Australian Government
Land & Water Australia

RipRap

RIVER AND RIPARIAN LANDS MANAGEMENT NEWSLETTER
Edition 31, 2006

Wrapping up riparian

The National Riparian Lands R&D Program has been around for 13 years, and this edition of *RipRap* features the researchers who have been involved, the key findings that have been made, and the products that have been developed to apply science to day-to-day management. It is a celebration of the accomplishments of the Program and a 'thank you' to all those who have been involved.

continued page 3

Contents

Correction

In the last edition of *RipRap*, page 3, there was a quote attributed to Chief Seattle. This was incorrect and it was in fact the screenwriter Ted Perry that penned the prose. Our apologies Ted!

RIParian lands:

WHERE LAND AND WATER MEET

From the Editor

When I began working on the National Riparian Lands R&D Program eight years ago I never thought that I would be putting together Edition 31 of *RipRap*! However, here we are and what an edition it is. This edition is all about showcasing and celebrating the work of the National Riparian Lands R&D Program. It is a Program that I have had the pleasure of working on over the years, with great people in the research, government, non-government, agricultural industry and wider community. As you look through the pages you will see the research that has been undertaken and how every effort has been made to ensure that it is produced in ways that makes it accessible and relevant for every-day river and riparian management.

I would like to extend a particular thanks to Phil Price and Allison Mortlock, who have worked tirelessly with me over the years — it is not hard to do when we have had such great material to work with and such a lot of support from *RipRap* readers across Australia. We hope you enjoy this edition, as well as our Christmas present to you of the National Riparian Lands R&D Program Legacy CD. You are welcome to join us in celebrating the Program when we hold our last workshop in Melbourne in February 2007 (see page 5 for details). Thank you, and all the best for the festive season!

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WRAPping up riparian

By Phil Price

Phil Price is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

How the Program came to be and key achievements...

Following its establishment in 1991, Land & Water Australia (formally the Land and Water Resources Research & Development Corporation) undertook a round of national consultations in all states and territories with land and water managers, researchers, industries, agency staff and community groups to help identify the priorities for research and development (R&D) to underpin natural resource management in Australia. The need for better use and management of riparian zones to protect and improve river health and water quality was one of the topics raised at almost all meetings.

In 1992, the Corporation commissioned a review of the scientific knowledge of riparian zones and their functions. This was undertaken by Stuart Bunn and colleagues at the (then) Centre for Catchment and Instream Research at Griffith University. It showed that although riparian zone processes were thought to be crucial for healthy rivers, there was very little published Australian data about these processes, or about how riparian land should be managed to maintain its key functions. Did riparian vegetation trap sediment and stabilise banks as some claimed, were riparian inputs vital for in-stream ecosystems? There was almost no local data to support or refute these ideas and show whether or not riparian land in Australia provided the sorts of ecosystem functions that had been shown overseas.

A new program to answer these questions commenced in 1993 after a national workshop of scientists and managers had identified the R&D priorities in more detail. Phase 1 of the Program ran for nearly seven years in total. It had three sub-programs, two based on scientific experimentation and one on practical application. The Physico-chemical Sub-program investigated the ability of riparian vegetation to trap sediment and nutrients and to reduce erosion processes and stabilise stream-banks, while the Ecological Sub-program tested the importance of riparian vegetation and nutrients in controlling in-stream production and providing food inputs and in-stream habitat. The Demonstration Sub-program supported projects with 10 community groups or agencies to test and demonstrate different aspects of practical riparian management. (For more details see www.rivers.gov.au)

Phase 1 had funding of $4.6 million from Land & Water Australia (LWA), $0.7 million from third parties (mainly state agencies) and $2.3 million from research organisations. It was guided by an advisory committee with invited representation from Commonwealth, state and territory agencies, and this group played an important role in making sure the R&D responded to issues faced by river managers, and in taking research results back into agency policy and programs. Phase 1 also started the strong communications effort that has characterised the entire Program, with series of fact sheets, technical guides and the *Riparian Land Management Technical Guidelines*

Photo Mike Wagg.

which summarised both the scientific knowledge at the time (1999) and provided practical guidance in riparian management as well as a summary of relevant legislation. These were complemented by the *RipRap* newsletter and establishment of the rivers.gov.au website.

Phase 1 provided for the first time a sound and scientific underpinning on which to base good riparian management. LWA decided to fund a second phase of the Program to then translate this into management practices that could be used by agencies, rural industries, land holders and community groups. A series of workshops with agencies and industry bodies identified 11 management issues that have been the focus of work within Phase 2, which ran from 2000 until 2005, with a harvest year to complete the synthesis and communication of new information in 2006. This edition of *RipRap* is organised around these issues, see contents list for details. Funding for Phase 2 was $3.5 million from LWA, $1.1 million from third parties, and $1.3 million from research organisations. The range of communication materials has been expanded and earlier editions updated, and several industry-specific guides on sound riparian management have been published through collaboration with other R&D corporations for sugar, cotton and wool.

This large, national investment equivalent to $1 million per year for 13 years has greatly increased the understanding and measurement of important riparian processes, enabling sound management practices to be developed and used with confidence. It has also been instrumental through a very effective communications effort in lifting the profile of riparian and river management within rural communities and industries.

Some of the key findings from this R&D program, several not anticipated at its commencement, are:

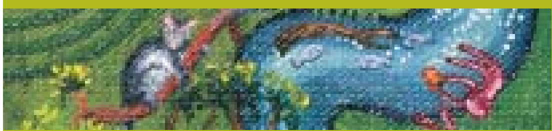
- identifying the different sources of sediments in streams and designing appropriate management responses,
- understanding of the main mechanisms by which streambanks erode, and design of effective management responses to them,
- the effectiveness of riparian vegetation, especially grass filter strips, in trapping sediment and attached nutrients,
- understanding of the mechanisms and quantification of the extent to which the roots of riparian vegetation roots reinforce and stabilise streambanks,
- the minor contribution of riparian trees to surcharge and slumping of streambanks, contrary to common belief,
- understanding the effects of riparian vegetation on flood peaks and duration within a catchment,
- showing the importance of riparian inputs from native vegetation to streams under natural conditions, and the deleterious effects of clearing and over-grazing,
- identifying nitrogen as the limiting factor of in-stream growth in many situations,
- demonstrating for the first time the role of shade in controlling growth of nuisance aquatic plants in waterways, even under conditions of elevated nutrient levels,
- the necessity to replant streambanks with native species since aquatic organisms cannot utilise the C_4 sources of carbon provided by exotics such as para grass and sugar cane,
- showing the importance of in-stream habitats such as large woody pieces and root armouring of banks, and the role of native vegetation in providing these,
- the role of shade from riparian vegetation in controlling stream water temperature,
- demonstrating the deleterious nature of uncontrolled stock access to streams due to large inputs of nutrients in dung and urine, trampling of vegetation and pugging of soil at the water's edge,
- showing how strategic management of grazing can be used to improve productivity and recoup fencing and watering costs while improving environmental management,
- developing and demonstrating practical methods for riparian fencing, alternative water point development, and revegetation, and
- demonstrating the importance of integrating social science with biophysical science so that the range of factors that impact on people and their behaviour in managing riparian areas is recognised and acted upon.

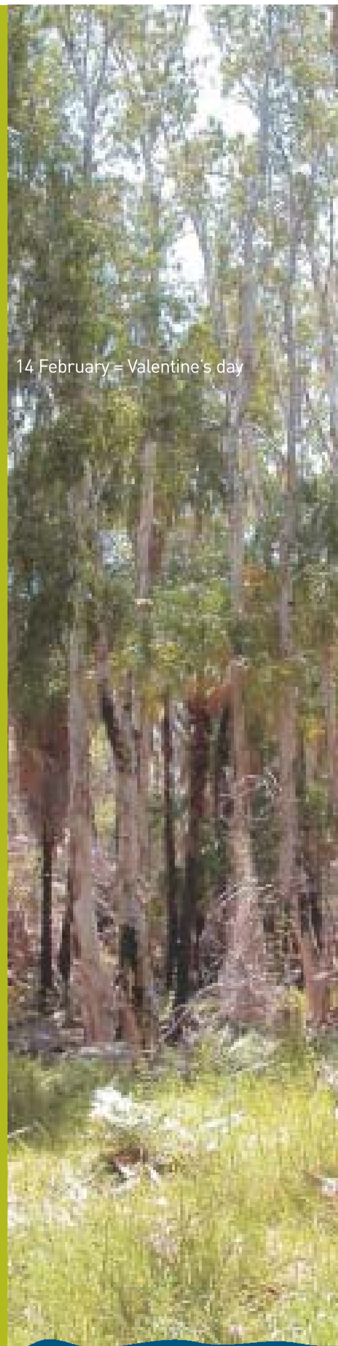
Many of these findings have been presented in quantified models, look-up tables or other forms that enable river managers and those assisting landholders to use their local data to develop specifications for a particular site or project.

The fact sheets and technical guidelines have been used throughout Australia by a range of groups and individuals and are strongly linked to adoption of improved management practices associated with riparian areas on private land. The regional groups established under Natural Heritage Trust (NHT) 2 and National Salinity and Water Quality Program have been strong users of the material. Users of the information products include government and non-government agencies, community based organisations including NHT recipients, Greening Australia, catchment management staff, individual land managers, industry organisations, and consultants. A range of government agencies has endorsed the guidelines.

The Program became the principal R&D program in Australia associated with riparian land science and management. The material has influenced and is influencing the priorities that are placed on riparian management in catchments and throughout natural resource management planning. An independent analysis of the Program has suggested an internal rate of return of around 90% and a benefit:cost ratio of about 6.5. This edition of *RipRap* is about celebrating the work of this program and thanking all those who have been involved. ■

The no frills free national riparian research and development WORKSHOP





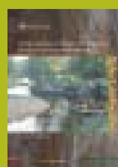
14 February = Valentine's day

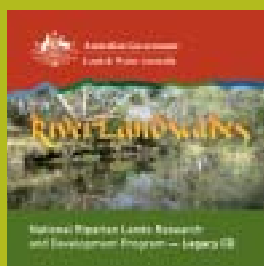
(♥ it) 14 February 2007, Melbourne

For those of you that missed out on our national workshop series, we are running a free, no frills workshop in Melbourne on the 14th of February. The workshop will cover key research findings from the National Riparian Lands R&D Program and speakers will include:

- **Professor Ian Rutherfurd** (flooding, erosion, catchment scale priority setting)
- **Professor Peter M. Davies** (in-stream temperature and ecological health)
- **Dr Andrew Brooks** (guidelines for reintroducing wood into Australian streams and rivers)
- **Dr Phil Price** (monitoring and evaluation, riparian widths)
- **Dr Siwan Lovett** (capacity building, effective communication, and the Program's legacy CD-ROM)

The workshop will also celebrate the launch of the new *Principles for Riparian Lands Management* book that brings together all the science developed through the Program over the past 13 years. The Program's legacy CD-ROM will be discussed, as well as the *Design guideline for the reintroduction of wood into Australian streams.*





The venue is the University of Melbourne and the workshop will run from 9.00 am to 5.00 pm. There will be a dinner/BBQ the night before for anyone who would like to come along and celebrate the Program's achievements.

What do I need to do?

Register your interest on-line at www.rivers.gov.au BEFORE you go on Christmas holidays as the first in are guaranteed a space. We need a minimum of 50 people and the cut-off for registration will be when we reach 150 people, or 15 January 2007. You will be notified by e-mail with updates on the agenda, accommodation options, etc. once we have enough participants.

www.**rivers**.gov.au

Changing face of *RipRap* by Siwan Lovett

RipRap began in 1993 as a modest newsletter that gave snippets of information about riparian management. In 1998 it underwent a transformation and became based around a riparian management theme. The theme approach has proved to be very popular and we are now up to our 21st edition using this format. I would like to thank the person that has done every one of these 21 editions with me — Allison Mortlock from Angel Ink — her creativity and skill at making scientific knowledge interesting, easy to use and attractive to look at, has been a huge part of the Program's success.

