RipRap

LWRRDC'S RIPARIAN LANDS MANAGEMENT NEWSLETTER
A COMPONENT OF THE RIVER RESTORATION AND MANAGEMENT PROGRAM

Benefiting from overseas knowledge and experience

The theme of this edition of *RipRap* is looking at overseas research, knowledge and experience to see what help we can get for river and riparian management in Australia. In many ways, waterway management is a relatively recent development in Australia because initially our focus, following European settlement, was on impounding surface flows and accessing groundwater to support agricultural and urban development. It is really only since the Second World War that issues of water quality, as well as quantity, came to prominence. The current emphasis on managing our rivers and riparian lands as dynamic ecosystems and crucial parts of our landscapes is even more recent. Hence, there is clearly a potential for us to learn much from overseas, where river management has been an important activity, in some cases, for hundreds of years.

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Land & Water Resources Research & Development Corporation

EDITION 13, 1999

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I know we said it last time but... this time it really is true!!

The Rehabilitation Manual for Australian Streams is on the web. You can access the manual either through the LWRRDC site at: lwrrdc.gov.au in the Commissioned Programs area OR you can get to the manual via the rivers.gov.au website (after 26 July 1999). Please take the opportunity to provide us with some feedback on the manual so we can incorporate it into any future publications.

Land & Water Resources Research & Development Corporation

This publication is managed by the Land and Water Resources Research and Development Corporation (LWRRDC), GPO Box 2182, Canberra ACT 2601.

LWRRDC's mission is to provide national leadership in utilising R&D to improve the long-term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation resources. The Corporation will establish directed, integrated and focused programs where there is clear justification for additional public funding to expand or enhance the contribution of R&D to sustainable management of natural resources.

LWRRDC's Home Page is: www.lwrrdc.gov.au

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RIPArian lands:

WHERE LAND AND WATER MEET

From the Editor

At the 2nd Australian Stream Management Conference there was a lot of interest shown in work being conducted in river and riparian management overseas. In response to this interest, this edition of *RipRap* features articles from John Quinn and the team from the National Institute of Water and Atmospheric Research in New Zealand; Scott Babakaiff from British Columbia, and Peter Downs, who is based in the United Kingdom. Gary Brierley and Peter Downs also provide some comments on how those of us involved in river and riparian management can benefit and learn from international experience.

The other set of case studies presented in this edition showcase the work that has been accomplished in LWRRDC's Riparian Lands Program. Ian Prosser, Stuart Bunn and their teams of researchers, have been managing a suite of projects investigating different ecological, physical and chemical processes in the riparian zone. The results of this research are exciting, and we are now reaching a stage where the information can be practically applied to day-to-day riparian zone management.

The other exciting development is the launch of the new rivers website for the River Restoration and Management Program. This site will be 'live' by the 26th of July, so please check it out and send us any comments and feedback you might have. The site has all of our publications, as well as information about each of the research and demonstration projects and, a whole lot more!

I hope you enjoy this 'bumper' edition of *RipRap*, and encourage you to follow-up the articles in this edition by a visit to our new website.

Siwan

BENEfITING from overseas knowledge and experience continued from page 1

In this edition of *RipRap*, some interesting parallels between Australia and Canada are drawn by Scott Babakaiff. Scott recently spent a period of time in Australia, supported by a LWRRDC Visiting Fellowship. Canada has access to a significant proportion of the world's total freshwater resources, while urban, forestry and agricultural development has led to massive changes in its river systems. Government agencies, community organisations and private companies, like the one established by Scott, have developed many innovative techniques to support river and riparian management, ranging from especially-effective legislation in the province of Ontario, through to wide experience in stream restoration in British Columbia.

There have also been recent developments in the United Kingdom, through the development of detailed catchment management plans in which rivers and riparian lands are a strong focus. These are largely driven by communities and local government, with technical expertise provided through the UK Environment Agency. The Agency developed the precursor to the AUSRIVAS biomonitoring tool, and has gone on to develop a quick and standardised procedure for river habitat survey. LWRRDC is hoping to bring people with expertise in these areas to Australia as part of our rivers and riparian work, to discuss and test their assessment and rehabilitation methods with State agencies and community groups.

The position in other European countries is varied. Denmark has a strong program of river restoration, while in other countries much of the focus on river management relates to nutrients (particularly nitrogen) and water quality. Much of the research and restoration work in Europe is driven by European Community (EC) directives, which require that individual governments take a range of actions, for example, to maintain the habitat of endangered species.

The situation in the United States is also varied. In some States, river and riparian management is fully market-driven. Anyone who has the money to pay can have the river and its adjacent lands reshaped and planted in the way they want. In other States there is a much stronger degree of government control, with involvement by agencies such as the Bureau of Land Management and US Forest Service.

Across the Tasman, our closer neighbours have also been doing some innovative work in river management, particularly for the smaller streams of the steep hill country of New Zealand. Some of this work is reported in this edition by John Quinn and colleagues. Their work on temperature and light modelling is particularly advanced, and we have been swapping information between Australian researchers and their New Zealand counterparts.

I think this issue shows that there is much to learn by improving the international linkages of Australian programs in river restoration and management and associated research. Although there are special requirements related to the Australian environment, and our unique ecosystems, there are also many principles and practical methods than can be adapted for use here. You don't always have to reinvent the wheel when someone overseas has a perfectly good one you can borrow!

Phil Price
Executive Director
LWRRDC

Undisturbed river system, Macquarie River, Tasmania. Photo by Michael Askey-Doran.

CASE STUDY 1

AUSTRaLIAN riparian research

Ian Prosser

LWRRDC Research Program A: sediment, nutrients and erosion

LWRRDC's Riparian Lands component of the River Restoration and Management Program has been investing in research and development activities over the past four years. As the research program enters its final year, results are coming to hand that can be integrated into practical riparian zone management strategies. Ian Prosser and Stuart Bunn provide us with a snapshot of the work that has been accomplished so far in the program.

Introduction

The aim of this research program is to investigate the potential of riparian vegetation to protect streams from inputs of sediment and nutrient from agricultural lands, as well as to assess its potential to prevent stream bank erosion and instability. At the start of the program it was realised that a lot of effort was being put into riparian management and restoration, with high expectations of improvements to creeks and rivers, although there had been little research in Australia to evaluate whether people's expectations were realistic. The aim of the program is to use the results, in combination with those of the parallel ecological research program, to demonstrate key riparian functions, with this information providing the basis for improved riparian management and restoration. Results of the program are showing that well targeted riparian management can be a very effective tool in catchment management.

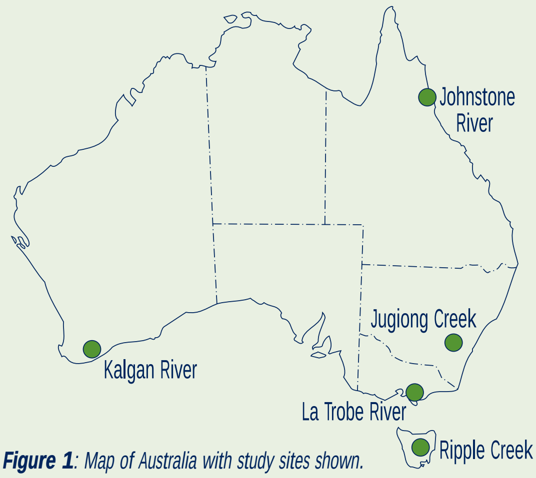

***Figure 1**: Map of Australia with study sites shown.*

The research is being conducted in five focus catchments around Australia (Figure 1) using a range of techniques that include reconnaissance surveys, monitoring, field experiments, and computer-based modelling. The program is funded by LWRRDC with strong support from the Cooperative Research Centre for Catchment Hydrology, Queensland Department of Natural Resources, Agriculture Western Australia, the Hydro-Electric Commission of Tasmania and the New South Wales Department of Land and Water Conservation.

The following sections provide some brief highlights of the research, much of which was reported in more detail at the 2nd Australian Stream Management Conference held at Adelaide in February 1999. Publications arising from the research are given at the end of this article and can be obtained from the contacts listed.

Identifying riparian functions

The two main functions we have examined are the effectiveness of riparian vegetation in buffering between hillslopes and streams, and in reducing stream bank erosion. These will not be of equal importance in all catchments, and the most important process may also change throughout a catchment between the headwaters and the mouth. Thus, some of our early work concentrated on conceptualising where process and vegetation functions were likely to be significant.

One way of approaching this issue is to construct sediment budgets: simple accounts of where sediment is mobilised and where it is stored in streams with consequent ecological impact. These studies, led by Ian Prosser, showed that the pastoral lands of south-eastern Australia are dominated by gully and stream bank erosion processes with less need for hillslope buffers. In contrast, intensive cropping in the wet tropics leads to dominance of the sediment budget by hillslope processes. Stream banks in the wet tropics there are generally stable because of the naturally stable bank materials and vigorous vegetation growth on stream banks, even in heavily disturbed sites. In south-west Western Australia both stream bank and hillslope sediment sources were important, and this is likely to be the case for much of the cereal cropping belt on sloping lands.

Bank erosion processes change systematically down through a catchment as the size of the channels increase. Ian Rutherfurd and Bruce Abernethy have demonstrated this effect of changing channel scale for the La Trobe River in Gippsland. In the headwaters, processes that loosen and prepare bank materials for subsequent removal by the flow dominate bank erosion. These include desiccation, seepage, stock trampling, and freeze and thaw cycles, which can be prevented by dense groundcovers or shading by trees. Further downstream larger flows are contained within the channel, which causes fluvial scour to become increasingly active. At some point, scour will begin to dominate over other bank erosion processes. Moving further downstream, the action of fluvial scour creates banks that are high enough and steep enough for mass failure processes to become the dominant erosion mechanism. All of these processes are affected by riparian vegetation to some extent, with mass failure processes strongly modified by tree root strength, as outlined below.

The potential for hillslope buffering similarly changes through a catchment. Most sediment in the stream network enters the system via the small tributary streams that tend to be flanked by steeper footslopes. Dense riparian vegetation is usually required to prevent sediment delivery to small tributary streams. Lower down the catchment, footslopes are gentler, or streams are bordered by floodplains. In these locations, the flat topography alone prevents sediment delivery to the stream.

Bank erosion processes

At the start of this project, there was no data available in Australia to assess where or when trees can prevent bank failure. To answer this question we assessed the strength and distribution of tree roots growing within stream bank sediments. By incorporating the root data with bank geometry and other facets of bank stability, we were able to compare the stability of river banks with and without root reinforcement. Bruce Abernethy has completed a PhD on this topic and found, for example, that River Red

A tree buttressing a column of soil on the Tarwin River. Photo by Ian Rutherfurd.

Scour of a stream bank leading to undercutting. Photo by Ian Rutherfurd.

Gum roots provide an effective cohesion of 25 kPa (kilopascal — a unit of pressure) at the soil surface, under the canopy dripline, some 17 m from the tree trunk. This compares to typical soil cohesion of just 15 kPa. Our study predicts that adding strategically placed trees to the banktop along a reach of the lower La Trobe River will stabilise all potentially unstable bank sections. This work demonstrates how effective mature trees can be in preventing bank failure.

Andrew Hughes and others have conducted research into bank protection on Ripple Creek in Tasmania. The creek is dominated by sediment loosening processes. The research has shown that while it is difficult to establish grass on unstable stream banks in this environment, a cover of just 50% is able to prevent sediment loosening processes. These processes were leading to 50 t of sediment generated per kilometre of bare bank, rates of erosion that are having significant downstream impact on fish habitat. Similar improvements have been found by Ian Bell for stock exclusion from stream banks on the Meander River in Tasmania.

