter River (ACT) and Queanbeyan River (NSW) which together supply Canberra's urban water. The ACT water managers are required to release environmental flow volumes up to and including the monthly 80th percentile. These flows are considerably larger than those required in most states. There is also provision for larger 'spawning' flows to be released in the upper Cotter River in September–November in two of every five years. They are designed to help preserve the two-spined blackfish and Macquarie perch populations in that river.



Map of the ACT and Canberra (grey shaded), showing the Cotter River with its three dams, and the part of the Murrumbidgee River within the ACT border. Map: P Liston

In general, little is known about the flow volumes and timing actually needed by river organisms and ecosystems. For managers setting environmental flows, one of the big questions yet to be answered is how the water creatures and plants in a river or stream respond to particular flow volumes or changes in the seasonal timing of flows. Since 2000, a team from the CRC for Freshwater Ecology and the University of Canberra has been evaluating the effects of dams and environmental flows on the downstream ecology of the Cotter River. In that time, much has been learned about the way fish, macroinvertebrates (such as water insects that are food for fish), algae, physical characteristics of channels, and water temperatures respond to the presence of dams and the environmental flows released from them.

The Cotter River is impounded by three dams: Corin Dam furthest upstream, then Bendora Dam, and, lowest, Cotter Dam near the junction of the Cotter and the Murrumbidgee Rivers. Water from Corin Reservoir supplies Bendora Reservoir. From Bendora, water is



Examples of flow types. Clockwise from top left: no flow, ripple, unbroken standing wave, broken standing wave, chute. Photos: F Dyer

piped to Canberra and environmental flows are also released into the reach between the dam and the top of Cotter Reservoir. Cotter Reservoir is usually kept full of water, and the environmental flows that run into it from upstream pass over the Cotter Dam wall and on into the Murrumbidgee River.

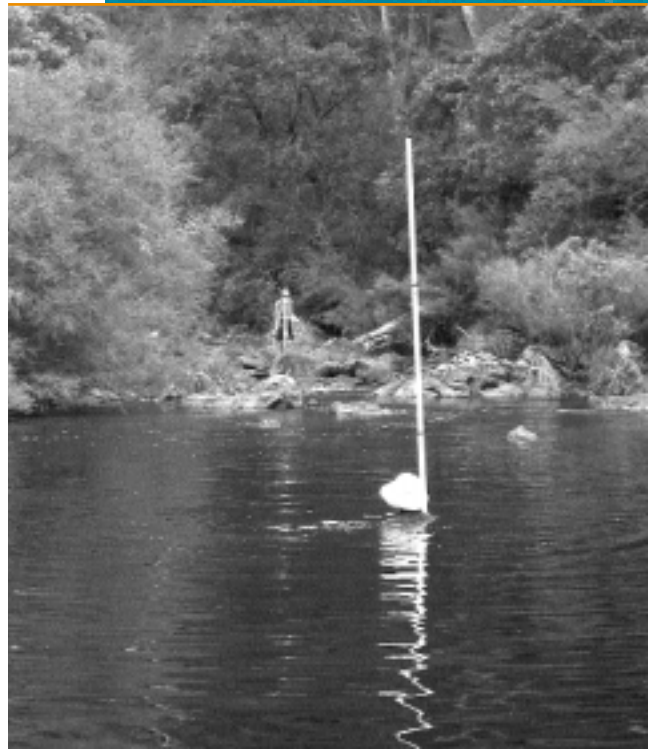
In the sections of river below Bendora Dam, much of the natural variability of the flow regime has been removed. The environmental flows are designed to attempt to restore it, because the river organisms are specifically adapted to variability. Therefore, each month, three-quarters of the environmental flow appropriate for that month is released during the first

three weeks. The remaining 25% is released as a flow 'spike' in the last week of the month, spread over 3-7 days according to volume required (the dam outlet has limited capacity).

Damming has evened out the temperature as well as the variability of river discharge. Not only are there now no small floods, but the river temperature for 6-8 kilometres below Bendora Dam is also relatively constant, daily and seasonally.

Although floods influence habitat in the broadest sense, it is the normal range of water velocities, turbulence and depth and the types of material forming the riverbed that are the main features of habitat for river organisms. These features control the hydraulic characteristics of the water surface — ripples or standing waves for example — that can be seen easily. The surface characteristics can be classified into eight 'flow types'. By measuring the proportions of the surface flow types in six 300-metre sections of river, Fiona Dyer and Martin Thoms are assessing the proportions of the underwater features that generate them — an indication of the types of habitat there.