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
Edition **14**, 1999	Managing and rehabilitating riparian vegetation
Edition **15**, 1999	Seeing is believing: the value of demonstration sites
Edition **16**, 2000	Managing snags and large woody debris
Edition **17**, 2000	Monitoring and evaluation
Edition **18**, 2001	Inland rivers and riparian zones
Edition **19**, 2001	River and riparian habitat for fish
Edition **20**, 2001	River contaminants
Edition **21**, 2002	What are ecosystem services?
Edition **22**, 2002	Riparian research
Edition **23**, 2003	Managing riparian land to achieve multiple objectives
Edition **24**, 2003	Building capacity for river and riparian restoration
Edition **25**, 2003	Catching up on contaminants
Edition **26**, 2004	Tools and techniques for river management
Edition **27**, 2004	Connecting communities
Edition **28**, 2005	Tropical rivers
Edition **29**, 2005	Environmental water allocation
Edition **30**, 2006	Knowledge and adoption
Edition **31**, 2006	Wrapping up riparian

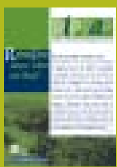
Edition 1

The first edition of RipRap was produced in September/October 1993. It would be a rare thing now.

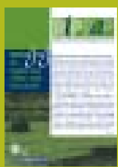
Edition 4

Edition 10 (1998)

Edition 11



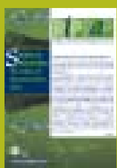
Edition 12



Edition 13

Edition 14

Edition 15



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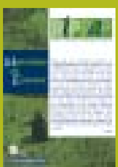

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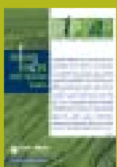

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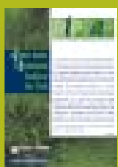

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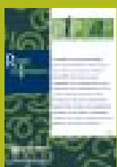

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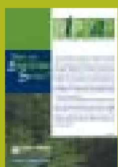

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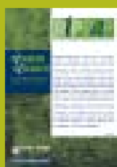

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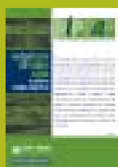
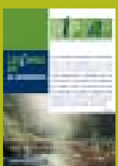


Edition 24 was the first full colour edition of RipRap

Edition 25



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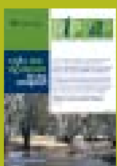

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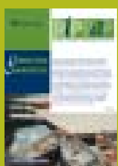

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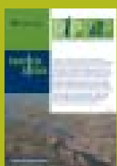
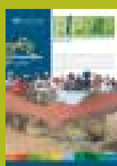


Edition 29

Edition 29 was the first newsletter that used Land & Water Australia's new corporate branding

Edition 30

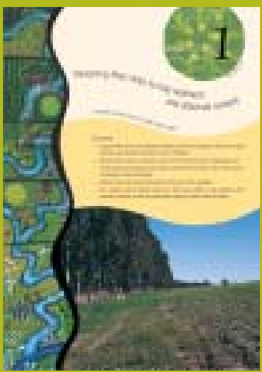
Edition 31

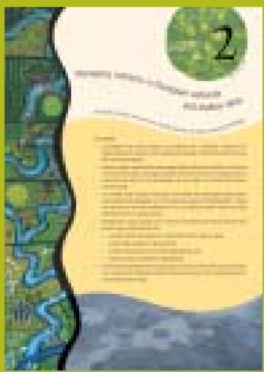


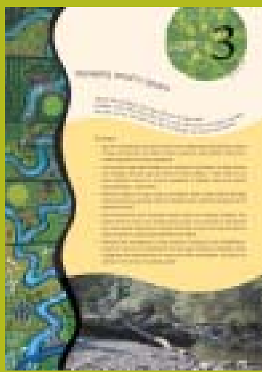
All editions of *RipRap* are available at **www.rivers.gov.au**

Technical guidelines

These guidelines are aimed at a more technical audience and provide detailed information about the science underpinning recommended best practice in river and riparian management. They have become central reference documents for most catchment management organisations in Australia, as well as providing the most up to date river and riparian science for researchers working in the area. There are now seven titles in the *River and Riparian Management Technical Guideline (Update)* series, with a new book *Principles for Riparian Lands Management* being released in 2007 that has all the research findings from the 13 years of research undertaken through the National Riparian Lands R&D Program.

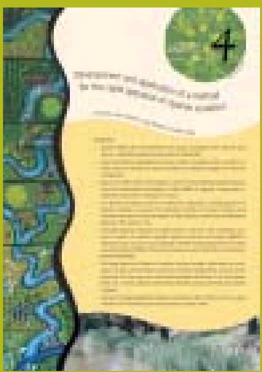


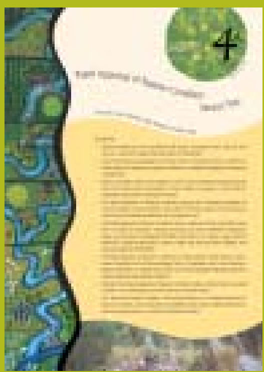


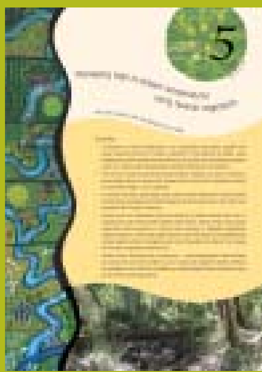


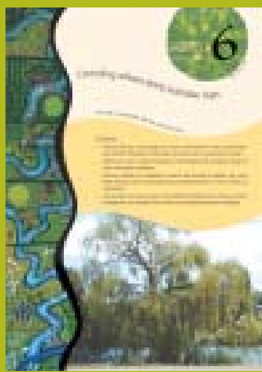
1 Designing filter strips to trap sediment and attached nutrient
2 Managing nutrients in floodplain wetlands and shallow lakes
3 Managing wood in streams
4 Development and application of a method for the rapid appraisal of riparian condition
4A Rapid Appraisal of Riparian Condition, Version 2
5 Managing high in-stream temperatures using riparian vegetation
6 Controlling willows along Australian rivers
7 Tropical Rapid Appraisal of Riparian Condition, Version 1 (for use in tropical savannas)

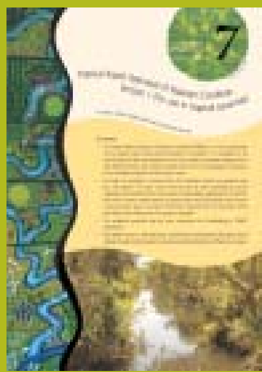
All technical guidelines are available at the website **www.rivers.gov.au**





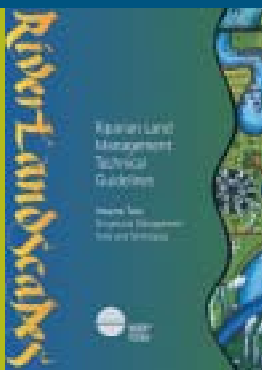






At the end of Phase 1 of the National Riparian Lands R&D Program we produced the two-volume *Riparian Land Management Technical Guidelines*. These became an important scientific reference document for anyone involved in riparian management. We have now updated these Guidelines and the forthcoming 'Principles for Riparian Lands Management' covers the main findings over the life of the Program. The authors of the chapters are those researchers that have been funded through the Program and include:

- Professor Stuart Bunn, Professor Peter M. Davies, Professor Ian Rutherfurd, Dr Andrew Brooks, Dr John Dowe, Dr Amy Jansen, Dr Siwan Lovett, Dr Phil Price and more!



This new book will be launched at the 'No frills free national riparian R&D workshop' on 14 February (see page 5).

Management issue 1: Understanding our river landscapes — training and education

By Siwan Lovett

Siwan Lovett is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

One of the aims of the National Riparian Lands R&D Program has been to develop products, underpinned by science, that can be passed on to others by facilitators, extension officers and those working directly with landholders. Providing materials for training and education has, therefore, been an important part of the Program's communication strategy. We now have a large number of educational institutions at university, technical college and high school levels using our products in their curricula, with much of this interaction via the www.rivers.gov.au website. The website is an excellent resource as it now provides a number of products that are free and able to be downloaded for use in presentations and other activities where the key findings and messages about river and riparian management can be communicated to others.

Understanding our river landscapes

This interactive educational tool is a part of the www.rivers.gov.au website and has been developed to help people learn about the way river and riparian areas function, as well as investigating the different values rivers hold for the people that live along them. It can be found under the 'tools and techniques' home page menu item. 'Understanding our river landscapes' brings together scientific and social information to enable you to explore different river types and river values across Australia. In the past, we have tended to conduct research by investigating individual aspects of river and riparian functioning, this is because it is the most effective way of finding out how these processes work. However, we need to be able to draw this information together so that we can start to understand the different interactions and processes that occur to make our rivers and riparian areas such special places to be.

To get started jump on to the website **www.rivers.gov.au**, select 'Tools and techniques' and click on 'Understanding river landscapes'. Once there you have a choice of two entry points to start your exploration — they are **river values** and **river types**. In river values you can see the range of ways people value their rivers. These then lead you to **riparian management aims** that are aimed at protecting one or more of these values. By taking this approach you are also linked to the **processes**, such as shading, erosion control and buffering, that are being affected by management actions.

If you start from **river types**, you begin with the **processes** that are most significant in each type of river (lowland floodplain, forested headwater stream etc.). From there you can explore the various **riparian management aims** (benefits) that each process provides. This approach keeps management activities and riparian processes at the centre of the material, before linking you to the **values** that people place upon these parts of the landscape.

Interactive catchment diagrams provide you with a fun way of moving through this material, in your own time. We also have a resources section that has all the diagrams and photos available for you to use in PowerPoint and other presentations.

River restoration and management course

Land & Water Australia have worked with Riverina TAFE to put together an introductory course that enables individuals or groups to take a self-paced learning tour through river restoration and management in Australia. The course is available at www.rivers.gov.au under 'training and education'. There are 16 PowerPoint sessions covering a range of topics relating to river restoration and management, including, why riparian areas are important, the impact of stock in waterways, channel morphology, and many many more. All the PowerPoint sessions can be downloaded on to your computer so that you can go through the course yourself, or facilitate a group to think through the range of issues that characterise river restoration and management in Australia. Notes are provided with the PowerPoint presentations, as well as links to other publications and supporting materials. The course is free and we encourage you to modify it to suit your situation.

www.**rivers**.gov.au

www.**rivers**.gov.au

Rehabilitating Australian Streams CD-ROM

This CD-ROM is an interactive version of *A Rehabilitation Manual for Australian Streams* by Ian Rutherfurd, Kathryn Jerie and Nicholas Marsh. It has been developed to assist anyone involved in stream rehabilitation and, whilst it does not cover every aspect of stream management, it does provide a dynamic and innovative way of working through the planning, implementation and evaluation processes that are important to follow when undertaking stream rehabilitation.

NEW National Riparian Lands R&D Program Legacy CD-ROM

The Legacy CD-ROM brings together all of the research, publications, tools and key scientific references from 13 years of work on the National Riparian Lands Research and Development Program onto one handy, easy to access product. The material is organised against eight management issues for those users that want to understand a particular riparian issue and how the science that has been undertaken supports the recommended practical guidelines. For those users that don't want to access the information by management issue, alternatives are provided so that the CD-ROM also works like a website, containing all the information produced by the Program.