Buffer storage capacity

Setting cropland back from the stream bank and installing a buffer of riparian vegetation could prevent sediment and nutrient pollution of streams in the right conditions. Linda Karssies, Lucy McKergow, Peter Hairsine and others have been addressing this issue through water quality monitoring and buffer strip experiments. They have shown that dense grass buffers can not only work on steep slopes in south-east Australia, but also under the extreme runoff conditions of the wet tropics. There are, however, some cautions. If runoff is very confined the buffer will not work. For example, a grassed waterway draining a 4 ha cropped paddock in far north Queensland provided little sediment trapping ability. Buffers also have a finite capacity to store sediment making it essential to reduce on-farm soil loss so that the buffer is not overloaded. A dense grass strip can only store 30–60 kg of sediment per square metre, and if the sediment deposit penetrates to within a metre or two of the stream side of the buffer, fine nutrient-rich sediment is unlikely to be trapped.

Stock tracks

Peter Hairsine has led experiments which show that stock tracks in pastoral lands can be fast pathways for sediment and nutrient delivery to streams, with the potential to bypass riparian buffers. These stock tracks can be either the informal tracks of uncontrolled stock access to streams, or the laneways of more intensive operations. Our research shows that relatively simple management techniques of diverting stock at the foot of tracks or diverting the runoff laterally off the track, can lead to vast improvements in the quality of water reaching the stream.

Conclusions

No research program can cover all issues and it is interesting to note the different emphasis between the Australian and New Zealand work reported in this issue. These differences result from the contrasting environments of the two countries which lead to different management issues, and has resulted in the development of particular skills within each of the research groups. This has led to valuable exchanges of information between the two groups. Our focus has been on identifying priorities for riparian management across diverse environments; phosphorus transport rather than nitrogen transport in riparian lands; and mass bank failure and sediment generation from stream banks rather than channel geometry.

Unfenced Blackman River in Tasmania showing stock ramp pugging. Photo by Michael Askey-Doran.

Further reading

Abernethy, B., Rutherfurd, I.D. 1998. Scale analysis of bank stability: targeting river reaches for riparian revegetation, in H.O. Hansen and B.L. Madsen (eds), *River Restoration '96: the Physical Dimension*, National Environmental Research Institute, Ministry of Environment and Energy, Silkeborg, Denmark, pp. 50–56.

Hairsine, P.B. 1997. Controlling sediment and nutrient movement within catchments, Cooperative Research Centre for Catchment Hydrology Industry Report, Monash University, Melbourne.

Hughes, A.O., Prosser, I.P., Rutherfurd I.D. and Haragli, J. in press, Processes of sediment generation from bank erosion of an incised channel, for *Water 99 Joint Congress – 2nd International Conference on Water Resources and Environmental Research*, Brisbane, July 1999.

Karssies, L. 1998. Sediment storage capacity of grass buffer strips, *Riprap*, vol. 11, pp. 8.

Rutherfurd, I. and Bartley, R. (eds), 1999. *2nd Australian Stream Management Conference Proceedings: The Challenge of Rehabilitating Australian Streams*, Cooperative Research Centre for Catchment Hydrology, Melbourne, see in particular sections: 'Riverbank reinforcement by riparian roots', B. Abernethy and I.D. Rutherfurd, pp. 1–7; 'Sediment storage capacity of grass buffer strips', L. Karssies and I.P. Prosser, pp. 371–75; 'Preliminary results on the effectiveness of riparian buffer strips in Far North Queensland', L. McKergow, I.P. Prosser and D. Heiner, pp. 439–44; 'Identifying priorities for riparian restoration aimed at sediment control', I.P. Prosser, pp. 511–16.

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see foldout

Check out the new rivers website for more details of these projects

CASE STUDY 1

AUSTRaLIAN riparian research

LWRRDC Research Program B: ecological processes

Stuart Bunn and Peter Davies

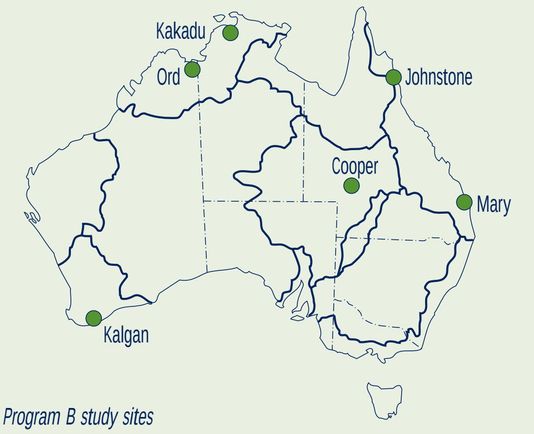
Introduction

Riparian lands have multiple ecological roles and, to a large extent, this is reflected in the structure of Program B and the diverse range of projects undertaken to date. We set out to identify the key processes by which riparian lands influence in-stream ecosystems and their functioning, and to quantify the major effects.

Our initial concern was that much of our knowledge of key riparian processes was based on temperate forest systems and may not be readily transferable to other parts of the country. Accordingly, particular emphasis has been given to projects in the arid, subtropical and wet/dry tropical regions of Australia. Most of our comparative and experimental research has been undertaken in four catchments in partnership with government agencies and community groups. Additional projects have been undertaken in the Ord River and Kakadu National Park.

Program B study sites

Much of our effort has focused on the degree to which riparian vegetation controls stream ecosystem processes and the structure of food webs — two important indicators of river health. An outline of some of the projects and their key findings are highlighted below. Other important ecological roles of riparian lands will be examined in subsequent issues of *RipRap*, which will feature research projects also undertaken within Program B. These include: the importance of riparian lands in maintaining biodiversity of terrestrial plants; the factors influencing recruitment and regeneration of vegetation; the importance of logs and other woody debris from the riparian zone as habitat for aquatic animals; and, the influence of logs and other woody debris from the riparian zone on downstream transport of energy and nutrients in streams and rivers.



Program B study sites

Influence of riparian vegetation on forest stream ecosystem processes

Riparian vegetation is known to have a controlling influence on ecosystem function in most forested streams and rivers. High levels of shade limit in-stream primary production and, largely as a consequence, food webs are considered to be almost entirely dependent on terrestrial inputs of organic carbon (e.g. leaf litter, twigs and fruit). Unfortunately, most of our knowledge of this key riparian function is based on temperate forest systems studied elsewhere, and the degree to which riparian vegetation influences stream ecosystems is poorly known in other forest biomes in Australia. Of additional interest, is whether stream ecosystem processes in catchments disturbed by land clearing and agriculture are influenced primarily by riparian, in-stream or by catchment-scale attributes. Direct measurement of ecosystem-level processes, which reflect the linkages between the terrestrial and aquatic ecosystems, offers an holistic approach to biomonitoring and views the health of streams and rivers in a catchment context.

The broad aims of this work are:

~ to determine the degree to which riparian vegetation influences stream ecosystem processes in a range of undisturbed forest biomes (vegetation and climatic region); and

~ in catchments disturbed by agricultural land-use, to determine the relative importance of riparian- versus catchment-scale attributes on stream ecosystem processes (and stream health).

These issues are being addressed through a combination of large-scale comparative field studies and manipulative field experiments. Comparative studies have been undertaken in three biomes: dry-sclerophyll woodland (Kalgan); subtropical rainforest (Mary) and tropical rainforest (Johnstone). In each biome, we have measured catchment features, riparian attributes and water quality at multiple sites (15–20). These stream sites encompass a broad range of catchment and riparian disturbance (undisturbed forest to open pasture; 0–100% riparian cover). Two major approaches have been used to assess stream ecosystem response to catchment disturbance and, particularly, to the loss of riparian vegetation:

~ Benthic gross primary production (GPP) and respiration (R_{24}) — measures of the amounts of organic carbon produced and consumed within the system.
~ Stable isotope analysis — to trace the fate of terrestrial and in-stream sources of organic matter in the aquatic food web.

Several manipulative experiments have also been undertaken. These include a field experiment in a tropical cane-land stream, using shade cloth to mimic the effects of riparian shading on aquatic macrophyte biomass and to predict changes in stream channel morphology and hydrology (Johnstone River). We have a continuing long-term project in the Johnstone catchment, monitoring recovery of in-stream ecosystem processes and stream health in several reach–scale revegetation trials in previously-disturbed pasture catchments. We have also examined the relative importance of shade and nutrients on algal growth in several experiments in the Mary River catchment.

The above studies have led to an improved understanding of the influence of riparian vegetation on in-stream ecosystem processes across a range of forest biomes, and enabled the development of predictive models. Furthermore, we have identified the major sources of organic carbon (e.g. riparian inputs like leaf litter, fruit) that 'drive' stream food webs, and established the importance of inconspicuous benthic microalgae in some systems. We have also recognised the importance of nitrogen as a limiting nutrient for benthic algal growth in some systems.

A key management outcome of this work has been the development of ecosystem-level indicators of stream health (e.g. using the food web structure) that are sensitive to catchment and riparian degradation. We have also provided graphic examples (e.g. proliferation of nuisance aquatic plants, sedimentation, loss of aquatic habitat) of the consequences of riparian degradation on stream ecosystem processes, aquatic habitat and river health. Furthermore, we have undertaken practical demonstrations of the potential for control of invasive aquatic plants by riparian shading, and identified factors that may constrain the recovery of stream ecosystem function.

Riparian influences in dryland rivers

Many Australian inland rivers are characterised by extensive floodplains and a network of anastomosing channels and distributaries (e.g. the Channel Country of the Lake Eyre Basin). These small channels provide a far greater terrestrial-water interface than would occur with a single large channel river. The river water is highly turbid and remains so, even during the long periods between episodic flood flows. Given these features, we might expect that the aquatic ecosystem would be driven by fluxes of energy and nutrients derived from extensive floodplain exchange during floods, and by continual input from fringing vegetation along the vast network of channels during the prolonged dry. We might also predict that aquatic plant production should be limited by low light penetration in the turbid water and thus make a minor contribution to the aquatic food web.

Unfortunately, knowledge of these important processes and the general structure and functioning of dryland rivers is extremely poor. However, of one thing we can be certain — we cannot hope to manage these rivers using existing knowledge derived from temperate river systems. To this end, several projects are underway within Program B to address key knowledge gaps, especially with respect to the strength of riparian linkages in dryland rivers. The broad objectives are to:

~ determine the importance of riparian inputs to aquatic food webs,
~ identify major sources of in-stream production and the factors that influence productivity, and
~ highlight implications for the management of riparian lands and river pools

As in our studies of small forest streams, we have used a combination of large-scale comparative surveys and focussed small-scale experiments to address the above issues. We have measured production and respiration in a range of permanent and ephemeral waterholes. We have also used stable isotope analyses together with conventional dietary analysis to determine food web structure. Plot-scale experiments have also been used to examine the impacts of desiccation and trampling on littoral algal production.

One of the significant scientific findings of this work has been the recognition that riparian and floodplain vegetation contributes very little to aquatic food webs or their inland channel systems. Despite the high natural turbidity, the river waterholes had a highly productive band of algae restricted to the shallow littoral margins. This *bathtub ring* of algae was the major source of energy driving the aquatic food web, supporting large populations of snails, crustaceans and fish.