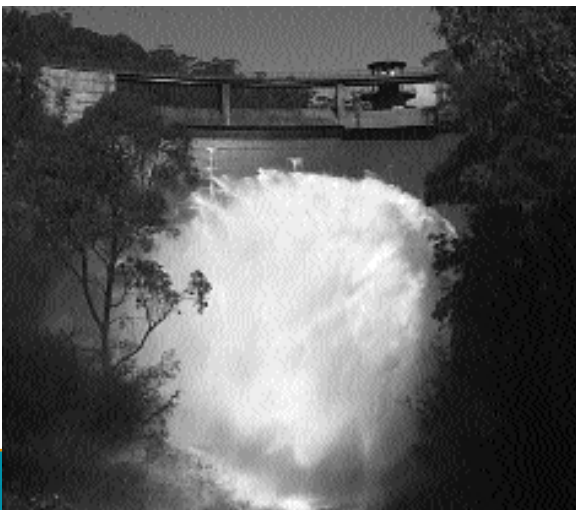
River habitats support many different organisms. Heath Chester has investigated the effects of the changed flow regime on algae and consequently on the freshwater insect (macroinvertebrate) community. Heath finds significant differences between the insects in the regulated river below Bendora and in its unregulated tributaries and a nearby unregulated river.



*In too deep? Surveying Cotter pools.
Photo: I Maddock*

As well, at sites affected by regulation there are more filamentous (hairlike) algae attached to rocks and other underwater surfaces. Yet these algae are not being consumed by grazing insects or insect larvae (such as immature mayflies). Heath has also found that the monthly flow spike produces measurable changes in the ratio of photosynthesis to respiration — a ratio that is fundamental to the food chain in rivers. For river managers, this study has produced some of the first detailed information about the way flow release patterns affect river organisms and their food supplies and habitat.

Visiting researcher Ian Maddock, from University College Worcester in the UK, is finding out if habitat preferences can be identified for the two-spined blackfish (*Gadopsis bispinosus*) at its various growth stages. Mark Lintermans (of the CRC for Freshwater Ecology and Environment ACT) earlier collected considerable data about the habits of this small fish

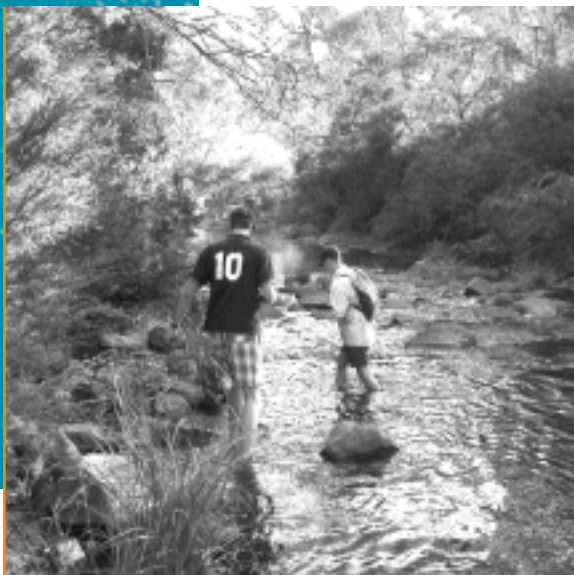


*An environmental flow spike being released from Bendora Dam.
Photo: S Nichols*

(usual adult size is 25 centimetres) in the Cotter River. All the fish, from juvenile to adult prefer still or very slow moving water about 40 or 50 centimetres deep, it seems. Now Ian Maddock is using this information in the model PHABSIM (Physical HABitAt SIMulation), which simulates habitat conditions in relation to flow in upland gravel-bed streams such as the Cotter. With this model, Ian is able to relate depth and velocity at various discharges (measured across transects at two sites) to habitat availability at those discharges, for various sizes and ages of fish.

Habitat assessment is producing information linking river discharge volumes to patterns of water movement within the stream. The team is beginning to understand how river discharge is related to the speed of the water flowing in particular river sections, and to the hydraulics and preferred habitat for this fish species. A later step will extend this study to other species of fish; and data have been collected for invertebrates as well. Eventually, river managers in control of environmental flows will be able to tell whether habitats for fish and invertebrates at key times in known stretches of river will be usable or not at, say, flows of 100 megalitres per day.