Tier 1

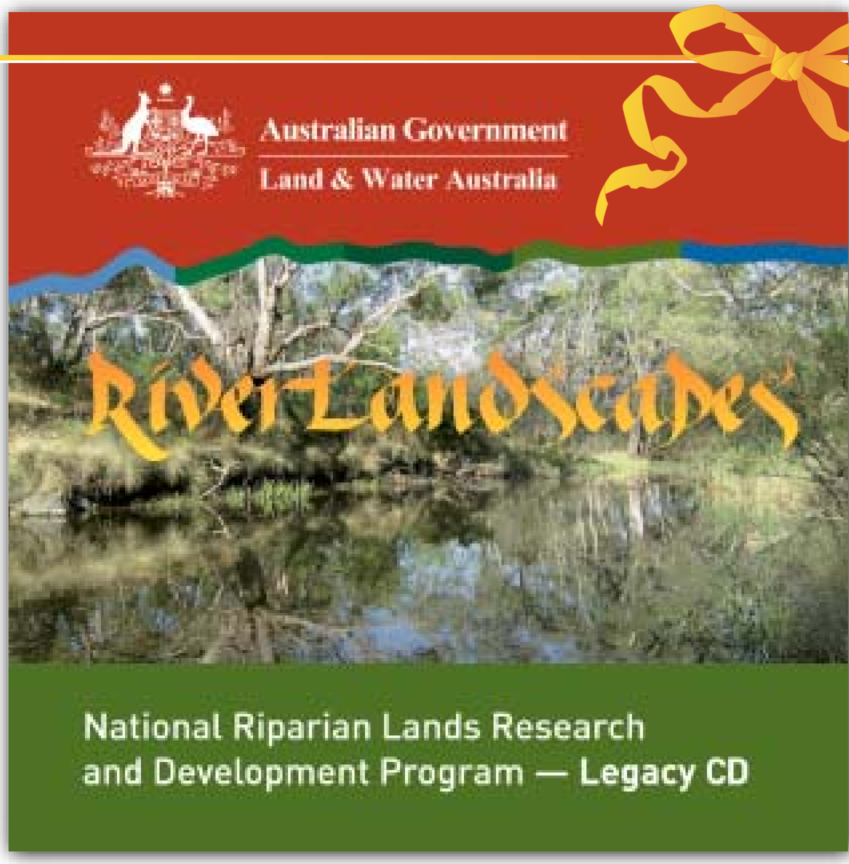
Tier 1 focuses on management issues identified by landholders and catchment management groups as being important. It provides a practical introduction to the topic with a PowerPoint presentation that can be modified and used to present practical management information for landholders to use on-farm.

Tier 2

Tier 2 enables the user to access those publications and tools that provide the scientific data and principles that underpin the recommended management practices for each objective.

Tier 3

Tier 3 takes the user to the relevant scientific papers published in refereed journals and books, providing confidence that the recommended management actions are underpinned by high quality, peer-reviewed science. ■



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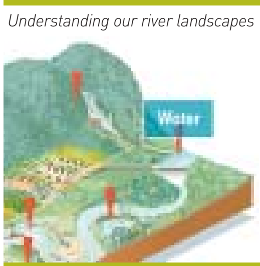
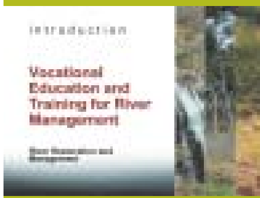
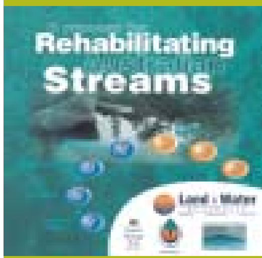
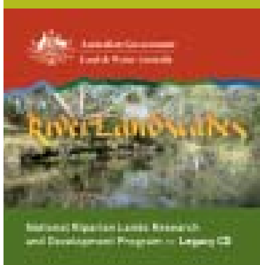
RESOURCES









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Management issue 2: How does riparian vegetation affect floods?

By Phil Price

Work undertaken by Ian Rutherfurd, Brett Anderson and colleagues

The fact that you are reading this article suggests that you are either revegetating riparian zones somewhere, or encouraging others to do so.

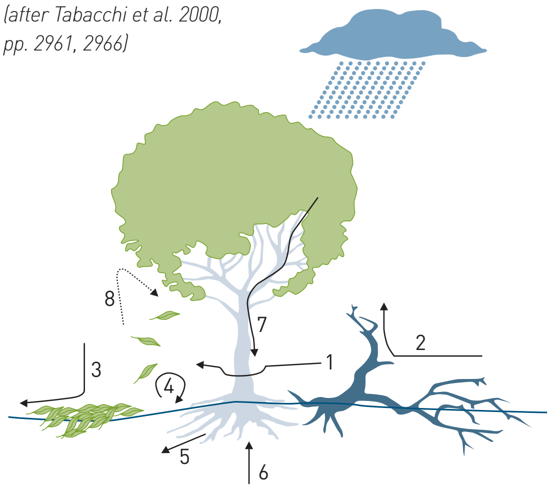
Have you ever paused to consider what the effect of that revegetation will be on flooding? Toiling away on the stream banks, have you ever been taken aside by old-timers who tell you that your revegetation is just going to cause flood trouble? Is this true? You might answer that revegetating smaller headwater riparian zones will 'slow-down' flood waves so that flood heights will be reduced in the lower reaches. Is that true?

The term 'flood' means different things to different people. We are confident that really large floods will not be affected by riparian vegetation because it is drowned out, but riparian vegetation could alter the duration (i.e. length) of 'nuisance' floods that may occur every year or two. The difference between two days or four days under water can make all the difference to, say, sugar cane or pasture.

When you think about it, riparian vegetation affects all aspects of the progress of a drop of water after it has fallen from the sky, until it reaches the sea. It affects the amount of water reaching the stream (hydrology) via physical and physiological processes (Figure 1 and Table 1), as well as affecting the movement of water down the stream and across the floodplain once it is in the stream network (roughness or hydraulic resistance).

Figure 1. Hydrological impacts of riparian vegetation (linked to numbers in Table 1)

(after Tabacchi et al. 2000, pp. 2961, 2966)



a) Physical impacts

b) Physiological processes

Phil Price and Ian Rutherfurd are just two of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

Photo Kerri Woodcock.

Some of the factors that influence the hydraulic resistance of vegetation include:

1. The height of vegetation relative to the depth of flow.
2. Plant characteristics such as stem diameter, leaf size, surface texture and specific gravity, which vary with the age of the plant and often the season.
3. Flexibility of the stems or the whole plant stand (e.g. in the case of a reed bank).
4. Orientation of stems within the plant and their areal density.
5. Degree of stem compaction with increasing flow velocity and the associated change in stand permeability.
6. Distribution of individual plants within a stand, their frequency and dispersion pattern.
7. Orientation of the plant with respect to the local flow direction.

Table 1. Hydrological impacts of vegetation (linked to numbers in Figure 1)

Role of vegetation	Mechanism
Physical impacts (Figure 1a)	
1. Interaction with overbank flow by stems, branches and leaves generating turbulence limiting rilling and rain splash	Quick flow*
2. Flow diversion by log jams	Quick flow*
3. Change in the infiltration rate of flood waters and rainfall by litter	Infiltration
4. Increase in turbulence as a consequence of root exposure	Quick flow*
5. Increase of substrate macroporosity by roots which prevents slaking	Infiltration
6. Increase of the capillary fringe by fine roots	Infiltration
7. Stemflow — the concentration of rainfall by leaves, branches and stems	Interception
8. Condensation of atmospheric water and interception of dew by leaves	Interception
Physiological processes (Figure 1b)	
1. Hydraulic lift, uptake of water from deep soil layers	Soil moisture
2. Hydraulic redistribution, lateral water flow to support root growth in dry soil zones which also limits soil moisture fluctuations, reducing desiccation	Soil moisture and Infiltration
3. Water storage in large roots	(Storage)
4. Water storage in the stem	(Storage)
5. Water storage in branches and leaves	(Storage)
6. Evapotranspiration	Soil moisture

** These processes also have significant hydraulic implications.*

The major effect of removing riparian vegetation and wood from streams has probably been the changes in channel form that have resulted (widening and deepening), and we need to remember that we are returning vegetation to a channel system that now has a much larger flow capacity. All of the hydraulic effects listed above are often lumped as 'roughness'. The major effect of returning vegetation to streams will be via its influence on roughness and flow resistance. We found that the hydrological effects of riparian vegetation on floods decrease downstream, whilst the roughness effects increase.

The work we completed on 'roughness' and on the effect of riparian vegetation on flooding has been brought together to produce a model that represents these vegetation characteristics in a hydraulic system (ROVER: **R**esistance **o**f **ve**getation in **r**ivers). The model incorporates a rainfall-runoff component to account for getting water off the catchment and into the stream network, coupled with a hydraulic model that routes water through the stream network and its floodplains.

Plants act to slow water down (and so back the flood up). The published literature contains many models that seek to predict how much a given plant, or community of plants will slow water down. For stiff vegetation, such as trees and large woody debris, the changes to the flow are relatively simple and can be predicted with reasonable confidence (Lopez & Garcia 2001, Shields & Gippel 1995). However, introduce either flexibility (saplings and pliant grasses) or architectural complexity (e.g. the porous branch-leaf complex of your typical blackberry bush) into the equation, and prediction becomes much more difficult.

Essentially, flow resistance due to vegetation is a three dimensional phenomenon, caused by changes to the turbulence structure of the flow. Our aim was to reduce three dimensional behaviour into a one dimensional framework by averaging flow quantities in time and space (Lopez & Garcia 2001). This allowed us to predict the form of hydrographs anywhere in the stream network, with and without riparian vegetation. From the hydrographs we estimated the height (stage) and duration of floods. It is important to be aware that there is plenty of uncertainty in all aspects of hydrological and hydraulic modelling at this scale, but we can now estimate the general effects of vegetation on flooding with some confidence. Our findings from this work can be summarised as:

Contrasting sites in terms of vegetation roughness and hydraulic resistance. Photos (left) Roger Charlton, (right) Ian Rutherfurd.

The major effect of returning vegetation to streams will be via its influence on roughness and flow resistance. We found that the hydrological effects of riparian vegetation on floods decrease downstream, whilst the roughness effects increase.

- Revegetating riparian zones, or adding large wood to stream channels, will increase the stage of floods at a cross-section and reach scale, although in many cases the effects are likely to be small. The effect will be greatest where the vegetation is planted across the full width of a floodplain. The effect of increasing flood level at one site is to hold back the flood-waters so that the downstream flood stage will be lower (thus we need to see these two opposing effects as occurring at a local, and at a network, scale). (See Figure 2.)
- Adding or removing large wood (snags) in streams has a very little effect on floods above bankfull capacity.
- At a cross-section scale, if vegetation does not block more than 10% of the cross-sectional area, it will probably have little effect on stage (this is why vegetation has more effect on small streams than large ones). If the stream has a width/depth ratio greater than 17, vegetation is unlikely to have any affect on flooding because the cross-section is too wide and shallow. Vegetation in the bed has more influence on flow than does vegetation on the top of the bank, and if the vegetation lies down during a flood, then it probably has little effect on the flood stage.
- At catchment scale, the cumulative effect of riparian revegetation is to increase flood stage

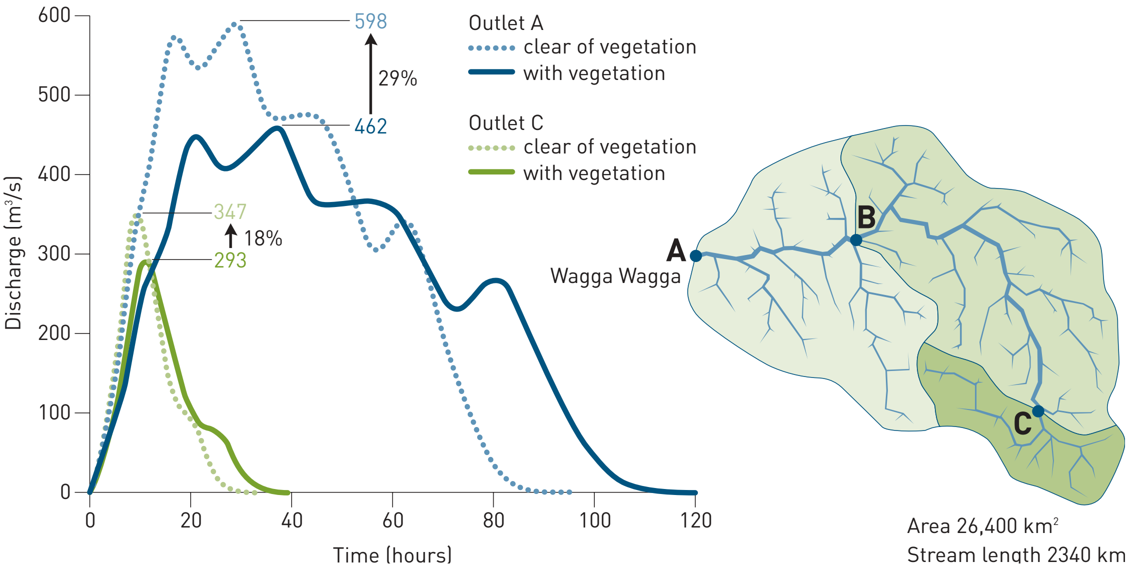


***Figure 2**. Effect of revegetation on discharge at two stations (upstream and downstream) of the Murrumbidgee, for two recurrence interval flows. The lumpy character of the hydrograph is a product of different tributary inputs (modelled for 20 mm rainfall for one hour duration).*

and duration in headwater streams (where flooding is usually not a problem anyway), and in larger streams to decrease flood stage further downstream, where flooding has in the past often been a major problem.