*Sediment accumulation and consequent smothering of Bamboo Creek, near Innisfail. Invasion of an introduced ponded pasture grass (*Brachiaria mutica*) has led to accumulation of organic rich sediments (up to 2 m deep). Photo shows experiments designed to assess the impact of shade on riparian vegetation. Photo by Ian Prosser.*

The recognition that littoral algae play an important role in these dryland rivers has several implications for the management of riparian lands. Rapid drawdown of water (e.g. for irrigation) will expose the littoral zone to desiccation which may limit aquatic primary production. Preliminary experiments suggest that, although benthic algae appear to be quite tolerant of short-term desiccation, repeated drawdown of waterholes and exposure of the shallow littoral zone is likely to greatly reduce overall productivity. A second issue is that uncontrolled stock access over large sections of waterholes may disturb the productive algal layer. Plot-scale experiments show a major impact of trampling on algal production, although post-disturbance recovery is rapid. The overall impact of stock trampling on littoral algae at the waterhole scale is yet to be evaluated and will need to consider frequency of access and the proportion of the shoreline disturbed.

The outcomes of the research undertaken in these two research programs, combined with the demonstration and evaluation projects also run through the program, will be presented in a series of workshops to be held in each State over the next 12 months. The soon to be released Riparian Technical Guidelines are also based on these outcomes, and will be a useful reference point for land and water managers. The guidelines will be available by the end of August 1999. Check out the website and RipRap for details.

For further information on these projects,

as well as further reading, check out the http://www.rivers.gov.au website under the activities section!

or

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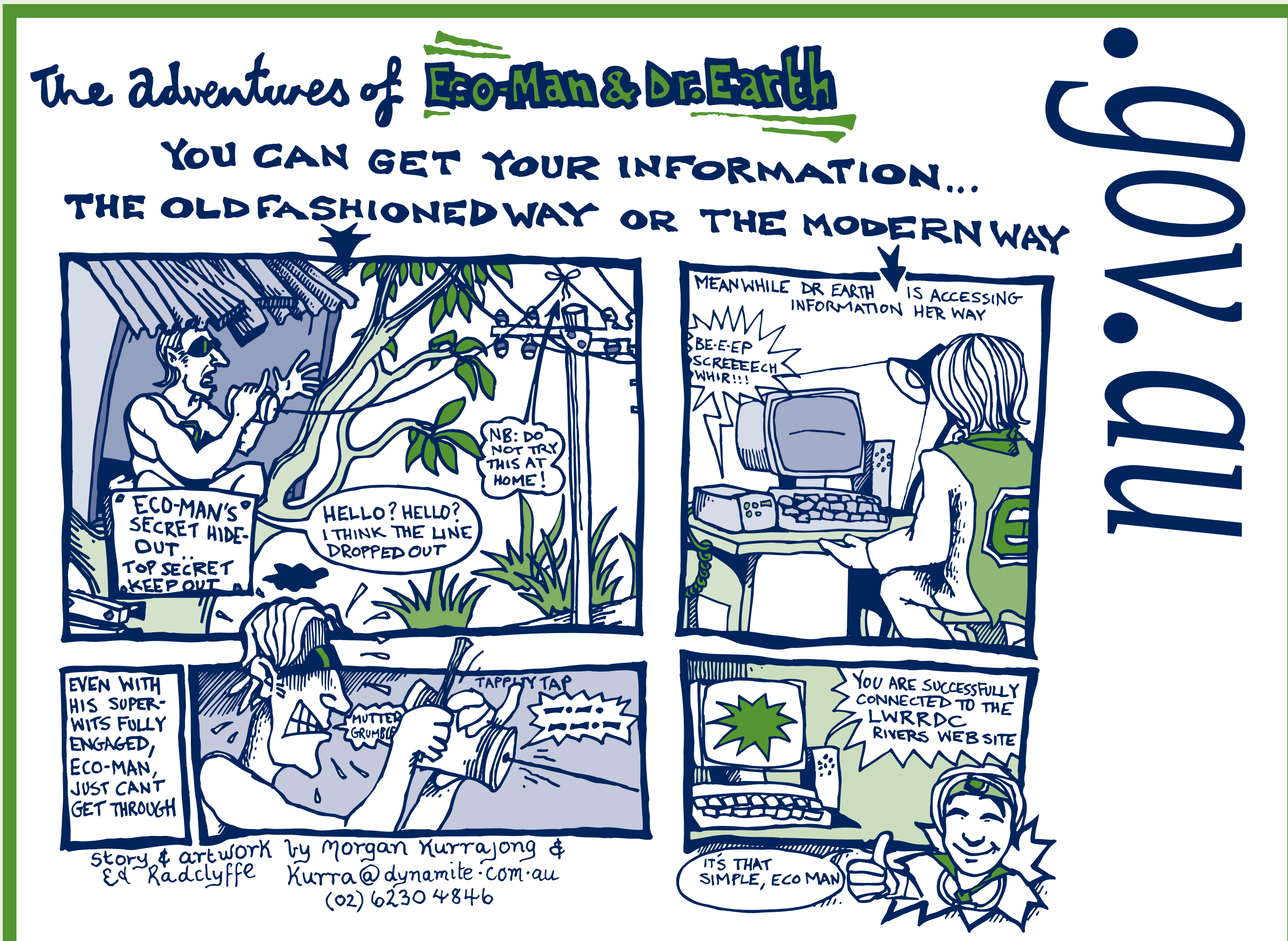

NEW ZEALAND research

The secret lives on land of adult aquatic insects

NIWA
Taihoro Nukurangi

From the National Institute of Water and Atmospheric Research

Kevin Collier and Brian Smith

Stream ecologists traditionally work with the immature larval stages of aquatic insects that live on and under stones in the streambed. It is easy to forget that insect larvae emerge from streams as flying adults, many of which live on vegetation in riparian areas. Recent work at NIWA has been delving into this poorly understood and secretive life stage of aquatic insects.

Overseas work has shown that survival of the terrestrial adult stage of aquatic insects can have an overwhelming influence on the population of larvae that occur in streams. This is because aquatic insects mate after emergence, and some species need to feed to develop eggs; poor habitat and high exposure to predation (e.g. by birds and spiders) can mean that few adults of vulnerable species survive to lay their eggs back in the stream. Fewer stream larvae means lower biodiversity, less food for fish, and may alter instream processes such as the breakdown of organic material and the growth of algae on which many larvae feed. A generalised diagram of the aquatic insect life cycle is shown in Figure 1.

In New Zealand, most work on the adult stage of aquatic insects has been on taxonomy, and very little is known about their ecology and habitat requirements. This knowledge is important for stream restoration so that:

1. appropriate plant species can be established in riparian areas to provide food and shelter from predation,
2. suitable environmental conditions (e.g. air temperatures) can be created to promote development and thereby enhance the size of the next generation, and
3. areas of restored stream can be recolonised by adult insects.

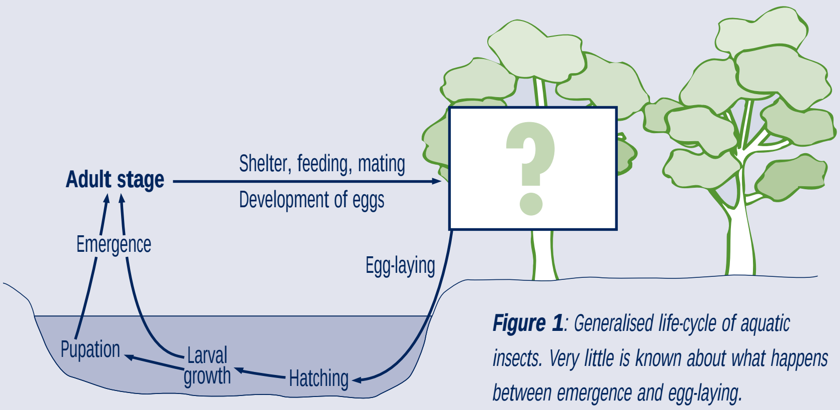

***Figure 1**: Generalised life-cycle of aquatic insects. Very little is known about what happens between emergence and egg-laying.*

Interactions between riparian zones and effects of land use

Most of the work carried out at NIWA has focused on caddisflies and stoneflies that can live from several days to several weeks as adults. Mayflies are common stream insects but are not used for our studies because they do not feed, are short-lived during the adult stage, and the eggs of many are already developed when they emerge. Light trapping of adult caddisflies over summer in catchments of different land use at Whatawhata, near Hamilton, has shown that the composition of the catches reflects the type of land use, in particular whether the catchment is in forest or in pasture. This pattern is shown in the ordination plot (Figure 2) and potentially reflects the suitability of both instream habitat for larvae and terrestrial habitat for adults.

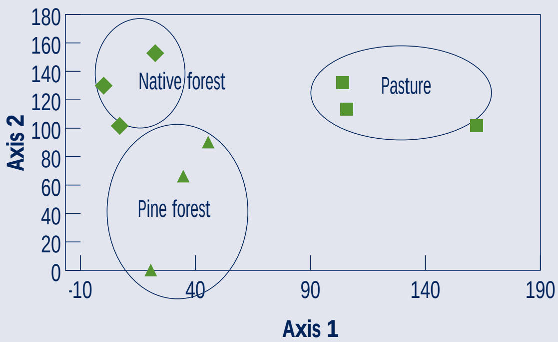

***Figure 2**: Ordination analysis of adult caddisfly faunas collected over summer in catchments of three different land use at Whatawhata. Each axis summarises the composition of the fauna at a site as a single point on two ordination axes; the closer the sites are, the more similar they are.*

Adult caddisfly movement

We have placed light traps at varying distances away from the edges of some North Island native forest streams to determine how far adult caddisflies move. We collected caddisflies up to 200 m away (the maximum distance tested), but most were caught within 20–30 m of the streams, suggesting that the main zone of interaction with the terrestrial environment is close to the stream

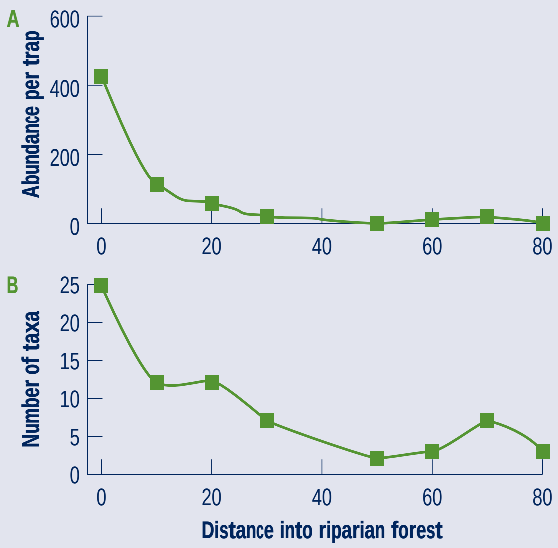

***Figure 3**: The number of adult caddisflies (A) and number of caddisfly species (B) caught in light traps placed at varying distances into riparian forest alongside a North Island stream.*

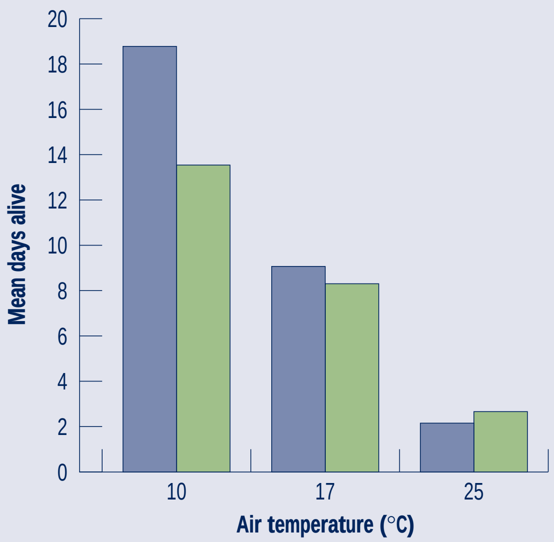

***Figure 4**: Mean days alive (+1SE) for male (blue bars) and female (green bars) Zelandoperla decorata adults kept in the laboratory at three constant temperatures and fed a dilute sucrose solution and water.*

edge (see example in Figure 3A). Individuals of several species ranged much more widely in riparian forests (Figure 3B), and these may play an important role in exchanging genetic material between neighbouring populations and in recolonising sites following restoration or large scale disturbance.