The Cotter team has also mapped the physical characteristics of the river in detail, throughout 50-metre segments of river for the whole 23 kilometres from Bendora Dam to the Cotter Reservoir. The resulting comprehensive map of river structure is being linked to



*Geomorphic mapping of the Cotter River at low flow. River discharge has varied from 8 to 300 ML per day during the study.
Photo: I Maddock*



*A typical cobble, about 25 cm across, on the Cotter River bed.
Photo: M Thoms*

the likely locations of suitable, and unsuitable, habitats for endangered native fish populations in the river.

This study of the Cotter provides some of the first quantitative data relating flow volumes with habitat and the resultant responses of particular organisms in a temperate Australian river. It should definitely help river managers understand that the way in which they release water for the environment is important for sustaining our river ecosystems. We often have only a limited amount of water to release for the environment. If we can release it in the smartest possible ways to match the needs of river organisms such as fish, we make the biggest gains for river ecosystems.

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ENDNOTE:

Because of the drought, the environmental flow discharge was halved in the Cotter River for the period from Christmas 2002 until February 2003. New monitoring is assessing aspects of the ecology of the river under these reduced flow conditions.

Turtles and Rice

by Bronwyn Rennie

A study of the activities of eastern long-necked turtles confirms farmers' observations that the turtles are using rice paddies as part of their habitat.

In a normal spring in southern NSW, approximately 150,000 hectares of rice is sown, in rectangular flooded paddies. Both rice-growers and ecologists have observed that the paddies are habitat for numerous wetland animals such as frogs, birds and turtles.

The Rice Growers' Association and the Rural Industries Research and Development Corporation (RIRDC) have recently funded a study of the native wildlife living on rice farms. The aim of the study is to measure the diversity of vertebrates (animals with backbones) on rice farms and to identify factors that may influence it. This study is being conducted by Dr Sean Doody and Dr Will Osborne, members of the Applied Ecology Research Group and the Cooperative Research Centre for Freshwater Ecology at the University of Canberra.

In a single year's work on ten rice farms, the group has collected 161 species of animals, including birds (116 species), reptiles (21 species), mammals (13 species), frogs (7 species) and fish (4 species). So far, frogs seem to be the most common vertebrate on the rice farms.

An important finding is that farms with remnant vegetation patches have a more diverse bird and lizard population than farms without vegetation remnants.

Among the reptiles, the eastern long-necked turtle (*Chelodina longicollis*) has been studied in greater detail. In agricultural areas this turtle species is known to live in farm dams and to make long journeys overland to reach newly available waterbodies such as ephemeral swamps. It prefers these temporary wetlands because of their high productivity. The turtle study was designed to find out whether rice farms serve as a substitute for natural wetlands — rice paddies are seasonal and shallow and very similar to wetlands.

To find out how the turtles use rice paddies, 14 turtles were fitted with radio-tracking devices on a rice farm near Finley. The farm has a typical complement of large irrigation-supply channels, small farm-irrigation channels, farm dams and seasonally-flooded rice paddies. The turtles were tracked for two weeks in each month from September 2001 to March 2002 — the whole rice cultivation period.

The results were interesting. The turtles lived mainly in the irrigation-supply channels, which are the most permanent waterbodies in the system during the rice cultivation season. But once the rice paddies were flooded (in September) many turtles travelled overland to them and then continued to use the paddies as habitat throughout the rice cultivation season. When the water



An eastern long-necked turtle (*Chelodina longicollis*). At full adult size, the shell is about 28 cm long.
Photo: A Georges



Young rice crops either side of an access row, showing tofos (trenches) that distribute water around the edge of the paddy. Photo: B Rennie

level in the rice paddies began to fall during draining before harvest in February–March, the turtles promptly retreated to the supply channels where water levels are relatively constant.

In total, 97 turtles were caught and examined during the study. Observations revealed that within the rice paddies the turtles consumed mainly macroinvertebrates (water insects and crustaceans). At least some of the insects are rice-crop pests. The turtles did not feed on the rice, nor did they burrow into levee banks. They are therefore likely to be welcome in the area. However, the rice-growing environment may be quite hazardous to turtles.

According to some farmers, Dethridge wheels (which measure the water flow into the rice farms) often injure or kill turtles that try to pass through them. Also, the annual draining of supply channels in winter, the pesticide treatments and the (less-frequent) dredging operations may be threats to the turtles. When the supply channels are drained in June–July, the turtles are overwintering and torpid. Without water to cover them, the turtles may be exposed to freezing temperatures and predators such as foxes and birds.