- Although the effect of riparian vegetation on flooding is modest in comparison to the effects of dams and regulation, it should be considered in planning major revegetation works. The effect is largely positive for downstream areas, where riparian vegetation will reduce the depth of flooding. The decreased flow depth comes at the cost of slightly longer flood durations at these lower depths.
- Riparian revegetation should be seen as a catchment scale tool that can have a beneficial effect on flooding in lowland areas. Whilst flow regulation and landuse change affect the amount of water available in floods (magnitude and frequency), riparian vegetation affects the velocity of the flood wave delivered to the stream. All of these interacting aspects need to be considered together.

For more details on this work refer to Chapter 5 in the forthcoming *Principles for Riparian Lands Management* publication. There are also some look-up tables for stream roughness coefficients available on the www.rivers.gov.au website. ■

Selected references

Lopez, F. & Garcia, M.H. 2001, 'Mean flow and turbulence structure of open-channel flow through non-emergent vegetation', *Journal of Hydraulic Engineering-ASCE*, vol. 127, no. 5, pp. 392–402.

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For further information

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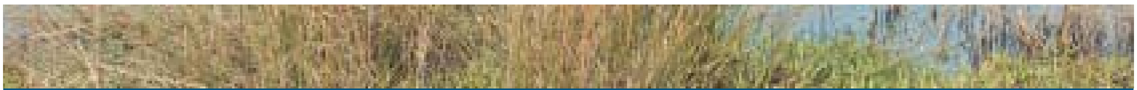

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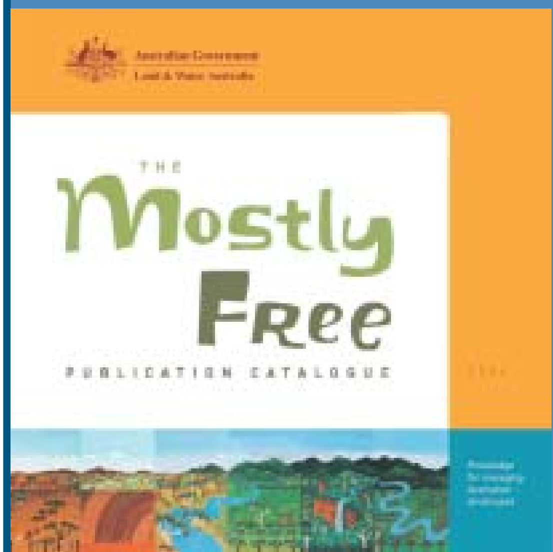

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14 February 2007, Melbourne

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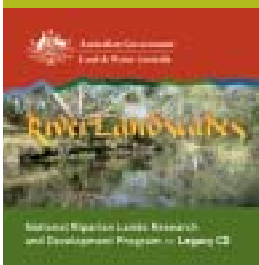

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Management issue 3: Stabilising streambanks and trapping contaminants

By Phil Price

Work undertaken by Ian Rutherfurd, Ian Prosser and colleagues

Phil Price and Ian Rutherfurd are just two of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

In Phase 1 of the National Riparian Lands R&D Program we examined the ability of riparian vegetation of different types to trap sediment, nutrients and other contaminants moving toward a stream from upslope. This work culminated in the *River and Riparian Lands Management Technical Guideline, no. 1*, 'Designing filter strips to trap sediment and attached nutrient'. Riparian filter strips, especially grass pasture, can be very effective in trapping and retaining solids. The Guideline explains the processes involved and the principles of calculating the width of filter strip required for a particular situation.

We are also interested in how riparian management influences the different types and processes of stream erosion. Erosion is a natural and essential process of rivers that has been accelerated by human impacts, often to unacceptable levels. Riparian and in-channel vegetation can reduce rates of erosion, but it is unrealistic to expect revegetation to eliminate all erosion. Maintaining or replanting native riparian vegetation is a core part of most stream restoration projects, and this includes vegetation growing on the bank face, along its top, and in the channel.

Planting trees and shrubs along streams will probably reduce erosion rates, but it is no longer good enough to do this in an untargeted way. Australian stream managers are now embarking on multi-million dollar programs to revegetate riparian zones across whole catchments, and riparian revegetation is now being targeted at specific management goals such as catchment scale control of, and targets for, turbidity and nutrients. The key message from a decade of research into riparian vegetation and erosion is that all riparian vegetation is not equal in its effects, and we need to become much better at predicting the likely effects of revegetation. This will enable river managers to plant vegetation where it will have the most effect on a specific process, and to plant the right sort of vegetation in the right amounts (e.g. densities) to achieve the required objectives.

The three key processes leading to erosion of streambanks are sub-aerial erosion, fluvial scour and mass failure. They often operate in combination (e.g. scour removes the bank soil loosened by sub-aerial processes), but their relative importance also varies within and across catchments. Sub-aerial erosion is more important in streams with catchment areas below 100 km^2. Fluvial scour dominates in catchments of 10 to 1000 km^2. Mass failure becomes the dominant process in streams with catchment areas over 1000 km^2.

The rate of bank erosion usually increases as you move down a river system, and the dominant mechanisms shift from sub-aerial processes in small upland streams to fluvial scour and mass failure in the mid and lower reaches. A detailed study of the Kiewa River in Victoria showed that erosion rates are about one tenth of the global averages for a stream with its catchment area, ranging from 50 to 200 mm of bank retreat per year. There is also a strong positive relationship between the size of the stream and erosion rates. Mass failure was the dominant erosion mechanism in the catchment as a whole, accounting for two thirds of all erosion in the period of our measurements:

The key message from a decade of research into riparian vegetation and erosion is that all riparian vegetation is not equal in its effects, and we need to become much better at predicting the likely effects of revegetation.

Photo Ian Rutherfurd.

Photo John Dowe.

- Mass failure = 63% (*0.051 t/m²/a*)
- Fluvial scour = 27% (*0.022 t/m²/a*)
- Sub-aerial erosion = 10% (*0.008 t/m²/a*)

One of the most interesting aspects of the Kiewa work was how deceptive a visual assessment of erosion can be. We would visit the sites and conclude from visual inspection that nothing had changed, only to find from the measurements that there had been dramatic erosion. Overall, a visual assessment at an erosion site seems to be a poor basis for deciding on the dominant erosion mechanism, an important finding for river managers.

What effects do plant roots have?

We cannot predict the effect of roots on bank erosion processes unless we can predict the character of roots in the riparian zone, particularly on the bank face. The general conclusions from the literature and our own work are:

- Riparian vegetation and associated roots have a positive effect on stream bank stability with regards to mass failure. This is through increasing bank cohesion and associated shear strength. While the tensile strength of roots is important, another factor which will also control bank stability is the shear resistance between the roots and the soil, which may vary significantly between species. As a result of their size, large riparian trees place a surcharge on the channel bank. However, the negative effect of the surcharge is very small when compared to the additional cohesion supplied by the trees on the form of roots.
- The root properties of trees scale with age. That is, older, larger trees can be considered as simply larger models of younger, smaller trees. There is not some special change that takes place in their root plate, or similar, as they age.
- Vegetation and associated roots have different structures and architecture in different climatic zones. We have examined date from tropical, temperate and arid sites. The general trend for the architecture of roots is one of increasing root distribution and biomass as percentage of the entire tree with increasing aridity. This will mean that arid species have the greatest positive individual impact on bank stability, and tropical species the least. However, this may not be true for an entire ecosystem due to overall vegetation density. As well, with tropical vegetation the maximum root depth may not be controlled by the groundwater level, as the trees may receive all the moisture they need from their surface roots so there is no need for deep structural tap roots. This may mean that some tropical vegetation does not have a significant impact on the mass failure of stream banks.
- Roots behave differently when in competition with other species. It is generally accepted that the greater the root density, the greater the improvement in stream bank stability. Total root biomass for fine roots is significantly higher when tree species are in competition with each other. This is a strong point in favour of multi-species revegetation rather than mono-species revegetation as it will,

through competition, more rapidly increase the root density on the stream bank and, therefore, the stream bank's stability.

- Root density and architecture is influenced by soil properties, and this is particularly true for fine roots. Root density is also significantly affected by the maturity of the vegetation with total biomass, even after decades of regrowth being only ~50% of that of mature vegetation. There is currently no data to show whether soil strength continues to increase with total root biomass or if it stabilises once the vegetation reaches a certain size and maturity.
- Maximum rooting depth is no deeper than the local groundwater level. This may cause stability problems for riparian vegetation planted on the banks of streams with artificially high base flows or weir pools. Riparian vegetation on natural or unregulated streams is likely to have a greater impact on reducing mass failure than that on regulated systems.
- Vegetation and roots adapt to local site conditions such as fire and hydraulic controls on the base flow of streams. At sites that get burnt frequently, riparian vegetation tends to place a greater percentage of total biomass underground where it is partially protected.

Our studies of tree abutments show that:

- Single trees will not alter the long term erosion rates of stream banks.
- Tree roots increase the resistance of gravels to erosion; trees begin to alter erosion rates when the stream bank cuts to within half of the canopy radius, or about 4–5 times the trunk diameter at breast height.
- Trees need to be planted close enough together to ensure that individuals cannot be isolated by erosion (that is, their root plates should overlap).
- Reinforcing stream banks with trees will probably lead to an increase in stream depth at the bank face.

When we studied roots in different types of bank soils, we anticipated that more roots would mean more resistance to erosion (i.e. greater critical shear required to erode). Our results showed the opposite: the more roots, the lower the critical shear required to erode the sediment. The explanation for this result is that the sediment controls the erosion rate, but it also controls the volume of roots. In the past, researchers have always treated the roots as being independent of the

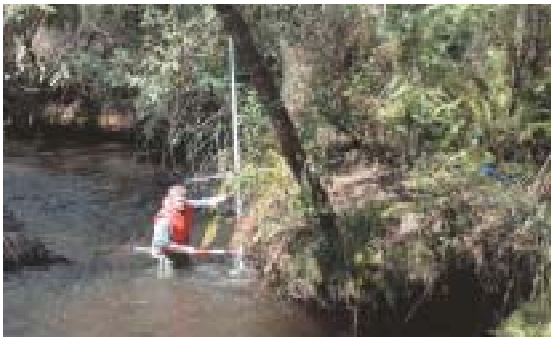
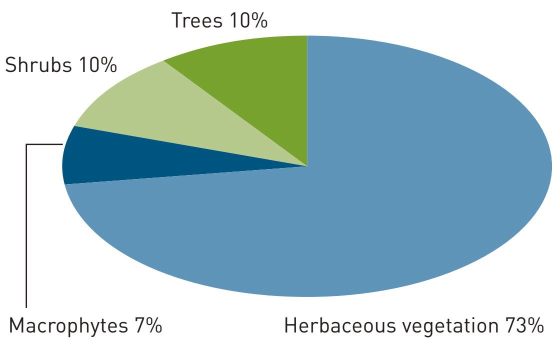


Photo Ian Rutherfurd.

sediment type. However, trees need more roots in well drained sandy soils (which hold little moisture), and less roots in heavy clays (which do hold moisture). We concluded that the character of the clay controls the erosion rate, and also controls the root content of the bank. The effect of the roots is a second order influence on bank erosion rates.