Effects of microclimate

Microclimate conditions, such as air temperature and humidity, can affect the survival and development of adult insects in riparian zones. We have examined these factors in three species of adult stoneflies. This group was used because:

1. stonefly faunas are more diverse in forest streams than in pasture streams, and this may be due in part to the suitability of adult habitat;
2. immature stages have been shown to be sensitive to high water temperatures and so we might expect similar sensitivity to high air temperatures in adults; and
3. they are easy to rear and maintain in laboratory conditions for experimental purposes.

The microclimate work was carried out on animals reared to emergence in the laboratory where they were maintained at different temperatures (10–25°C) or humidities (15–100%). Both air temperature and humidity had significant effects on adult longevity, as shown for temperature with *Zelandoperla decorata* in Figure 4. Our results predicted that half of the adult female stoneflies used would have died within four days at 22–23°C; this is frequently exceeded during summer in pastoral areas suggesting that air temperature may be an important factor limiting the distribution of some stoneflies. However, our experiments were conducted at constant temperatures and comparisons need to be made using realistically fluctuating air temperatures similar to those that occur naturally.

Future work

As well as influencing life-span, diet and microclimate have the potential to affect sexual maturation of stoneflies. The role of these factors on ovary development and, therefore, on the number of eggs produced for the next generation of larvae will be investigated over the next two years by carrying out laboratory feeding experiments on different types of food and under different temperature regimes. In addition, we are investigating links between adult aquatic insects and terrestrial predators such as spiders, because emerged adults potentially represent an important food source for riparian food webs at certain times of year. It is hoped that this work will help to further unravel the ecological secrets of this poorly known stage of aquatic insects and lead to better recommendations for riparian management to enhance stream biodiversity.

This work is shedding light on another of the multiple benefits of restoring riparian vegetation along streams in pasture and urban catchments.

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CASE STUDY 2

NEW ZEaLAND research

Riparian wetlands — maintain, don't drain

Long Nguyen and John Quinn

Riparian wetlands are the boggy areas that develop along stream/river banks and first order stream channels where groundwater seepage emerges into the channel (Fig. 1, Photo 1). Common agricultural practice is to drain these areas by lowering the water table. However, research indicates that these areas play a key role in controlling stream water quality in agricultural catchments in moderate and high rainfall areas of New Zealand.

Soils in boggy areas are typically water-saturated and anaerobic (no oxygen). This anaerobic condition encourages the natural process (denitrification) of removing nitrate transferred in groundwater seepage from agricultural land. Soil micro-organisms responsible for this process are most active in boggy areas, stripping nitrate into nitrogen gas. This gas is then released to the atmosphere, rather than entering the stream as nitrate. Riparian wetlands can remove over 90% of the nitrate in groundwater. However, soil denitrification potentials vary with seasons, increasing by a factor of 5 from late winter-early spring to late summer, suggesting that nitrate removal by riparian wetlands is lower during the winter months when soil temperature may be unfavourable for soil microbial activity. The ability of riparian wetlands to strip nitrate to nitrogen gas is also dependent on the soil-water contact time. Our recent results suggest that there is an inadequate soil-water contact time for nitrate denitrification in a wetland draining a 3 ha catchment when the wetland outflow rate exceeds 75 m^3/day. We are now seeking a better understanding of how flow rates influence contaminant processing in wetlands to provide an improved basis for managing these areas.

Riparian wetlands not only strips seepage nitrate, but also act as buffer zones between farmed land and receiving water bodies in trapping sediment, phosphorus and faecal materials in water runoff. Wetland plants can filter these materials and incorporate nutrients into plant and soil biomass. The retention of faecal materials within the wetlands over a period of time may also enhance the inactivation of bacteria/pathogens. For example, we found that first order streams draining pasture at Whatawhata Research Centre had substantially lower suspended solids concentrations (median 1/3rd) if they had wetlands in their headwater channels (Figure 2).

Besides the function of nutrient and pollutant stripping, wetlands are a key source of dissolved organic carbon ("catchment tea"). Studies show 5–10 fold increases in organic carbon in groundwaters after passing through riparian wetlands. This provides energy for the

To get a copy of the NIWA guideline on the use of artificial wetlands for tertiary treatment of farm waste water, check out the website . . . . . . **www.niwa.cri.nz**

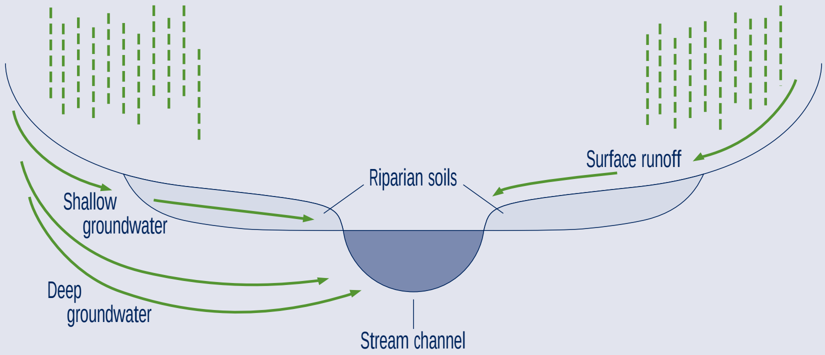

***Figure 1**: Riparian wetlands intercept water surface runoff and shallow groundwater as it passes into streams from the surrounding land.*

***Photo 1**: A riparian wetland at Whatawhata Research Centre, near Hamilton, where factors affecting contaminant-trapping efficiency are under investigation. Note the weir in the foreground to measure water yield and the array of wells throughout the wetland (Photo: Kit Rutherford).*

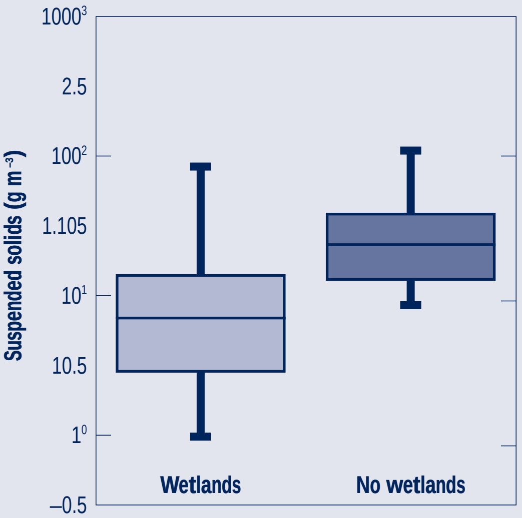

***Figure 2**: Comparison of suspended solids concentrations amongst headwater streams with and without wetlands in their headwaters. Boxes and whiskers represent the range of the data for three streams of each type over 18 monthly samplings.*

food web that supports invertebrates and acts as a binding agent for water contaminants.

Current research at NIWA aims to understand:

1. effects of flow paths and rates on biogeochemical processes;
2. effects of grazing on the water quality functions of these boggy wetlands; and,
3. how much wetland is needed to perform these functions.

Our fundamental research approach is aimed at providing detailed guidance principles of riparian wetlands so that land managers and land users can adapt their day-to-day farming activities. We realise that it is difficult, and possibly uneconomic, to fence off all riparian areas, especially in New Zealand hill country that has high stream density. Under these situations, maintaining/recreating wetlands in strategically located areas may be the next best option for protecting downstream water quality. Part of our research involves testing this approach to diffuse pollution management.

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Local government focus featuring the Johnstone Shire Council

Protecting habitat for animals and plants has become an issue in which local government is increasingly playing an active role. The example below shows how one local government responded to calls to conserve and protect habitat for Cassowaries. This model could be used in other areas, with the involvement of local government a crucial element in developing long-term sustainable land and water management strategies for catchment communities all over Australia.

Rate discounts for habitat conservation

One of the largest threats to Cassowaries within the Wet Tropics Area is clearing of vegetation and the subsequent fragmentation and isolation of habitat areas. In response to this threat, the Johnstone Shire Council (based at Innisfail about 1 hour south of Cairns) with the support of community groups such as the Community for Coastal and Cassowary Conservation (C4), has established a system of Voluntary Conservation Agreements (VCA's) for private land within the Shire. Substantial discounts (40–60%) on general property rates are provided for any landholder who enters into an agreement

Natural Heritage trust funds have been granted to the Council to cover the costs of employing a Conservation Officer for a period of 18 months to identify priority areas for conservation, contact and negotiate with landholders and assess properties for their habitat value particularly for the Cassowary. Council will meet the ongoing costs of rate discounts which currently total about $30 000 per annum.

One of the major areas targeted by the Council for VCA's is the Mission Beach/Bingil Bay area. Known as a Cassowary "hotspot" this area contains a very dense population of Cassowaries. The forests of Mission Beach are one of the very few remaining stands of lowland *Licuala* (Fan Palm); the fruit of which is a favourite for the Cassowary. Most of the area is classified as Critical Cassowary Habitat and the local community is very active in promoting the plight of the cassowary and, restoring lost habitat through revegetation.

In the period August 1998 to mid June 1999, Council has entered into 34 agreements protecting 1112 hectares of Cassowary habitat within the Shire of Johnstone. Half of these are in the Mission Beach area.

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CASE STUDY 3

CANaDIAN research and management practice

"I need help. I need help to get rid of the 'rehabilitation experts' that want to help me."

Source: Landowner, rehabilitation practitioner and 1998 award recipient for stream rehabilitative efforts on his property adjacent to the Murray River mouth.

Scott Babakaiff

As I recall, these were the words that began a lunchtime keynote presentation at the 2nd Conference on Stream Management in Adelaide in February, 1999. I had been on Australian soil for less than 48 hours, and was able to add 'stream management' to my list of observed differences between Southeastern Australia and my home province, British Columbia (BC). Up to that point, the list included differences which were readily apparent and not particularly surprising: the abundance of Speedo bathing suits in Australia and a general absence of long-sleeved woolen plaid shirts. Over the following three months, I came to realize that the international differences in stream management issues and philosophies were complex and that key issues would not be easily resolved with an updated assessment guidebook or rehabilitative procedure.

As a LWRRDC Visiting Fellow, my Australian visit included participation in university lectures, field-based assessments, public meetings, and academic conferences in New South Wales, Queensland, Victoria and South Australia. River rehabilitation issues were discussed with academics, agency representatives, professionals, and community members; regional and state-based differences were noted, but several complaints were repeatedly noted in Australia:

~ a paucity of biophysical data, particularly at catchment and reach scales;
~ an absence of long-term funding sources for river rehabilitative efforts;
~ desires to 'work with the community' were affected by a limiting number of well-informed and interested community members.

Australian scientists have acknowledged the paucity of basic biophysical data and the associated difficulties in river rehabilitation in light of these knowledge gaps[1]. Fluvial and ecological conditions vary considerably in Australia, and the widely-reputed 'distinct nature' of Australian systems may lead to difficulties in developing effective rehabilitative prescriptions[2]. University and CRC-based researchers have made progress in recent years, assisted in part by state-based funding programs. A good example is the NSW Department of Land and Water Conservation funding of catchment-scale geomorphic data collection based on the River Styles methodology developed by Dr Gary Brierley and colleagues at Macquarie University. Such programs are absolutely critical, particularly in regions where demands upon water and land-based resources are high, and agency decisions are based upon sparse information.