One management recommendation arising from the study is that a ‘turtle-friendly Dethridge wheel’ or associated structure could benefit both turtles and channel managers during the rice-growing season. For example, a metal grate placed in front of the wheel would prevent turtles from entering the wheel. After all, with a turtle stuck in it, the water meter cannot work.

Local land-holders can help travelling turtles by not using wire-netting fences that turtles cannot get through. While on the move, turtles also need the cover provided by shrubs and bushy vegetation so they can take refuge from predators and the sun.

By enhancing the potential for rice agroecosystems to support long-necked turtle populations, people in rice-growing areas make a valuable contribution towards the broad goal of biodiversity conservation.

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HAS A LONG WARM SUMMER SPAWNED A CARP OUTBREAK?

Data being collected by PhD student Ben Smith, of the University of Adelaide, suggest that long warm summers may promote carp outbreaks.

Carp grow fast, maturing at 1–2 years of age. They are prolific breeders and can produce up to 200,000 eggs per kilogram of body weight each time they spawn. The eggs stick to underwater plants and hatch in a matter of days, depending on temperature. The 6-millimetre-long larvae then feed on microscopic zooplankton for 3–4 weeks before developing into juveniles.

It takes an adult carp approximately three months to produce a batch of eggs. As soon as the batch of eggs has been spawned, egg production begins again. The carp then waits until water temperatures are between 17 and 25°C to spawn the next batch of eggs. Therefore, when the spring–summer–autumn period is sufficiently warm for about six months, it is possible that a carp could spawn up to three batches of eggs in a single season.

Ben's data suggest that there may have been multiple spawnings in the 2001–2002 season in at least two River Murray backwaters: the Punyelroo backwater (near Swan Reach) and Walkers Flat South (near Walkers Flat) in South Australia.

Ben collected fish samples monthly from August 2001 to August 2002 from amongst submerged vegetation in shallow water. Carp larvae were caught in several samplings during November–June. Each fish's age was estimated from its length, and then its hatching and spawning dates were calculated.



*Ben Smith with a 4 kg carp (Cyprinus carpio) about 80 cm long.
Photo: B Smith*

The results suggest that strong spawning occurred throughout the mid-October to mid-May period. Within this timeframe, approximately eight discrete spawning events were indicated at these sites, each lasting approximately 2–3 weeks. If verified, this seven-month spawning season would represent the longest period of continuous spawning so far recorded for carp in Australia.

Critically, this preliminary finding will be checked by direct aging of the larvae, later in the project. The direct-aging process measures growth rings in calcium carbonate structures ('otoliths') in the head of the fish. It is much more accurate than estimating age from body-size, because growth rates of individual carp can vary six-fold during the early phase of their life. If Ben's initial estimates are proved correct, his data could add significantly to our knowledge of Australian carp populations. Previous accounts of carp breeding report only one or two spawning events per year, with October the most common month.

The autumn temperatures during 2002 were above average. Therefore, adult female carp may have had the opportunity to spawn up to three times, with each batch of eggs potentially containing up to two million eggs. If so, the resulting year-class of this pest will be very strong, though its effects will only be realised in 2–3 years when the fish grow large enough to begin foraging on the riverbed and reproducing.

With carp already the most common fish in the Murray-Darling Basin, this news is not good. It underlines the importance of seeking sustainable and effective carp-control strategies.

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SideStream

Prestigious Awards for Two CRCFE Staff Members

Associate Professor Bill Maher (University of Canberra) has been awarded the Royal Australian Chemical Institute's Analytical Chemistry Medal. This medal has been awarded only five times previously, including once to Professor Barry Hart, also of the CRCFE.

Associate Professor Martin Thoms (University of Canberra) won the prize for Innovation in Geomorphology at the Binghamton Geomorphology Symposium held at Bloomsburg University, Pennsylvania, USA, in October 2002.

Ninth International Conference on River Research and Applications (NISORS)

Variability in Riverine Environments is the title and theme of the NISORS conference, to be held on 6–11 July at Albury, NSW. The conference, hosted by the CRCFE, is an opportunity for scientists and managers from all parts of the world, and from a range of disciplines and riverine environments, to share advances in river science and management. The four day-long sessions are expected to cover these themes:

- Natural variability in river systems,
- Integrating concepts of variability into models of river systems,
- The consequences of changes in natural variability to river systems,
- Restoring variability in managed river systems,

with two keynote speakers for each theme.

See <http://www.conlog.com.au/nisors/> for more information.