Grass in streams

Most of the discussion about riparian vegetation deals with woody plants. This ignores the fact that the most common vegetation type in streams is almost certainly grass. This point is demonstrated by analysis of over 6000 photographs of Victorian rivers taken for the Index of Stream Condition assessments by the Department of Sustainability and Environment. From an analysis of these photographs we concluded that 20% of streams have horizontal surfaces of some type in the bed of the channel, and of those surfaces, three-quarters were covered with pasture grass. We then explored whether these grass surfaces would survive the shear stresses experienced when the stream was in flood. This is an important question for gully management; for example, if grass can be established in the bed of a gully, will it stabilise it? How will grazing alter the resistance of grass in streams?



Occurrence frequency of vegetation types on vegetated horizontal surfaces in Victorian streams (percentages refer to the percentage of vegetated horizontal surfaces with each type of vegetation).

Grassed benches. Photo Guy Roth.

Revegetation to control erosion. Photo Greening Australia.

The implications of this research are that grass is tremendously effective at stabilising stream beds if it is able to grow to maturity, and particularly if it is not grazed.

The results were very clear: mature grass growing in the bed of a Victorian stream is able to easily resist the shear stresses likely to occur. Although grass grown in sandy and gravel is less resistant than grass grown in silt/clay, neither will erode in Victorian streams. The reason that the grass is so tough, is that it lies down and physically protects the surface. Young (sub-mature) grass is much less robust than mature grass. It will erode in the larger, longer flows experienced in Victorian streams, particularly if the grass is growing in sand or gravel. However, the grazing of grass makes it very susceptible to erosion at natural shear stresses and durations. Grazed grass is more easily eroded than young grass, because grazing animals nip of the long, flat blade. It is this blade that protects the surface when it lies down. The implications of this research are that grass is tremendously effective at stabilising stream beds if it is able to grow to maturity, and particularly if it is not grazed.

We have also studied the effects of removal and replanting of riparian vegetation on channel width and shape, and associated processes such as mobilisation of entrained sediment, and related the results to other models of where to place vegetation in a catchment to have the greatest impact on sediments and nutrient loads. You will have to read the full story in the forthcoming *Principles for Riparian Lands Management* publication featured on the panel at right.

To summarise our research in the second phase of the Riparian Lands R&D Program, many of the conclusions can be remembered in an acronym: the phrase "Please Think" — PLS-T:

1. **P**ROCESS — Managers will be most effective in targeting riparian revegetation if they first understand the erosion mechanisms that are acting in a particular stream or river reach.
2. **L**EVERAGE — Once we understand the erosion mechanism, then we can understand the influence (the leverage) that specific revegetation or other riparian management will have on that mechanism.
3. **S**CALE — Size is everything! Where you are in a catchment influences both the erosion processes that operate, and the leverage that riparian vegetation has over those mechanisms.
4. **T**IME — the interaction between the vegetation and the erosion mechanisms will change with time as the vegetation grows, and as it alters other aspects of the system. ■

For further information

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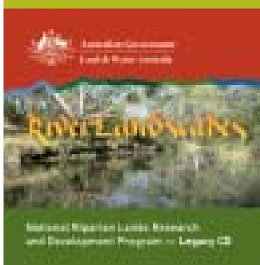

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A little more **history**

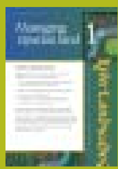
River Landscapes poster

When I first began working at Land & Water Australia I wanted to create an image that would evoke emotion and attract people to the work of the National Riparian Lands R&D Program. By working with the artist Annie Franklin, Hilary Huggan and Allison Mortlock we were able to create the River Landscape poster. This image has served us well over the past few years, it shows Australia criss-crossed by different rivers and travelling through different landscapes. Importantly, people are shown in the rivers as they meander past our major cities. It is an evocative image and one that has become well loved by people working in river and riparian management.

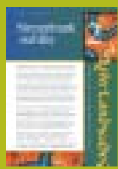
Fact sheets

These *Fact sheets* cover 13 river and riparian management issues in easy to understand language and in a user-friendly style. Over the past eight years they have been updated and new titles added. Due to their popularity, we have reprinted them four times. They can be used to introduce groups and landholders to management issues in a non-threatening and conversational style, and are ideal for use at Landcare and other meetings where people are interested in river and riparian management but not sure how to get started.

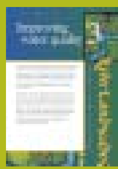
Fact sheet 1



Fact sheet 2



Fact sheet 3



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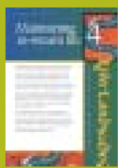

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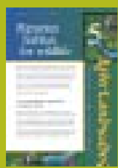

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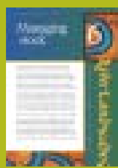

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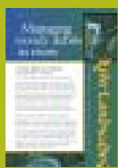

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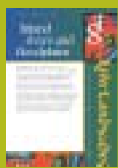

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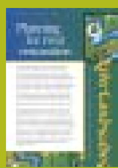
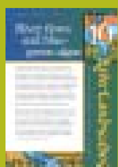
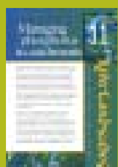


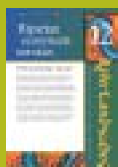
Fact sheet 10



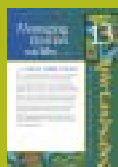
Fact sheet 11



Fact sheet 12



Fact sheet 13



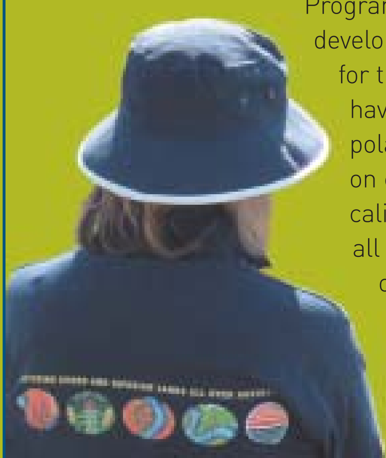
The issues covered are:

1 Managing riparian land
2 Streambank stability
3 Improving water quality
4 Maintaining in-stream life
5 Riparian habitat for wildlife
6 Managing stock
7 Managing woody debris in rivers
8 Internal rivers and floodplains
9 Planning for river restoration
10 River flows and blue-green algae
11 Managing phosphorus in catchments
12 Riparian ecosystem services
13 Managing riparian widths

All fact sheets are available from **www.rivers.gov.au**

Promotional items

Over the 13 years of the National Riparian Lands R&D Program we also had some fun developing some promotional items for the Program. Our polo shirts have travelled far and wide. Our polar-fleece vests kept us warm on chillier days. Our fabulous calico shopping bags carried all the groceries, and on formal occasions the men had the opportunity to get spruced up and wear a tie that used Annie Franklin's fabulous River Landscapes image.



One of two designs that are now collector's items.

Management issue 4: Shade, temperature and river models

By Phil Price

Work undertaken by Peter M. Davies, Stuart Bunn and colleagues

Riparian areas and their associated streams and rivers are considered to be the *ecological arteries* of the Australian landscape. It is now widely acknowledged that the health of our waterways is directly linked to the condition of their riparian zones. Although many of the important ecological roles of riparian zones are well recognised, there is a need for additional scientific information to underpin sound management. In Phase 2 of the National Riparian Lands Program, we investigated several important ecological knowledge gaps.

Riparian shade and stream temperature regimes

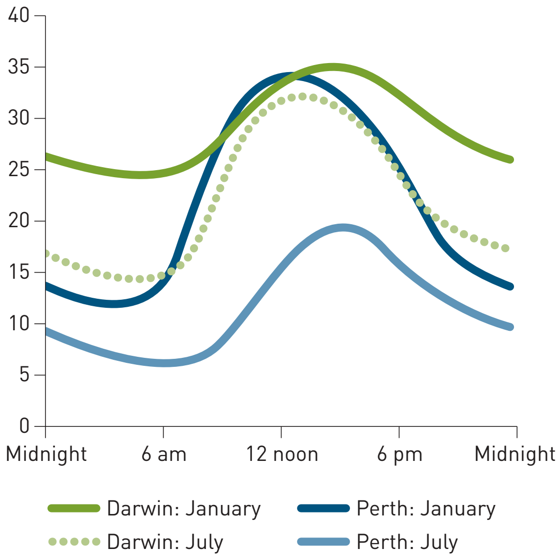
Riparian vegetation shades channels and consequently reduces in-stream water temperatures. Temperature controls many ecological processes and can directly affect biodiversity by exceeding upper lethal limits of resident aquatic fauna, or indirectly by both increasing oxygen demand and decreasing oxygen saturation.

In this work, the use of LT_{50} (lethal temperature) tests conducted over 96 hours indicated thresholds of about 21°C and 29°C for mayflies, the most sensitive macroinvertebrates occurring in "cool" and "hot" climates, respectively. The 21°C and 29°C thresholds refer to exposure times of 96 hours. Sub-lethal effects would be observed at lower temperatures or lesser exposures. To account for sub-lethal effects, it was desirable to include a safety buffer in either the temperature threshold or the exposure time. The approach adopted was to define eight hours as the daily "window" of time beyond which temperatures in excess of the threshold were regarded as intolerable.

High water temperatures are associated with low oxygen level due to its decreased solubility, as well as increased microbial activity, thereby further reducing the amount of oxygen available. Add to this the huge nighttime oxygen demands of aquatic plants that grow well in the absence of shade, and it is easy to see that elevated temperature can lead to anoxia and death of aquatic fauna.

High stream temperature is an environmental stressor that is variable in space and time. The differences between Australian bioregions and catchments are largely a function of the seasonal effects of air temperature and rainfall. Summer stress will be more exaggerated where high air temperatures co-occur with periods of low river flow, as is the case in bioregions with a Mediterranean climate. In contrast, in the tropics, where high flows typically occur in summer, in-stream temperatures will exhibit considerably less diurnal variation.

Although a range of factors affect in-stream temperature, the predisposition of a stream reach to thermal stress is essentially related to the surface area: volume ratio of the water it carries. Smaller streams cool and heat quicker than larger streams because a greater proportion of their water volume is exposed to weather conditions and any conduction effects of the stream bed substrate. We simulated first-order streams, and assumed that if these shade targets were satisfied, the thresholds for downstream receiving rivers would also be suitable for their fauna.



Biogeographic and seasonal contrasts in diurnal in-stream temperature. The curves are model simulations representing first order streams having zero shade under flow and weather conditions typical of summer and winter in Darwin and Perth. Note that Darwin's summer curve is considerably flatter than Perth's summer curve because of the higher summer flow in the tropics relative to Mediterranean climates.

Phil Price and Peter Davies are just two of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

In the absence of shading, stream organisms are often faced with extremes of both (high) temperature and (low) dissolved oxygen. Photo Ian Prosser.