Funding for river rehabilitation in Australia has been a consistent problem, and a range of state-based programs have developed, such as:

~ environmental levies applied to residents and managed by a catchment-based group (i.e. Catchment Management Authorities (CMAs) in Victoria and River Trusts in NSW);
~ policies in NSW that match in-kind landowner contributions of labor and equipment time.

A co-dependency of sorts has developed: landowners are discouraged from completing instream projects without agency input and approval, and agencies have come to rely on landowner contributions. Unfortunately, agencies have often adopted reactive river management policies that focus on site-specific problems (e.g. bank erosion) and solutions (e.g. rip rap). Ideally, rehabilitative efforts would fit into a broad catchment-based plan, where processes occurring over larger spatial scales and longer time scales are considered. Federal funding under the Natural

River rehabilitation in Australia: Informal observations from a Canadian perspective

Heritage Trust program has provided additional money for river works, but problems with project selection and timely fund distribution were noted by several practitioners.

A common theme for discussion at the 2nd Conference on Stream Management in Adelaide was the 'burn-out' of volunteers and community members involved in river rehabilitation. Site-specific instream projects may only involve one landowner (and his or her backhoe), but more broadly-based riparian projects often require the efforts of many persons. Community interest in issues relating to river management is often high, particularly with riverside landowners, and most agency reps seem to appreciate efforts of locals. From a strictly economic rationalist point-of-view, financial responsibility for long-term monitoring and maintenance of rehabilitative efforts is transferred to locals if ownership or responsibility for the works are accepted. A common consensus at the conference was that few community-based programs served to inspire, educate, or reward individuals involved in river rehabilitation. Ongoing involvement of a relatively small number of community members has resulted in over-work and high turnover rates. Some States pay community members for input and effort, but many programs simply would not function without the efforts of volunteers. Education and inspiration of potential volunteers is fairly limited; typical community outreach programs simply include brochure publication and intermittent field meetings.

Primary issues associated with river rehabilitative efforts in BC are similar to those noted in Australia, despite a longer history of implementation and greater availability of funding. River rehabilitation in Canada, particularly the province of BC, has a history that dates back several decades. Although there are significant differences in the biophysical environment and legislative frameworks between British Columbia and Australian states, I believe that river managers and rehabilitation practitioners in Australia could benefit from a careful assessment of the rehabilitative successes and failures in BC.

Until the early 1990s, money for rehabilitative efforts in BC came from general operating budgets, provincial post-flood emergency funds, or short-lived programs such as the Fish-Forestry Interaction Program. The Federal Department of Fisheries and Oceans has completed some river rehabilitative works in BC, but most efforts have historically been completed by provincial agencies, such as the present Ministry of Environment, Lands and Parks. The prime funding source in recent years has been the Watershed Restoration Program (WRP), a component of the Forest Renewal program. Forest Renewal was initiated in the early 1990s with the mandate to improve aquatic ecosystems impacted by forest harvest practices, while also providing transitional re-education and work for unemployed forest workers. Revenue for Forest Renewal was generated by an increase in "stumpage rates": a volume-based tax charged to logging companies for harvesting trees on Crown lands. Since 1994, approximately 2.2 billion Canadian dollars have been generated for Forest Renewal. Much of the money went into non-WRP components (e.g. silviculture, educational programs) and program administration, but several hundred million dollars have been spent under the WRP on rehabilitation of BC hillslopes, riparian areas and channels. Total expenditures over the next five years (1999–2003) are expected to be up to $1.5 billion Canadian[3]. The focus of WRP until 1998 was collection of catchment-based data to allow prioritization of rehabilitative efforts. In recent years, site-specific rehabilitative prescriptions have been designed and implemented, and efforts are now concentrating upon effectiveness monitoring of the works completed. The WRP has followed a broad seven-step process:

1. Prioritization of catchments to be assessed;
2. Catchment-based assessment;
3. Prioritization of rehabilitative sites and prescriptions;
4. Detailed field inspections;
5. Design and approval of site-specific prescriptions;
6. Construction/implementation of prescriptions;
7. Monitoring and maintenance of prescriptions.

Scott Babakaiff is a fluvial geomorphologist operating a consulting firm in Vancouver, Canada. His work focuses primarily upon the development and implementation of river rehabilitation prescriptions, but he is also a sessional university lecturer. During his stay in Australia, Scott worked closely with Dr Gary Brierley and colleagues at Macquarie University in Sydney. Scott's visit to Australia was funded by the Land and Water Resources Research and Development Corporation (LWRRDC); supplementary funding was provided by the NSW Department of Land and Water Conservation (DLWC), the Queensland Department of Natural Resources (DNR) and the CRC for Catchment Hydrology at Monash University. Scott may be contacted via e-mail at bag@bc.sympatico.ca

Agency representatives typically complete catchment delineation and prioritization; GIS platforms are used on occasion, but a low-tech approach using hard-copy 1:20 000 scale maps is more common. Instream works funded under the WRP typically include a component addressing benefits to aquatic ecosystems, specifically fish and fish habitat. Instream works are generally not completed in catchments greater than 200 to 300 km^2; previous experience indicated that instream rehabilitative efforts in BC catchments exceeding this limit had a lower likelihood of surviving flood events and meeting intended objectives. Although several hundred agency positions were created under Forest Renewal, most catchment-based assessments were contracted out to consulting firms. A suite of such assessment procedures exist; a broad analysis of catchment impacts (a 'Watershed Assessment Procedure') is completed first; subsequent inspections consider impacts to specific components of the hillslope-floodplain-stream system (e.g. Landslide, Riparian, Channel, and Fish Habitat Assessment Procedures). In this phase, the prime responsibilities of WRP agency representatives are to review assessments, monitor contracts, and liase with the community. A round-table group consisting of representatives from industry and catchment-based communities (native and non-native) also provides input on any proposed actions.

If the assessments suggest that rehabilitative efforts would be likely to accelerate natural processes of recovery presently underway in the catchment, a series of detailed prescriptions will be developed to address specific impacts. The source of the impacts are targeted, rather than the physical manifestations of the impact, and the prescriptions aim to augment recovery processes. For example, a common impact to aquatic ecosystems in BC catchments is bank erosion and aggradation of stream channels associated with an abundance of sediment provided to the stream from logging-related landslides. In such a case, a 'top-down' approach is adopted: initial efforts aim to reduce sediment inputs from the landslide; bank stabilization is only considered once the processes that caused bank erosion have been dealt with. Again, consulting firms typically complete detailed inspections and design development, with agency reps providing input and serving to discuss the proposed works with the round-table group.

Photo 1*: Wood and rock structures were placed in a tributary of the San Juan River, BC to create fish habitat and protect the banks. Flow is toward the bottom of the photo.*

Several iterations may be required to get all necessary approvals for the proposed rehabilitative works. Members of the local community are often hired to construct the rehabilitative works, but agency reps and consultants provide project supervision and quality control. Depending on the type of works completed, the designs may require sealed drawings from a Professional Engineer or Geoscientist. As-built drawings based on post-construction surveys may also be required. Effectiveness monitoring of rehabilitative works completed to date has been minimal, but is identified as an immediate WRP priority in 1999. Most work is likely to be completed by agency reps with intermittent support from consultants.

Despite the lack of rigorous and effective monitoring of instream works completed in BC, many lessons have been learnt from observation of stream responses to various prescriptions. Techniques utilized in BC in the early 1990s were adapted from works implemented in the United States Pacific Northwest in the 1980s. They typically concentrated upon bank stabilization and creation of habitat components for specific life stages of target fish species such as salmonids[4] (e.g. Photo 1). Techniques have been refined in response to additional research[5], and prescriptions commonly used in BC are now based upon examination of failure rates following a series of moderate flood events[6]. The most dramatic changes in best management practices over the last decade have been associated with instream prescriptions that aim to reduce the likelihood of post-flood changes in stream bed elevation. The general philosophy has shifted from treating sensitive areas in isolation (e.g. nickpoints or spawning riffles) to manipulating the processes over a broader section upstream of the sensitive areas, to minimize the likelihood of future flood events inducing undesirable changes in bed elevation. For example, rather than placing cross-spanning structures of rock or LWD[7] to vertically stabilize nickpoints, the preferred option is to place LWD jams upstream of the nickpoint (e.g. Photo 2) to:

1. increase flow resistance during flood events, thereby dissipating stream energy and,
2. reduce local bed gradient by creating a series of deep pools; such variability in bed elevation will also serve to increase flow resistance.

***Photo 2**: Log jam placed at bank in Lukwa Creek, BC to increase flow resistance, dissipate stream energy and reduce the likelihood of sediment wedge or nickpoint migration. Flow is from left to right.*

Australia–BC differences affecting stream rehabilitation efforts

There are opportunities for Australian stream rehabilitation practitioners to learn from the experiences in BC, but there are many key differences between Australia and BC that one must be aware of. Issues of particular importance are differences in the biophysical environments and regulatory/resource constraints.

Many prescriptions commonly employed in BC (and elsewhere in the Northern Hemisphere) may be inappropriate for application in an Australian stream setting due to differences in the biophysical environments. Prescriptions that target habitat improvement for fish species not present in Australia may be easily identified and avoided. However, more subtle problems may arise from the implementation of prescriptions that rely upon similar biophysical processes acting in Australian and BC streams. Dr Ian Rutherfurd has developed an excellent comparison of stream conditions and rehabilitation issues between the Northern Hemisphere and Australia[8]. Biophysical differences[9] displayed by Australian catchments compared to BC catchments include:

~ lower sediment loads;
~ lower stream power;
~ greater variability in flow and a lesser frequency of channel-forming events;
~ a greater dominance of channel planforms associated with fine sediment loads (i.e. vertically accreted floodplains);

***Photo 3**: Looking downstream, nickpoint in Mary River Catchment, Queensland.*

~ a greater dominance of channel features associated with degradational processes (i.e. bed lowering as in Photo 3) as opposed to aggradational processes (i.e. bed raising);
~ different riparian and macrophyte vegetation species;
~ low levels of nutrients resulting in low rates of Gross Primary Production;
~ impoverished fish fauna and a pre-European absence of salmonid fishes.

Consider two examples where rote application of BC-based rehabilitation prescriptions could have undesired results in Australian streams:

1. Cross-spanning structures placed at the stream bed have had very low success rates in BC due to localized sediment deposition, subsequent bank erosion and structure outflanking; they may have a higher likelihood of success in Australian streams if sediment loads are low and lateral stability is high.
2. Bank-anchored structures placed in aggraded pools to renew bed scour have high success rates in BC, but may be inappropriate in Australian streams if stream power is extremely low and channel-forming flood events rare (e.g. Photo 4).

Photo 4: *Cross-spanning LWD placed in the Pappinburra River, New South Wales. The structure has not been outflanked (yet) and has produced little associated bed scour.*

The other key differences between Australian states and BC relate to legislation and funding availability. In general, Australia has less money available for stream rehabilitation and weaker legislation (or less compliance) that would lead to mitigative or rehabilitative efforts by resource users. These constraints have led to innovations in cost-sharing ventures between the Australian government, industry and/or citizen-based groups. Land tenure in Australia often dictates that agencies work with private land owners, who may own the bed and banks of perennial stream channels; there are also issues associated with water rights and access for ranching and agricultural activities. Although there have been difficulties associated with such agency-land owner partnerships, the degree of public involvement and input in Australia is much stronger than in BC, and any long-term solutions must include local communities.

Historically, there has been little public involvement in BC stream rehabilitation efforts. Some federally-funded projects involve the community but the WRP rarely funds projects on private land; WRP works are generally completed on Provincial Crown Lands, which occupy 94.7% of the land base in BC. In contrast to some Australian states, legislation in BC provides government control of the bed and banks of perennial streams, even where bounded by non-Crown land (i.e. privately held). As a result, BC agencies are able to implement rehabilitative works without consulting local community members. Minimizing public involvement has reduced delays and costs associated with pre-project consultations but there are many negative aspects of such an approach:

~ no community 'ownership' of the works;
~ negligible public awareness of programs such as the WRP;
~ agency-based responsibilities for monitoring and maintenance of works are subject to the whim of changing government policy and funding availability.