Scoping Study for the Narran Lakes and Lower Balonne Floodplain Available

The Narran Lakes are a Ramsar-listed wetland of international significance, set in the floodplain of the Lower Balonne river system. A scoping report for a forthcoming management study of the area is now available on the web. It reviews the hydrology, ecology and cultural issues of the Narran Lakes ecosystem and Lower Balonne floodplain in northern NSW. It discusses the implications of draft management plans for the ecosystem, and outlines an ecological management framework. Visit <http://freshwater.canberra.edu.au> > Publications > Technical Reports > Scoping Study for the Narran Lakes and Lower Balonne floodplain management study. December 2002. Technical report 3/2002.

Chris Walsh Wins the Coveted Chairman's Award for 2002



Photo: J Hawking

Dr Chris Walsh of Monash University and the CRCFE received the Chairman's Award for 2002 at the Annual General Meeting of the CRCFE, in Albury in late November. Chris and his team are researching the effects of aspects of urbanisation on the ecological function of urban streams (see *WaterShed*, November 2002).

Finalist for Young Water Scientist of the Year 2003

Samantha Capon is the CRCFE's finalist for the award of Young Water Scientist of the Year. She will represent the CRCFE at the OzWater conference in Perth in early April 2003, along with one finalist from each of the other four Water-Forum CRCs: Coastal Zone, Catchment Hydrology, Waste Management and Pollution Control, and Water Quality and Treatment.

We Feature in the AWA Journal *Water*

The CRCFE was the featured cooperative research centre in *Water*, the journal of the Australian Water Association, December 2002 issue.

See <http://www.wateraus.net.au/>.

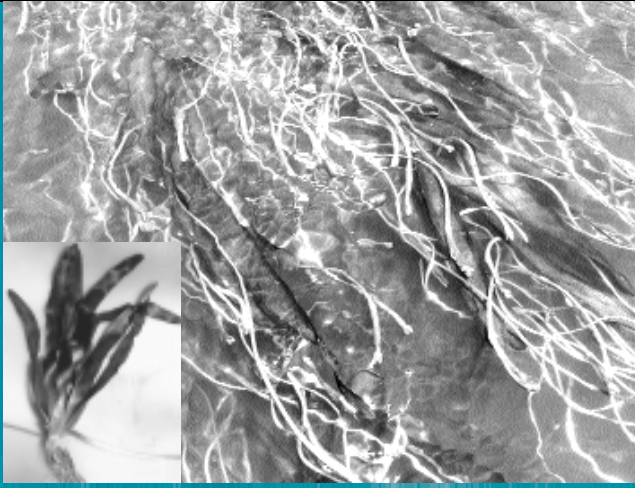
New Leader Appointed to Knowledge Exchange Program

Associate Professor Ralph Ogden is the new leader of the Knowledge Exchange program at CRCFE. He is based at Building 15, University of Canberra.

Ralph has degrees in biology, geography, ecology and palaeoecology, from University of Maine, USA, and the Australian National University. He also has experience in senior management and community and political liaison. As a researcher at the University of Canberra and CSIRO Land & Water, he has recently been examining the ecology, palaeoecology and conservation of river-floodplain systems. To contact Ralph, phone 02 6201 5167 or email Ralph.Ogden@canberra.edu.au.



Photo: B Rennie



Feature Plant

by David Williams

Ribbonweed is the feature plant for this issue.

Family: Hydrocharitaceae

Species: *Vallisneria gigantea*

Ribbonweed (also known as eelgrass) is a common, wide-spread and easily recognised submerged waterplant which spreads by sending out runners. It has thin, strap-like leaves that grow towards the water surface and may then trail on it. Pictured above are trailing pale female flowers and darker leaves, and (inset) a young shoot with leaves, roots and stolons. The species is common in lakes, wetlands, channels and rivers in all States, but has become less widespread in rivers. In clear lake waters, *Vallisneria* can grow at considerable depths (>6 m) but the species' root and stolon system also enables it to exist in shallow water (0.2 m) subject to wave wash. Waterbirds, turtles and aquatic invertebrates are known to graze on ribbonweed. Pyralid caterpillars are especially common. Carp can influence ribbonweed abundance and are implicated in the loss of ribbonweed beds.



Areas mentioned in this issue.

Comments and ideas are welcome and can be sent to:

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- Goulburn-Murray Rural Water Authority • Griffith University
- La Trobe University • Lower Murray Water • Melbourne Water
- Monash University • Murray-Darling Basin Commission
- Natural Resources and Mines, Queensland • Sunraysia Rural Water Authority • Sydney Catchment Authority • University of Adelaide
- University of Canberra

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