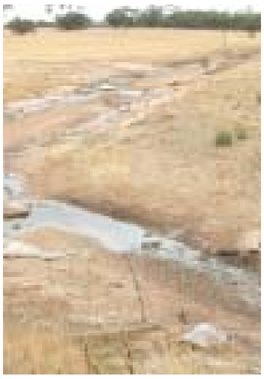
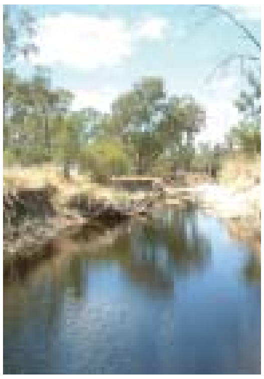
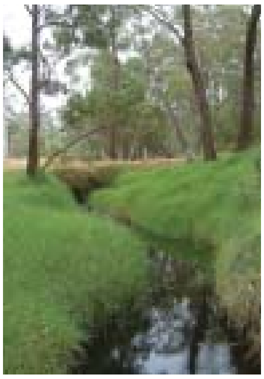
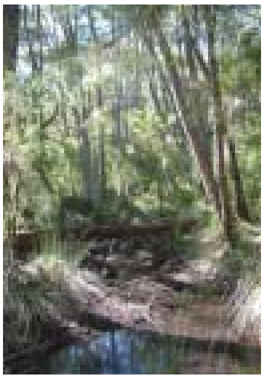
Adapting STREAMLINE for Australian environments

'STREAMLINE' is a predictive model for stream temperature developed by New Zealand's National Institute of Water and Atmospheric Research. The model allows broad description of contrasts in stream temperature regimes between biogeographic regions. Simulation modelling undertaken in this project sought to identify shade targets needed to relieve heat stress to an ecologically tolerable level.

The input variables for the STREAMLINE model relate to weather conditions, flow and channel morphology (form and function). The output of a single simulation run is the diurnal trend in in-stream temperature over 24 hours. Twelve simulations for each of 14 selected Australian locations were run under conditions of zero shade, with each of the 12 simulations representing average monthly flow and weather conditions. We then determined the average daily hours of temperature threshold exceedence that could be expected at each location for a stream having no shade.

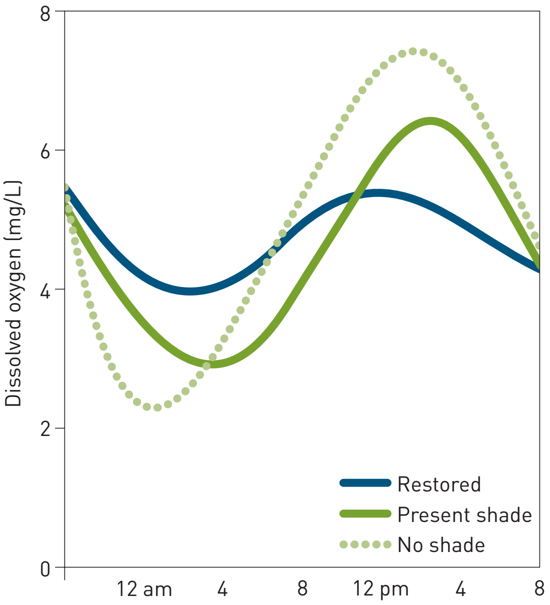
Location	Threshold	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Darwin	29.0°C	10.50	9.75	10.25	9.25	7.50	5.75	6.00	7.00	8.75	9.75	10.25	10.50
Cairns	29.0°C	9.50	9.25	8.25	6.25	5.00	2.25	1.25	3.50	6.25	7.50	8.50	9.00
Broome	29.0°C	11.00	10.75	10.50	8.75	6.50	4.50	4.75	6.25	7.75	9.00	10.00	10.50
Townsville	28.4°C	10.00	9.50	9.00	7.25	5.50	3.25	2.50	4.00	6.50	8.00	9.00	9.75
Rockhampton	26.5°C	10.75	10.25	9.25	7.50	5.75	2.50	3.50	5.00	7.00	8.75	9.50	10.25
Alice Springs	26.3°C	9.50	9.00	6.00	0	0	0	0	0	0	5.00	7.50	9.25
Carnarvon	25.8°C	10.25	10.50	9.00	7.50	5.00	2.00	1.75	4.25	5.50	6.50	7.75	9.50
Forrest	23.0°C	9.75	9.75	8.75	7.50	4.75	0	0	1.50	5.75	7.25	8.75	9.50
Perth	22.5°C	11.00	10.50	9.00	7.50	3.25	0	0	0	4.25	7.50	9.25	11.00
Sydney	21.5°C	11.50	11.50	9.25	6.75	2.00	0	0	0	5.00	7.50	8.75	10.75
Adelaide	21.0°C	10.75	10.50	9.00	6.25	1.00	0	0	0	2.75	7.00	9.50	10.25
Albany	21.0°C	10.00	9.75	8.25	6.25	0	0	0	0	2.50	5.75	7.50	9.50
Melbourne	21.0°C	11.00	10.25	8.50	4.75	0	0	0	0	0.50	6.50	9.00	10.25
Hobart	21.0°C	8.00	7.75	5.50	0	0	0	0	0	0	2.75	5.25	6.75

Average daily hours of threshold exceedence by month and location, under conditions of zero shade. Cells coloured in the darker green represent months and locations where average conditions under zero shade result in intolerable exposure to high in-stream temperatures. Pale green cells indicate where temperatures are high but exposure times are within a tolerable limit. Blue cells show months and locations where high in-stream temperatures are not considered to be ecologically important.


From left to right: Canopy shade = 1%, 18%, 38%, 49%, 80%. Photos Peter Davies.

For each location, simulations were re-run with varying shade levels to work out the shade required to reduce the average daily exposure time to eight hours or less within each month. For example, Broome, Townsville and Melbourne required shade targets of 60, 50 and 55% respectively. Of the 14 locations modelled, the most extreme shade targets were for Sydney (75%) and Hobart (5%). We then examined the lengths of shaded stream that would be required to reduce water temperature by a specified proportion (and, conversely, the impact of cleared reaches), and developed a method to enable catchment groups to determine priority reaches for riparian rehabilitation when the objective is to reduce stream temperature. Both are described in detail in 'Managing high in-stream temperatures using riparian vegetation', *River and Riparian Lands Management Technical Guideline*, *no. 5*.



The effect of riparian clearing on the amplitude of 24 hour dissolved oxygen concentrations.

Testing ecological models of large rivers

Collaborators: Fran Sheldon (Griffith University), **Alistair Robertson** (formerly Charles Sturt University now University of Western Australia)

Our current ability to manage large river systems is hampered by a limited understanding of basic ecological processes. Three contemporary models of large river ecology place different emphasis on the direct role of riparian vegetation. The River Continuum Concept (RCC) emphasises the importance of terrestrial (derived from the land) carbon and nutrients "leaked" from tributary streams to the structure and function of lowland river reaches. In contrast, the Flood-Pulse Concept (FPC) emphasises the importance of lateral (sideways) river-floodplain exchanges and proposes that riverine food webs are more dependent on production derived from the floodplain, rather than from tributaries upstream. The Riverine Productivity Model (RPM) provides an alternative view of ecosystem function in large rivers and highlights the importance of local in-stream production and, to a lesser extent, direct inputs of material from the adjacent riparian zone.

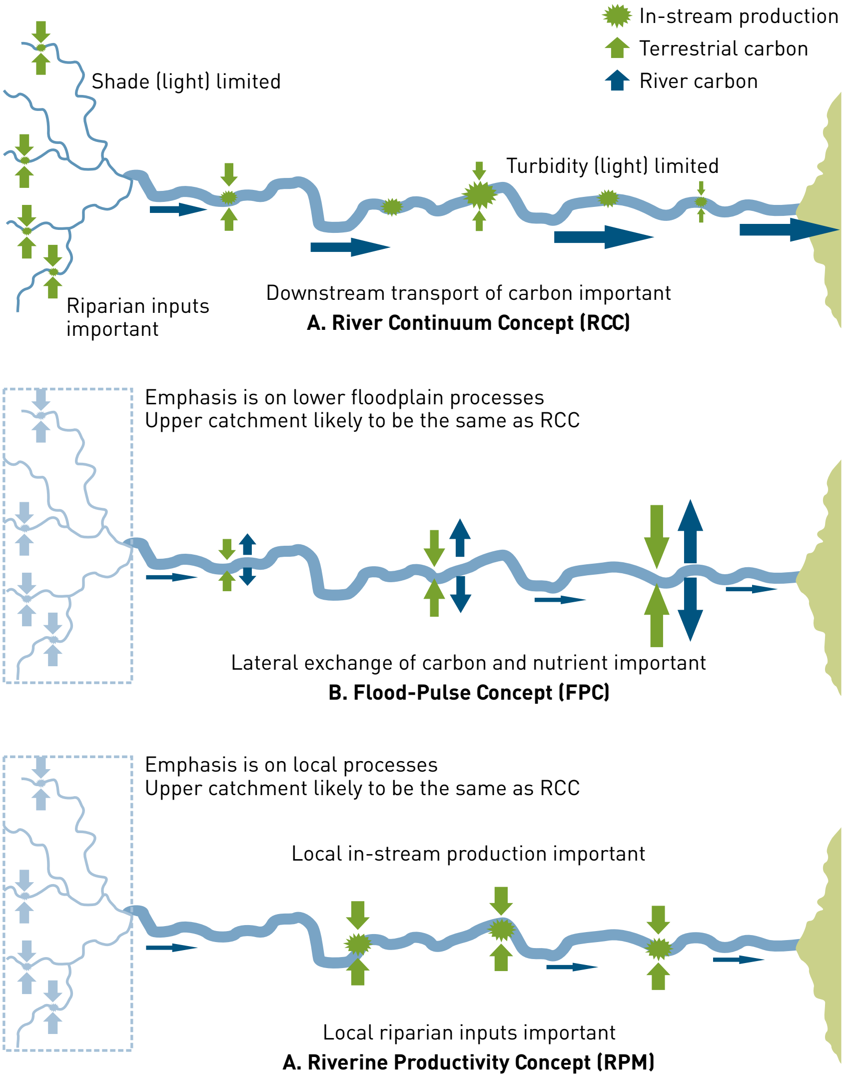
Three contemporary models of large river ecology place different emphasis on the direct importance of riparian vegetation

The applicability of such models to large rivers in Australia is largely untested and has major implications for management (especially of riparian and floodplain regions). We were interested in the degree to which riparian vegetation directly influences ecosystem processes (and overall "health") of large rivers. We examined the influence of riparian shade on littoral (edge of the river) algal production, as well as assessing the importance of the direct inputs of leaf litter and insects from riparian vegetation to the aquatic food web. Replicate sites differing in channel orientation (north–south versus east–west) and riparian cover (shaded versus open) were sampled in the Mary and Brisbane catchments in southeast Queensland.

Can rehabilitation of riparian vegetation have a direct influence on ecosystem processes and the overall health of large open river channels?

Our conclusion from the studies within the National Riparian Lands R&D Program is that in temperate forest streams, coarse-particulate organic matter, fine-particulate organic matter and dissolved organic matter are derived largely from the riparian zone and are important sources of carbon for aquatic food webs. Riparian fruits and arthropods are also an important food source for fish and other vertebrates. In many stream and river systems, the inputs of organic matter from riparian and catchment sources far exceed the amount produced from aquatic plants within the stream channel. This is especially true for small forest systems, but is also the case for many large rivers. Where more organic carbon is consumed and respired (e.g. by animals and bacteria) than is produced by aquatic plants, stream ecosystems are described as heterotrophic — that is, they are dependent on external sources of carbon energy.

Food webs in tropical, subtropical and arid zone streams show a greater dependence on algal carbon as do those in most lowland rivers.



A. River Continuum Concept (RCC)

B. Flood-Pulse Concept (FPC)

A. Riverine Productivity Concept (RPM)

Photo Andrew Brooks.