These negative aspects are likely to begin manifesting themselves in BC as the operating budget of the WRP and Forest Renewal continues to diminish in the next few years. These budgets have decreased since 1998 due to reduced volumes of harvested timber in BC (i.e. less revenue generated from stumpage). Reduced forest harvest is related to a number of factors, including changes to the legislated code of practices governing forest harvest in BC, a global decrease in the value of forest products, and a diminished demand for BC forest products, particularly in Asia. Cuts to the operating budget have affected Forest Renewal staffing levels: nearly 300 positions in 1998 have been reduced to less than 200 positions in 1999 and are expected to decrease to less than 100 positions by 2001. Some administrative tasks have been shifted to companies receiving funds for rehabilitation, and the WRP will persist, but the present consensus is that there will be little implementation of new instream works in the next few years.

Some suggestions for future rehabilitative efforts in Australia

It has been an interesting experience to be able to compare and contrast rehabilitative efforts in Australia to BC through personal communication with rehabilitation practitioners and assessment of Australian rivers. Although many of my suggestions for future rehabilitative efforts in Australia are somewhat general, most of my Australian stream inspections occurred in catchments east of the Great Dividing Range in NSW and Queensland, and my suggestions may reflect this bias.

~ Fund programs that encourage landowners to conserve intact or sensitive reaches. Reactive decisions to "do something" in response to perceived risks associated with flood events has often led to completion of invasive instream works that are visible and serve to satisfy short-term concerns of landowners, but do little to address long-term causes of channel impacts.

- The objectives of any rehabilitative effort must be clearly identified and prescriptions must treat the *processes* that are responsible for the instream impacts, not simply treat the physical manifestation of the process. Many rehabilitative prescriptions applied in Australian streams have been based on designs that are simply transferred from previously-completed projects, and may not be appropriate for meeting objectives in the fluvial setting where they are subsequently applied.
- Continue to direct efforts at understanding biophysical processes in Australian streams, and to develop a suite of rehabilitative prescriptions appropriate for such processes. It is not reasonable to expect that a ‘cookbook’ approach to rehabilitation may be developed, but a range of best management practices could be developed for a variety of ecological and geomorphic ‘problems’ in a range of fluvial environments. Results from overseas rehabilitative programs should be considered, but assessed carefully and critically.
- Increase utilization of naturally occurring instream components into rehabilitation designs, such as woody debris. Designs funded under the WRP typically utilize woody debris, and are based on ‘template’ features from intact stream reaches. As in Australian streams, woody debris was cleared extensively from BC streams in the 1970s under a federally-funded flood control and habitat enhancement (fish access) program. BC agencies have since acknowledged the adverse impacts of that program, and have placed thousands of woody debris pieces back instream. These prescriptions are often designed to serve multiple objectives: habitat creation, bar stabilization and/or bank protection (e.g. Photo 5). I observed many Australian streams that would benefit greatly from such placement of woody debris.
- Efforts to minimize removal of woody debris and coarse sediment within Australian streams must continue. The beneficial effects of instream woody debris have been well documented in many research projects, but some agency policies reflect the misguided opinion that woody debris has a significantly detrimental impact on channel stability or flood water passage. Similarly, any short-term financial gains associated with sales of gravel resources must be considered in light of subsequent impacts to channel stability and ecological processes.
- Ensure that a portion of funds available for design and implementation of rehabilitative prescriptions are retained for monitoring and maintaining works. Monitoring and maintenance is essential to maximizing the likelihood of long-term project effectiveness. Failure to meet rehabilitation objectives is typically attributed to problems in design and implementation of phases, but it is often related to insufficient maintenance or a poor understanding of natural processes acting in a catchment.

Photo 5*: LWD with rock ballast was placed in Big Tree Creek, BC to dissipate stream energy and to deflect the thalweg (the line joining the deepest points of a stream channel) away from the outside bank. The root wads at the end of the LWD will increase the likelihood of pool formation and may also provide additional fish habitat. Flow is towards the bottom of the photo.*

Footnotes

1 Rutherfurd, I. et al. 1997. Research and development needs for river restoration in Australia. Land and Water Resources Research and Development Corporation Occasional Paper No. 15/98. 91 pp.

2 Brierley, G.B., Fryirs, K. and Cohen, T. 1996. Geomorphology and River Ecology in Southeastern Australia: An approach to catchment characterization. Working Paper 9603 for LWRRDC Project MQU 1. Graduate School of the Environment, Macquarie University. 54 pp.

3 Vancouver Sun Newspaper: 27 May 1999

4 Patterson, J.H. (ed), 1986. Proceedings of the Workshop on Habitat Improvements, Whistler, B.C. Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1483. 219 pp.

5 Koski, K.V. 1992. Restoring Stream Habitats Affected by Logging Activities. Chapter 8 in G.W. Thayer (ed) *Restoring the Nation’s Marine Environment*, Maryland Sea Grant Books, College Park Maryland.

6 Frissell, C.A. and Nawa, R.K. 1992. Incidence and Causes of Physical Failure of Artificial Habitat Structures in Streams of Western Oregon and Washington. North American Journal of Fisheries Management. vol. 12, pp. 182–97.

7 Large Woody Debris, generally defined as having a diameter exceeding 0.3 m and length exceeding 1 m.

8 Appendix 4 of Rutherfurd et al. (1997) ibid.

9 These differences are obviously generalized and focus on catchments in non-arid regions of Australia where most rehabilitative efforts have previously been concentrated.

SUMMARY

LEaRNING from international experience

River rehabilitation in Australia / UK: convergence or divergence?

Thoughts by Gary Brierley and Peter Downs

River restoration is being pursued world-wide as the basis for future river management. In so doing, there is a recognition that river management during most of the twentieth century has been damaging to the physical environment and the ecosystems that depend on a naturally-functioning relationship between the hydrology and fluvial geomorphology of a river. There is also widespread recognition that the opinions and good-will of the 'catchment community', the people whose lives are connected closely with the river in many different ways, are the cornerstone of effective river management.

The extent to which public participation plays a role in river management varies markedly from catchment to catchment, from region to region, and from country to country. While this has been influenced by a multitude of factors at the local level, the profound variability in the extent of community involvement in river rehabilitation at a national level appears to be determined primarily by the history of the organisational frameworks adopted for river management in differing countries. In England and Wales, for instance, there is a long history of government-funded, catchment-based management agencies. These probably reflect the high population density, and associated use of floodplains for settlement and other human needs, which have resulted in a river management framework that focuses on infrastructural concerns. Restoration efforts are led by the management agency and the public is still, to a large degree, not involved in the management process unless they have a particular grievance. There is still a national belief that the management agency will 'fix' any river concern, including matters related to conservation enhancement. Indeed, this concept is an explicit part of legislation governing river management in England and Wales.

This perception of river management can be contrasted to those existing in certain parts of 'new world' countries such as eastern Australia and the western United States. Here, the more recent European development and exploitation of these 'virgin' lands has left the public far more aware of pre-development natural river conditions. This provides a stark contrast to contemporary degraded conditions, which have resulted from rapid land-use changes, inappropriate management techniques and non catchment-based management. As a result, there is far greater public concern for community-based river enhancement programs, such as 'Friends of the River' and Rivercare groups, that actively work alongside publicly-funded agencies in pursuing 'new' river management goals. These distinctions are beginning to blur, as a world consensus emerges for 'sustainable' approaches to river management that include significant public appreciation and participation. It is, therefore, timely for those involved in river management to share their experiences on the international stage and develop methods for appropriate, environmentally-aligned river management for the twenty-first century.

Sharing of experiences does not end with the organisation of river management. Rather, it extends to the physical basis for achieving the goals desired by dedicated river management employees and by a concerned 'catchment community'. Again, marked differences exist in environmental setting from country to country, but the procedures for achieving those goals are increasingly similar, revolving around experts who can interpret their physical environment not only according to its unique characteristics, but also in terms of a global understanding of river processes.

A shrinking world does not necessarily equate to a convergence of ideas, but there are many indications that international trends in river rehabilitation are moving in similar directions. Some of the parallel trends in international approaches to river rehabilitation include:

A shrinking world does not necessarily equate to a convergence of ideas, but there are many indications that international trends in river rehabilitation are moving in similar directions.

- **A recognised need for greater community / landowner / stakeholder representation and involvement *throughout* the rehabilitation process** — maximising the potential for empowerment in the design, implementation, maintenance and auditing of river rehabilitation programs.

- **The desire to 'work with nature', in proactive rather than reactive management strategies**, requiring knowledge on the character and behaviour of the individual river system in question. Emphasis must be placed on addressing the causes of river degradation rather than the symptoms, over long-term (decadal) timeframes. The natural geomorphological-setting and the impact history of human disturbance must be understood.

- **Each site or reach must be placed within its catchment context**. Otherwise, the end result of river rehabilitation programs will not be sustainable, and approaches such as 'prompted recovery', which allow individual flood events to re-create environmental value, are likely to out-live large-scale re-engineering of the channel 'back to a natural condition'.

- **Increased emphasis on conservation values**, based on identification of relatively intact sections of river, rather than placing undue emphasis on degraded sites. Efforts to achieve this strategy are based on assessment of the recovery potential of rivers, and strive to enhance 'natural' processes of river recovery.

- **A recognised need to redress the lack of substantive, integrative monitoring programs** which audit the effectiveness of management efforts. In many instances auditing will move beyond assessment of environmental (ecological) outcomes to greater appreciation of economic benefits and costs. For example, the outcomes of riparian revegetation programs are currently being evaluated in various countries. At present though, the number of auditing and post-project evaluation schemes is limited, and it makes complete sense for the experiences to be shared by the international community of scientists. By comparing the rates and outcomes of river restoration in widely different environments, the development of a general consensus, that benefits individual countries, will be made more rapidly.

- **The desire to carry out higher profile, more integrative efforts at landscape rehabilitation** within a single (or few) catchments, rather than spread our efforts too thinly.

Significant advances in knowledge about how rivers work have been gained over the past decade — think of the vastly increased appreciation of the significance of riparian vegetation and coarse woody debris as 'controls' on river character and behaviour. The key to effective river rehabilitation is a balance of approaches based on informed debate. Prescriptive solutions imported without due understanding of the underlying causes of 'problems' will not yield sustainable outcomes.

The potential for emplacement of effective river rehabilitation practices in Australia is quite remarkable. The enthusiasm to 'do the right thing' presents an incredible opportunity to achieve substantive outcomes. However, a hint of caution and realistic appraisal of the changing basis of knowledge is required, and needs to be effectively communicated. We need to learn from our mistakes. River rehabilitation strategies in various parts of Australia have demonstrated remarkable flexibility and capacity to embrace and adopt new ideas. However, it must be remembered implicitly that our approaches are often experimental, and that we haven't got it right yet. New ideas and approaches will continually emerge. The pace of change is phenomenal, as exemplified by the recent switch from desnagging to emplacement of coarse woody debris in many river management programs. In many instances, however, we lack substantive baseline data with which to make informed judgements about river rehabilitation programs. We will not achieve long-term goals by proceeding in an *ad hoc* manner. International experience indicates that there is no effective and sustainable alternative to effective planning and design strategies. An informed basis of knowledge is imperative in determining meaningful visions or goals for river rehabilitation, framed at catchment scales over long term (decadal) timeframes.