Macrophytes in larger rivers and wetlands appear to contribute very little directly to aquatic food webs, though they are clearly an important food source for some water-birds. Terrestrial inputs can also be an important contributor to the carbon pool of streams in semi-arid or sparsely wooded catchments. However, the open riparian canopy in these systems diminishes the controlling influence on in-stream primary production (shade) and the relative contributions of in-stream sources of carbon are often greater than in similar-sized streams in forested catchments. Our work on waterholes in turbid, arid rivers highlighted the importance of local sources of primary production during dry spells, supporting the Riverine Productivity Model. However, periodic flood pulses also play a significant role in these systems, although in contrast to the FPC, much of the production during floodplain inundation appears to be driven by aquatic sources.

In summary, the River Continuum Concept seems to be the model most applicable to Australian river systems, especially to the smaller, forested headwaters and some large, lowland rivers. The Riverine Productivity Model may better explain the functioning of some rivers in semi-arid country where riparian cover is sparse. The lower River Murray may well have functioned according to the predictions of the Flood Pulse Concept prior to European settlement, but the extensive reduction in duration and frequency of flood pulses following river regulation has undoubtedly changed this. ■

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Management issue 5: Vegetation, wood and rivers

By Andrew Brooks

Andrew Brooks is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

A retrospective view of achievements and changing perceptions

It was in 1995 that I first began my association with the National Riparian Lands R&D Program, as an enthusiastic young PhD student, setting out to nail one of the hot research questions of the day — quantifying the extent to which we Europeans had an impact on the geomorphology of rivers in south-eastern Australia. It is worth acknowledging, that in 1995 the south-east axis from Brisbane to Melbourne *was Australia* for many of us! Eleven years on such a research question seems almost trite, given that we now know that the impacts have been significant, albeit spatially variable! The fact that this question may seem trite today, is testimony to the success of the National Riparian Lands R&D Program, in not only funding research, but ensuring the outcomes of the research are publicised.

Over the last decade there has been an explosion in our understanding of historical changes to Australian rivers, and more importantly the processes and mechanisms bringing about these changes. The mechanics of geomorphic change to rivers are now parameterised in models such as Sed-Net; and in the south-east at least, we can predict (or retrodict) with reasonable accuracy the magnitude of change to the sediment budget associated with land use change and the associated geomorphic changes to sediment storage. Land & Water Australia's National Riparian Lands R&D Program has unquestionably been a key driver in the research leading to this heightened understanding.

In 1995, one of the central themes in contemporary fluvial geomorphology in Australia was the extent to which our highly variable flow regimes were responsible for the morphology of Australian (read, south-east Australian) rivers. While this was, and remains, an important theme for understanding recent dynamics of channel morphology, at the time it was thought to dominate, and largely explain, the dramatic channel expansion that was common throughout the south-east (and we now know other parts of the country too). What was not fully appreciated, in the scientific literature at least, was the role played by riparian vegetation and its close associate, then known by the decidedly un-politically correct term "large woody debris", as a controlling influence on

Natural log jam.
Photo: Andrew Brooks.

channel geomorphology, sediment transport rates and even long term channel and floodplain evolution, to say nothing of aquatic habitat.

We now appreciate that human development in Australia, and most new world countries, imposes what is effectively a permanent step transformation on system functioning once riparian vegetation and wood are removed from river corridors. At a forum discussion, as part of the recent (October 2006) Binghampton geomorphology symposium focused on human impacts on fluvial systems, (see *Geomorphology*, vol. 79) it was generally accepted by the leading international researchers in the field, that the last decade has seen a paradigm shift in our understanding of some of the fundamental controls on fluvial geomorphology. This change was associated primarily with the mechanics of vegetation and wood as controls on river channel boundary conditions. Research supported and funded through the National Riparian Lands R&D Program, by scientists such as Ian Rutherfurd, Nick Marsh, Chris Gippel, Ian Prosser, Bruce Abernethy, Rebecca Bartley, Tim Cohen, and others have been at the forefront of this paradigm shift.

In 1995, setting out to understand the impacts of land use change on an alluvial river using a paired catchment approach (see Brooks et al. 2003), I expected most of the impact to be associated with riparian vegetation removal. It was to my great surprise that it wasn't just the vegetation on the banks that effectively stabilised the relatively pristine Thurra River, but wood accumulated within the bed was fundamental to the functioning of this system (see Brooks & Brierley 2002, Brooks et al. 2003). In this case, the in-channel wood load had a demonstrably greater effect on bed stability, channel complexity and sediment transport rates than did bank vegetation (Brooks & Brierley 2004). This realisation, and the growing awareness of the habitat implications of wood (see Gregory et al. 2003), provided a natural move to the next phase of research — developing strategies for putting some of the wood back into rivers. On the face of it, this seems like a relatively straight forward and logical step to take, however, for 150 years or more, wood in rivers had been blamed as being the cause of bank erosion, flooding and navigation obstruction, so there were some fairly major institutional resistance to be overcome. Very efficient programs had been set up to remove wood from many rivers since the early days of settlement, and shifting cultural perceptions surrounding the negative perceptions associated with wood in rivers would prove to be just as challenging as some of the technical issues involved.

Constructed logo jam.
Photo: Tim Howell.

Commencing in 1999, we set out to tackle this issue head on, through the establishment of a couple of large field experiments to test the reach scale geomorphic and ecological effects of reintroducing reasonably large volumes (from a practical and logistical point of view) of wood within a sizable reach. Just as important as tackling some of the technical and scientific questions associated with the efficacy of wood reintroduction, was changing cultural perceptions regarding the benefits of even having wood in streams, let alone putting it back in. Addressing the engineering aspects of stabilising wood in streams was central to people's fears of wood in rivers.

To cut a long story short, I don't believe it is crowing too much to say these trials have been a resounding success — or at least the Williams River experimental site has been, given that the sand-bed site on Stockyard Creek has been in the grip of drought since construction in 2002, and has effectively provided no results over the last four years. The Williams River site, which has been in place two years longer, demonstrated very effectively that wood can be reintroduced safely to rivers, and that it can have demonstrable effects on improving channel stability, increasing sediment storage and providing diverse fish

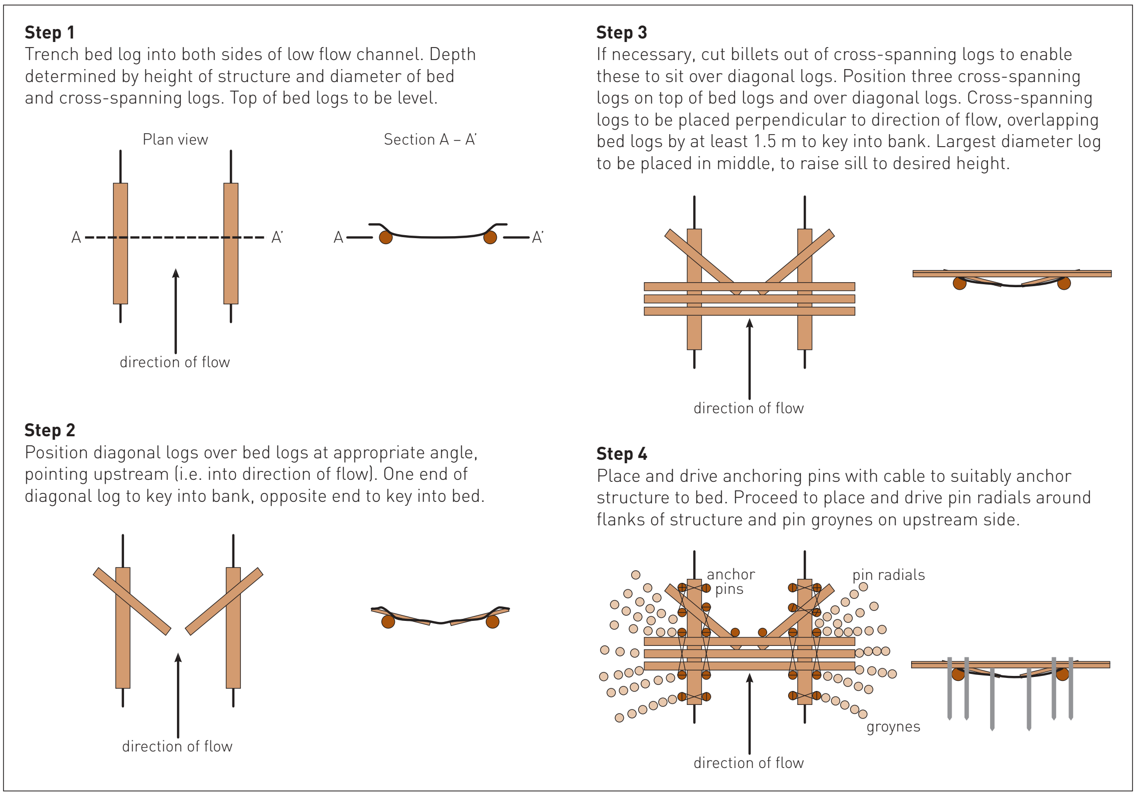

Photo: Dan Keating.
***Diagram**: Generic elevated log sills with log pin abutments structure design and construction notes. Redrawn from original by Tony Broderick and Peter Menzies, NSW Northern Rivers CMA.*

habitat (see Brooks et al. 2001, 2006). Additionally, this project provided a great case study in the benefits of undertaking large scale field trials, and how critical these are for turning around negative community perceptions about an issue. Indeed, the success of these and other trials around the country over the last few years, has in some cases led to a situation where wood is seen as the solution for all the ills of sick rivers. It is certainly not this, but both reintroducing wood and retaining it within rivers, is now an important component of any river manager's bag of tricks.

The project also provides a cautionary tale with regards to our expectations about the benefits of wood, and what can be achieved by community based rehabilitation efforts, given the hysteresis associated with rehabilitating degraded systems. In other words, threshold exceedance associated with riparian disturbance, causes massive changes over relatively short timescales (decades), which can take much longer to turn around (centuries or more). The results from the Williams River study presents huge challenges for managers in terms of managing expectations about timeframes for turning systems around, as well as the resource commitment that will be required. While we did measure some important improvements in system functioning during the five years of the experiment, when placed in the context of the magnitude of change since European settlement, these improvements seem fairly minor.

The outcomes from this research are encapsulated within the new Land & Water Australia publication titled "Design guideline for the reintroduction of wood into Australian streams". This manual also provides some step by step design principles for undertaking similar wood reintroduction strategies in your own rivers.

In a final ironic twist, on the day I am writing this article, the NSW Government has just announced that it plans to build a dam immediately downstream of our experimental reach on the Williams River, which will drown the whole experimental reach! Such are the sacrifices we seem to be paying with our huge thirst for water. ■

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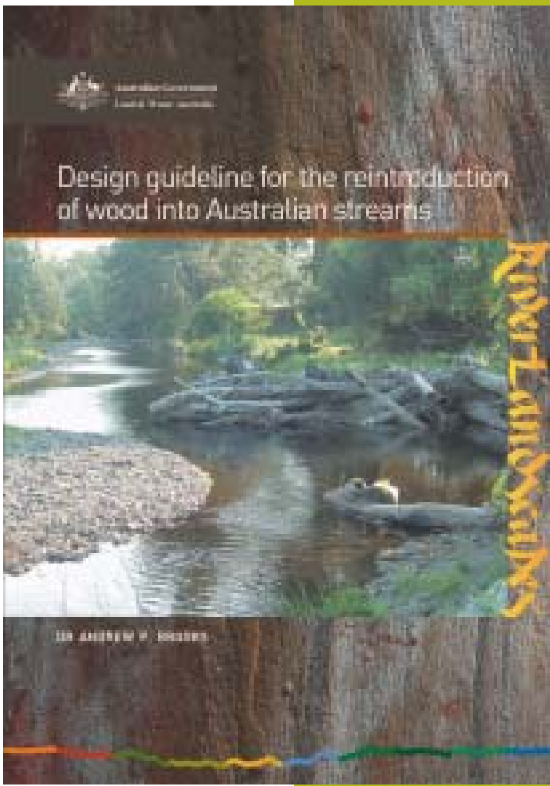
NEW

RESOURCES



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Available from www.**rivers**.gov.au

RAPt in rivers

ON TRACK

On track for better river and coastal management in tropical Australia

Northern Australia's rivers and coasts are set to benefit from a major new research initiative focusing on Tropical Rivers and Coastal Knowledge (TRACK). This follows the announcement by Australian Government Environment Minister Ian Campbell that a multi-million dollar world-class research hub will be established with funding from the Commonwealth Environmental Research Facility (CERF) program.