Dr Peter Downs (Peter.Downs@Nottingham.ac.uk) is a lecturer in the Department of Geography at the University of Nottingham, UK. He attended the 2nd Stream Management Conference in Adelaide. As part of his visit, he had several discussions with Dr Brierley and his research team at Macquarie University, focussing largely on catchment-based approaches to river recovery.

Dr Gary Brierley (gbrierli@laurel.ocs.mq.edu.au) is a Senior Lecturer in the Department of Physical Geography at Macquarie University. Much of his recent research has focussed on river responses to human disturbance in south-eastern Australia, and implications for river geomorphology, ecology and rehabilitation.

It's a WRAP

Keeping up to date with what is happening across Australia in the area of natural resources management is vital. This section provides States and Territories with the opportunity to 'wrap up' key activities, research and upcoming events. This edition's focus is on Tasmania, page 24.

Queensland

Land and water management plans

The Queensland Government has introduced a requirement that new irrigation developments be carefully planned to minimise potential adverse impacts on land, water, and the natural environment. To ensure the impacts are fully addressed, landholders purchasing a new or increased water allocation for irrigation will need to draw up an acceptable Land and Water Management Plan for the development before the water can be used. Similarly, plans are required whenever an irrigation development involves State Government funding assistance.

Both the Government and the community have recognised that both inappropriate land development and the excessive use of water can adversely effect the land on which it is used as well as surrounding land, downstream users, and the receiving environment. With careful planning, landholders can ensure that their irrigation enterprises operate in a sustainable way with limited impacts on and off the farm.

The planning process can also save the operator significant costs over the life of the development. By carefully examining the proposal, the proponent is able to explore those practices which will lead to increased operational efficiency, optimising the use of available land, water, and human resources. Hence the requirement is a "win-win" situation for the landholder and the community.

The required plans take an overview of the proposed development, linking infrastructure elements such as crop areas, roads, channels, drains, storages, and pumps with farm landscape features such as topography, soils, groundwater, drainage, vegetation, and streams. On top of this, the plan will detail planned management practices for preparing land, irrigating, applying chemicals, and controlling farm runoff. The information is usually laid out on maps with supporting text so that the relationship between the various elements is clearly portrayed.

The Queensland Department of Natural Resources is assisting landholders to draft their plans. As lead agency for the management of the State's land, water and vegetation resources, it is in the Department's interest to have suitable plans developed and adopted by landholders. Also many landholders do not have a full range of skills to optimise layout designs and to explore management options. The Department also administers the *Water Resources Act*, under which the plans are required and water is allocated.

These plans will lead to improved riparian and stream health by several means. By placing a focus on application practices for fertilisers, herbicides and pesticides as well as the management of tailwater, the amount of nutrient and pollutants escaping to the riverine environment can be substantially reduced. Also, the provision of riparian buffer strips to trap sediments and nutrients mobilised during storm events will further reduce the potential for nutrient enrichment in the stream. Erosion of stream banks, often leading to the loss of valuable agricultural land, can be addressed by providing an appropriately vegetated riparian strip along the stream frontage.

While there is no legal requirement for the plans to directly consider ecological factors, the environment will be indirectly enhanced through the reduction of adverse impacts. Other environmental regulations, such as the *Environmental Protection Act* and the *Nature Conservation Act*, continue to apply to the development and operation of the enterprises.

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Australian Capital Territory

Murrumbidgee river restoration project

The Murrumbidgee River in the ACT has been greatly modified since the early 1800s due to the settlement and development of Canberra and surrounds. Modifications have included the removal of a large proportion of native riparian vegetation, introduction of weeds, willows and non-native fish, sedimentation, an influx of pollutants from urban development and agriculture and an increase in recreational use of the river. These factors have dramatically altered aquatic ecosystems.

Recently, through education, research and a more sympathetic approach to river management, steps have been taken to minimise impacts on local waterways including an attempt to rehabilitate badly affected sections of the river. As part of this rehabilitation, the Murrumbidgee River District (ACT Parks and Conservation Service), successfully applied for an NHT Fisheries Action Program grant to rehabilitate a 15 km section of river extending from Kambah Pool to Tharwa. This is in addition to works already undertaken by the District.

There are two components to this project:

Riparian rehabilitation

This involves weed and willow control, erosion control, revegetation (within the river and catchment areas), monitoring (water quality, aerial and on-ground photography, and on-ground evaluation), and a small scale trial of propagating aquatic plants. This has a strong community involvement and is currently supported by nine schools and community groups. These works have been ongoing for 2 years and immense progress is being made, with particular regard to habitat provision and weed control.

Management trial in the provision of fish habitat

Using knowledge gained through research on native fish, geomorphology, flow hydraulics and river history, a management trial was set up to determine if the provision of habitat is useful to increase populations and/or diversity of native fish. Prior to European settlement, the riverstrip at Lanyon (ACT) was found to have a gravel substrate and a series of deep pools. Sedimentation from land clearing and erosion has led to the filling up of these holes with sand and, in so doing, restricting habitat for fish.

Work undertaken to address this problem has involved the construction of two rock groynes, which are structures often used to alleviate bank erosion, and in this case to scour holes in midstream sand. Many species of fish are known to rely on deeper holes for survival and the aim is to accommodate this need. Works are accompanied by geomorphological monitoring, fish and macroinvertebrate surveys. In addition, this section of river has also been fenced from stock, and revegetated over the last five years.

The groynes were constructed in October 1997, and already we are seeing changes in distribution of aquatic vegetation and scouring of sand in spite of the lack of major flood events. Eastern Water Dragons have taken up residence and are breeding in both groynes, and they are proving to be reliable vantage points for aquatic birds. Any changes in macroinvertebate and fish numbers and species, should become apparent over time.

***Left**: Groyne 1 being installed.*
***Below**: Groyne 1 in place, October 1998, Lanyon.*

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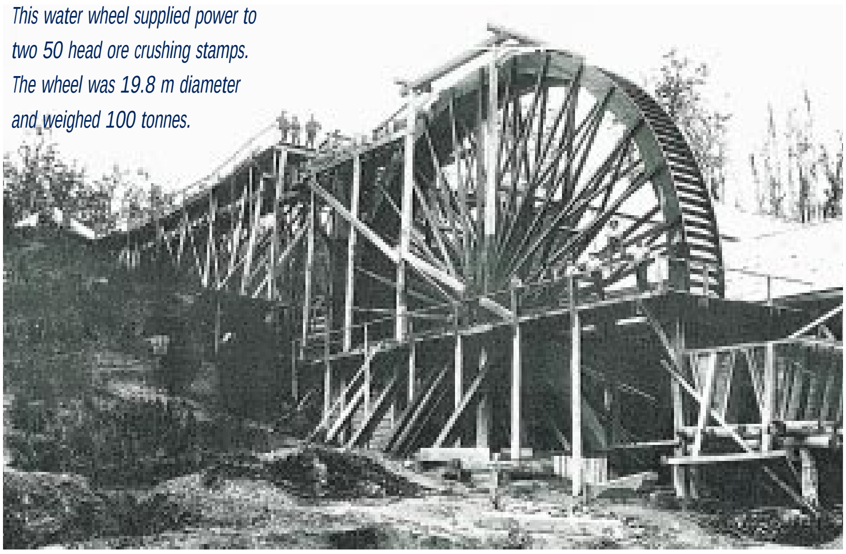
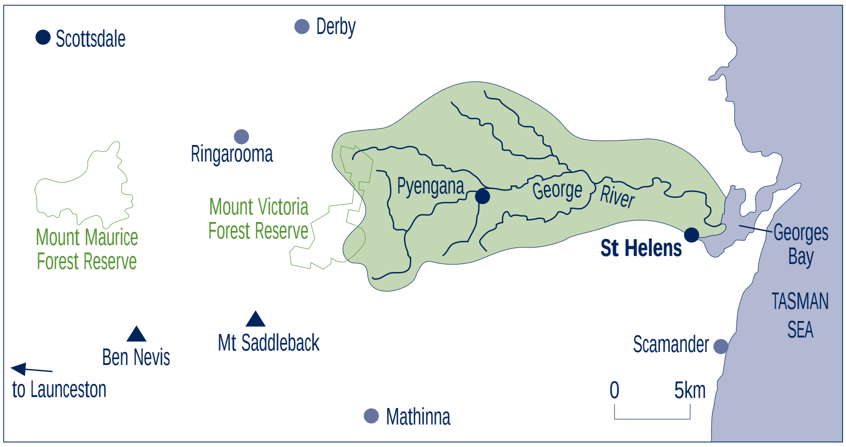
River rehabilitation in north-eastern Tasmania

George River community maintains its links with early pioneers

The development of Tasmania's north eastern corner owes much to the spirit and practical skills of its early pioneers in opening up the area's rich farmlands and tapping its productive timber and mineral resources. The George River and its catchment, west of the popular east coast tourist destination of St Helens, figured prominently in the area's early mining heyday. Numerous relics of this past era can be seen throughout the valley and at the local museum, as a reminder of the skills of the early miners, engineers, timber workers and land developers in harnessing the area's rivers and clearing its floodplains for primary production and mining. A notable example is the Siamese water race constructed in the 1800s to carry water some 40 km along the valley for high pressure sluicing operations at former alluvial tin mines. The Anchor race from the North George River flowed 44 km to power the water wheel shown here.

This water wheel supplied power to two 50 head ore crushing stamps. The wheel was 19.8 m diameter and weighed 100 tonnes.





The George River catchment discharges through St Helens into Georges Bay.

The George River catchment drains some 550 km² of heavily forested highlands, productive farmlands and coastal plains. The river has many pristine headwaters flowing from the highlands through scenic rainforest and dropping through several waterfalls, including the magnificant St Columbia falls upstream of the dairying district of Pyengana. The river's course takes it through expansive forests, lush farmlands and picturesque coastal scenery to its mouth at the holiday and fishing centre of St Helens on Georges Bay.

The riparian lands along the George River have a long and productive history. The highly productive river flats consist of deep alluvial loam along most of its length. In the 1870s the river was cleared to the waters edge for pasture establishment and alluvial tin mining in the area drained tailings into the river system. Over the years, various methods have been undertaken to 'assist' the river and its users. As in many other areas of Tasmania, willows were planted along the George River early this century to attempt stabilisation of the banks. During the 1960s, some straightening took place which increased the flow velocity and resulted in vertical bed erosion and subsequent embankment collapse. Later, rock rip rap was installed, but this had varying success, and was dependent on landholder cooperation and area of placement. Early in the Decade of Landcare some of the willows which were choking the George River were removed, however there was not yet any catchment based planning and this removal again had varying success rates.

As with numerous other rivers in Tasmania, the George River is now undergoing a changed management regime. This change has resulted from recognition by the community of the critical importance of the river's natural assets and the need, in particular, for widespread rehabilitation of riparian lands as an essential part of our natural heritage. River engineers, together with geomorphologists, ecologists and riparian land owners, are now working with the broader catch-

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ment community to realise their goal of sustainably managing the river and its riparian corridor.

With the assistance of a dedicated Rivercare Plan, the Pyengana Area Landcare Group has adopted a strategic and coordinated approach to stream management. Part of the strategic plan involves the implementation of a works program. These works consist primarily of the installation of a series of rock riffles that are designed to slow water velocities, greatly improve in-stream habitats and have allowed the regeneration of vegetation on the banks. To support this regeneration, fencing has been constructed to exclude farm livestock.

The Landcare Group has found that riffle construction is the most subtle method of river stabilisation which, when coupled with livestock exclusion, allows the river to repair itself through natural processes. This contrasts sharply with the earlier practice of placing rock revetment which, in many cases, merely relocated the erosion site.

The Pyengana group has completed 50% of its planned on ground works. Along with these works, their community communication strategies have engendered a solid base of local support for the project. They have fostered nearly 100% landowner support and involvement and have created the George River Authority, as a special committee of the Break O'Day Council. This body has full responsibility for the project, including future management and maintenance through a catchment levy and other sources of revenue.

***Before (above left) and after**: River Engineer David Klye and Catchment Coordinator Terrance Rattray inspect site rehabilitation on the Groom River. (Note the log protruding from the bank.)*

Funding for the capital improvement phase of the project has been mainly shared between the riparian landowners and the Commonwealth Government under the Natural Heritage Trust Program. The Break O'Day Council and its staff have also made a significant contribution to this project. With the solid backing of the local and regional community, the success of the George River project is assured. The project has become a valuable case example of how a partnership approach to river management, between catchment and riverland communities and all levels of Government, is essential in achieving sustainable management of our rivers into the future.

New South Wales

Catchment information packages: a format for the distribution of environmental information

At present electronic presentation media are an under-utilised resource in environmental management. The salient transferal of geographical information system (GIS) data into an electronic publishing environment is obviously a beneficial process. Results developed from this type of work can act as a first sweep of readily accessible environmental information. This provides a platform for more indepth studies and other projects, and helps to indicate data deficiencies, to avoid project replication, to augment reports, and to provide communicative and educative tools. Further, lessons learnt are invaluable for research into even more interactive presentation media, such as online GISs (e.g. ICMISS).

Researchers from the Rivers Group in the Department of Physical Geography at Macquarie University, in collaboration with LWRRDC and DLWC have carried out initial work on the development of a "Catchment Information Package" format for the presentation and distribution of environmental information. This work has built on the river styles platform, developed by Dr Brierley and colleagues, striving to place the character and behavior of differing river styles within their landscape setting.

continued over

New South Wales continued

The research involved the production of hard copy, CD-ROM (PDF), and Web (HTML) publications for the Hastings Basin of Northern NSW. Guiding their development were the following factors

~ integration of environmental themes
~ catchment focus
~ hierarchical frame
~ inclusion of interpretive elements

An object-oriented design (each page can stand alone) was devised where each object included

~ thematic title and location title
~ environmental data, normally graphical
~ a caption, expanding on information in data
~ metadata; a background to the data
~ publication details

The themes that were initially used were

~ executive summary
~ location map
~ geology
~ landscape
~ streams
~ hydrology
~ vegetation

Obviously, this list is not exhaustive. The beauty of electronic formats, however, is that they can be readily expanded and edited; they are a living database. Other advantages that electronic media have over hard copy are their interactive nature, allowing the smooth integration of themes, and the capacity to explore them non-linearly.

The HTML format (web pages) comes into its own on this score. It also has an advantage over the PDF format in that the multiple use of presentation features (e.g. titles, bars and borders) can be processed efficiently using frames (where the web page is divided into separate sub-pages). The PDF format (viewed with the freely available Adobe Acrobat) meanwhile has the advantage of a stable presentation design.

The jury is still out on which format will dominate the world of the web. Fortunately, after the setup of a presentation structure and the collation of raw information, the production of each of the electronic formats is straight forward.

Examples of these PDF and Web documents can be found in the Current Projects folder of the Rivers Office web site listed at right.

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Commonwealth

$1.1 million Natural Heritage Trust funding for Brisbane and Bremer Rivers

The goal of the Natural Heritage Trust is to stimulate local action contributing to the national effort to achieve the conservation, sustainable use and repair of Australia's natural environment. A major focus of the Trust is the better management of our rivers through the National Rivercare Program, Murray-Darling 2001 and the National Landcare Program. The combination of these three Programs provides an integrated approach to natural resource management of rivers throughout Australia.

Some of the Natural Heritage Trust projects that help improve rivers are based on community education and planning while others focus on on-ground implementation and rehabilitation of stream banks. The National Rivercare Program aims to ensure progress towards the sustainable management, rehabilitation and conservation of the rivers outside the Murray-Darling Basin and to improve the health of these rivers.

Recent media reports have reflected increasing community concern about the level of pollution in the Brisbane and Bremer Rivers in Queensland. Natural Heritage Trust funds are accelerating the work that the State Departments, Universities, local government and community groups are doing to solve this complex problem.

The Natural Heritage Trust has funded 10 projects on the Brisbane and Bremer Rivers in the past two years worth over $1.1 million. These projects have raised community awareness about the health of the rivers and helped with on-ground implementation of works to improve water quality and bank stability, as well as enhance the in-stream and riparian corridor habitat. The community and State agencies have matched the $1.1 million contributed by the Natural Heritage Trust with $2.3 million. This is a good example of how the Natural Heritage Trust is providing assistance to the community and State programs to fix up a priority river.

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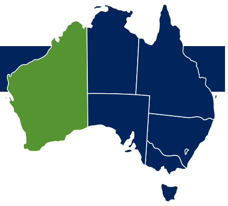

Large woody debris demonstration site, Dandalup River, Western Australia

Western Australia's Water and Rivers Commission, in collaboration with LWRRDC and the University of Western Australia, is developing a range of sites demonstrating restoration techniques in urban and rural waterways. The techniques seek to restore channel stability, rehabilitate riparian vegetation and enhance the habitat and ecosystem value of waterways.

The aim of establishing the demonstration sites is to achieve environmental and educational benefits by promoting adoption of different waterways management techniques. A site demonstrating the use of woody debris to restore instream habitat is being established on the Dandalup River, on the Swan Coastal Plain 80 km south of Perth.

The rivers of the Swan Coastal Plain are typically sandy and therefore "unstable". Much of the native riparian vegetation of the Plain has been cleared for agricultural purposes. The majority of rivers were extensively de-snagged to the extent that little large woody debris (LWD) remains in the channels. The removal of LWD has subsequently increased the amount of unstable habitat, where during the high flows of winter, the river channels are almost devoid of fauna. Additionally, the lack of LWD has reduced the frequency of pools, which are typically a refuge for aquatic fauna and a major focus for fish.

The project involves restoration of the instream habitat through the reconstruction of riffle-pool sequences on a 500 m section of the Dandalup River. The site was established to monitor improvements to the riverine ecosystem through the installation of large woody debris to create pools. Approximately 40 large logs have been installed at the site. The logs range in size from 4.7 to 9.4 m in length and 250 to 900 mm in diameter. Three "v" shaped riffles were installed. The remainder of the logs were orientated to provide toe protection around the outer bends of meanders.

During sizeable spring flows in 1998, some movement of the LWD occurred. This was primarily due to the high mobility of the sediment and consequent undermining of the logs. The majority of the installations are becoming bedded into position. Scour pools have formed in the centre of the channel, downstream of the riffles.

Enhancement of the site was undertaken in February 1999, including re-positioning of some of the logs and stabilisation of most of the LWD along the reach by securing to pine posts driven to a depth of approximately 2 m into the bed. Twelve additional logs were installed, primarily as toe support along eroding banks.

Changes to channel stability, water quality and biodiversity are being monitored to evaluate the applicability of the restoration technique to the sandy river systems of the Swan Coastal Plain.

WATER AND RIVERS COMMISSION

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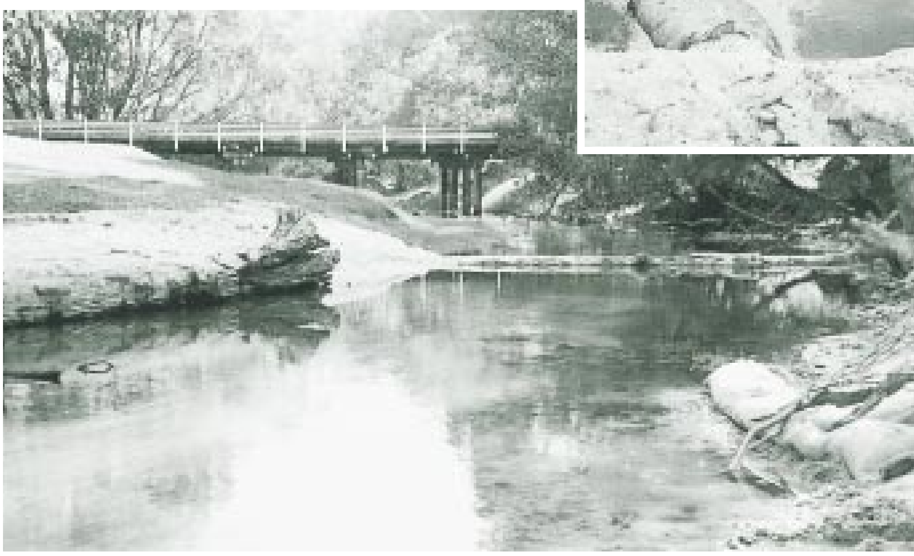

***Top**: Site for Riffle C prior to installation, May 1998. **Right**: Riffle C, June 1998. **Above**: Riffle A, May 1998.*

Victoria

The River Basin Management Society (RBMS) is holding its Back to Basics Winter Seminar on the theme: 'The Basics of Riparian Management'.

The aim of the seminar is to provide participants with an understanding of the physical processes operating in the riparian zone, how the zone might best be managed and to give some guidance on strategic issues. There will be three key sessions:

1. Physical interactions in the riparian zone and the benefits of riparian land management
2. Elements of a healthy riparian zone (Planning and management)
3. Strategic issues (Barriers and responsibilities)

Speakers include Tim Doeg, John Riddford, Chris Gippel, Siwan Lovett, Geoff Carr, Ed Thexton, Roger Lord, Dan Terrill, Scott Seymour, JaneDoolan and John Tilleard.

The Welcome and Opening Address will be given by Dianne McPherson, Chair of the Goulburn Broken CMA Vegetation Plan Steering Committee.

For more information on the seminar, please contact

Jennifer Davis
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or

Wayne Tennant
0417 503 436

Conference details

Wednesday 21 July, 8:30am – 4:30pm. Registration closing date: 12 July.
Cost: RBMS members @ $80; Non-members @ $95.
Venue: Goulburn Ovens Institute of TAFE, Seymour Campus, Seymour (about 100 km north of Melbourne just off the Hume Highway).

River Basin Management Society Inc.

ASLO-2000

Research Across Boundaries

presented by the American Society of Limnology and Oceanography
Copenhagen Denmark, 5–9 June 2000

This meeting will include a broad scientific program that should be of interest to aquatic science researchers and students from all over the world. Contributed oral and poster sessions will cover the full range of limnology and oceanography, with special sessions and plenaries devoted to aquatic research across boundaries; e.g. land/water, air/water, freshwater/marine, sediment/water, rivers/lakes, physics/biology, solutes/particles, empirical data/theoretical models. The European location provides an opportunity to also highlight the significance of international collaboration and the increased number of research issues which transcend international boundaries. We invite you to this historic event.

For more information

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Fax: +45 4492 5050 Web address: www.aslo.org/copenhagen2000

River Landscapes

www.rivers.gov.au

RipRap

LWRRDC'S RIPARIAN LANDS MANAGEMENT NEWSLETTER

A COMPONENT OF THE RIVER RESTORATION AND MANAGEMENT PROGRAM

Edition 10, 1998: Streambank stability

Edition 11, 1998: Riparian zones: what are they?

Edition 12, 1999: Managing the riparian zone within a total farm system

Edition 13, 1999: Benefiting from overseas knowledge and experience

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Some LWRRDC publications are available from the AFFA Shopfront situated in the Edmund Barton Building, Core 2 Entrance (off Blackall Street) Barton ACT 2601 Tel: 1800 020 157

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☐ *Intersect* — LWRRDC general newsletter

☐ *Focus* — Dryland salinity

☐ *Rivers for the Future*