Led by researchers from Charles Darwin University, Griffith University, the University of Western Australia, CSIRO, the North Australian Indigenous Land and Sea Management Alliance, CRC Tropical Savannas Management and Land & Water Australia, the TRACK research hub was one of three selected from almost 150 proposals. CERF will contribute $8 million, and this has recently been added to with $5 million from the National Water Commission. Land & Water Australia will provide a further $3 million, with substantial in-kind and financial support being received from other partners in the project.

The TRACK research hub intends to increase understanding of the important natural assets and ecosystem services provided by tropical rivers and coasts, assess the social, economic and environmental impacts of proposed developments and identify opportunities to develop genuinely sustainable enterprises in the region. A critical feature of the research will be engagement with Indigenous people, who own and manage large parts of the region's catchments and coasts.

The TRACK research hub will draw on Land & Water Australia's considerable experience and expertise in managing national, integrated, research programs. It will be physically hosted in Darwin at Charles Darwin University.

For further information

- Mr Jim Donaldson (LWA, Canberra), tel: 02 6263 6061
- Dr Michael Douglas (Charles Darwin University, Darwin), tel: 08 89 4667 261

THE BIG PICTURE

The big picture in native vegetation research

Land & Water Australia in partnership with CSIRO recently commenced a third five-year phase of research through the Native Vegetation and Biodiversity R&D Program. This program is investigating the role that healthy ecosystems play in providing us with essential services such as fresh water, controlling salinity and erosion, providing shelter for stock and carbon sequestration. Fifteen research projects have been contracted with details of the Program and related projects available on the Program website. The projects are diverse and will build on our knowledge of landscape design, the role of fire, waterpoint management, the value of regrowth in conserving biodiversity, and understanding genetic flows for maintaining the persistence of local species.

The Native Vegetation and Biodiversity R&D Program Plan can be downloaded from the Program's new website. The website will also include links to partner organisations, details of research projects and publications including online access to the latest edition of the *Thinking Bush* magazine which provides a summary of research results from the second phase of the Program. The website can be accessed at **www.lwa.gov.au/nativevegetation**.

Bore outlet in the Simpson desert. The new Program will concentrate on native vegetation management issues in rangelands including the impact of water points on vegetation condition. Photo Rob Ashdown.

ENVIRONMENTAL FLOWS

Environmental Water Allocation

The project "Using Market-Based Instruments to Secure Water for Environmental Flows", completed in August 2006, examined a number of economic instruments, for acquiring water from irrigators for environmental benefits. These instruments included different types of options over future water allocations as well as outright purchases of water licences. The instruments were tested against environmental water needs for the wetlands at one of the Murray River icon sites — the Gunbower Koondrook-Perricoota Forests. At such sites, where environmental water requirements are peaky, infrequent and large, purchasing licences outright is very expensive. Allowing generous carryover provisions reduces the cost but impacts on carryovers for consumptive water users. Acquiring entitlements on the seasonal water market would require such large purchases that it would drive up water prices. The upshot is that no single instruments would provide the water required for this test site; a portfolio of instruments would work best. Irrigators were generally supportive of governments entering into water markets to acquire environmental water provided there was transparency and accountability.

www.lwa.gov.au/environmentalwater

5th Australian Stream Management Conference

Charles Sturt University Institute for LAND, WATER AND SOCIETY

Australian rivers — Making a difference

22–25 May 2007, Albury, NSW

The 5th Australian Stream Management Conference will focus on how research and practice has made a difference to river management. The aim of the conference is to enable stream management practitioners (landholders, program managers, researchers and educators etc.) to share their experiences, showcase new developments and reflect on lessons learned. The sub-themes are:

1. What is the science underpinning restoration practises?
2. Is new policy evidence based and are new policy initiatives working?
3. What have been the outcomes of restoration investments?
4. Are we really doing adaptive management?
5. How effectively are we building capacity and investment to enable action?

To be held over four days, the conference features 15 keynote speakers, oral and poster presentations, field trips to demonstration sites and a conference dinner at All Saints Winery, Rutherglen.

Registration costs

Early bird	$550 (due by 19 March 2007)
Full conference	$650
One-day rate	$180

For further information and registration visit the website

www.csu.edu.au/research/ilws/news/conference.html

Wonga Wetlands. Photo Greening Australia.

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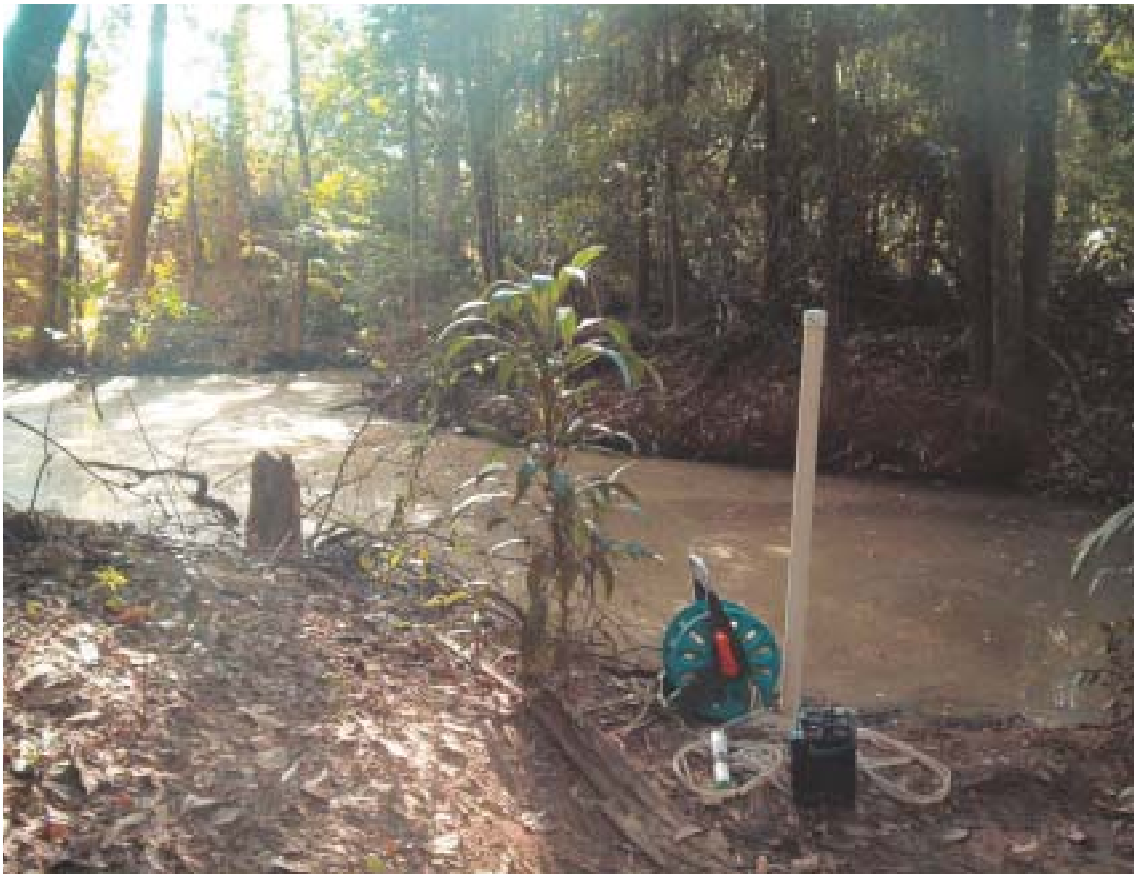
Management issue 6: In-stream and riparian zone nitrogen dynamics

By Christie Fellows

Nitrogen plays a critical role in the functioning of Australian aquatic ecosystems, with excessive inputs typically impairing river and coastal health. Scientists in Europe, North American and New Zealand have explored the nitrogen removal capacity of in-stream environments and riparian zones with the aim of managing diffuse nitrogen inputs. These environments can serve as buffers between land-based activities and downstream ecosystems by removing excess nitrogen. However, little is known about the extent to which this nitrogen-buffering effect occurs in Australia, given the large variation in climatic, geological and surface water-groundwater interactions. This lack of data hampers our ability to successfully manage freshwater resources in Australia, and was a major issue raised at the 2000 Land & Water Australia "Nitrogen workshop".

To address these knowledge gaps, the project "In-stream and riparian zone nitrogen dynamics" was initiated in 2002. The project was a collaborative effort of researchers from Griffith University, Monash University, the University of Western Australia, and Queensland Natural Resources, Mines and Water. The overall aim of the project was to increase our understanding of nitrogen cycling processes in streams and riparian zones to improve water quality and ecosystem health.

The focus of past studies has typically been on either the riparian zone or stream, but not both. This project took a unique perspective in examining both ecosystem components, and doing so in multiple sites across three distinct bio-geographic regions: southeast Queensland (SEQ), southern Victoria (VIC) and south-western Australia (WA). These regions were chosen on the basis of their contrasting climates and soil types, and to build on data from past and ongoing research being conducted in these regions. This article serves to highlight some of the key research findings and outputs of the project.



Groundwater well with sampling pump in the riparian zone of Running Creek, Qld. Photo Carol Conway.

Conceptual models and knowledge gaps

Conceptual models of stream ecosystems were developed to portray the interactions between hydrology, riparian zone vegetation, soil organic carbon and nitrogen cycling processes. Two main research questions were developed based on knowledge gaps identified during conceptual model development:

Firstly, what influences rates of nitrogen cycling processes in streams and their adjacent riparian zones? A particular focus was placed on *denitrification* (see definition in box), as this process is of great interest from a management perspective with respect to the removal of nitrogen from the ecosystem. In addition to nitrate, the microbes that carry out denitrification require a source of organic carbon for energy and a low/no oxygen environment (often present under saturated conditions). As saturated conditions and nitrate concentrations influence the actual denitrification that occurs, the second research question focussed on how do ground water/surface water hydrology and chemistry vary across sites?

Testing the conceptual models — What influences rates of denitrification?

Collecting data

Four to six sites were selected in each region to span a gradient of riparian zone vegetation from sparsely to densely treed. Sub-catchment land use was generally dominated by agriculture, including grazing and horticulture, with some forest and residential areas. Laboratory measurements of soil/sediment denitrification potential were completed for different zones identified in the conceptual models: both within and outside of the riparian zone and in the stream at each site. Surface water and groundwater hydrology and chemistry were obtained from a combination of existing data and sampling conducted as part of the project.

Research findings

Initial conceptual models focused on well-treed riparian zones that were predicted to have soil higher in organic carbon than sites without trees and, therefore, support higher rates of denitrification. However, measurements of denitrification potential for the 16 sites across three regions revealed that background concentrations of nitrate, not organic carbon, explained much of the observed variation in rates of denitrification potential. These results suggest that soil/sediment microbial communities that experience high supplies of nitrate are 'primed' to carry out high rates of denitrification. When nitrate is present and saturated, low oxygen conditions occur. While denitrification potential showed a strong relationship with background soil nitrate concentration, high rates of denitrification can only be maintained over time if sufficient organic carbon is present. Based on the relationships observed, a combination of measuring soluble nitrate and some form of soil organic carbon (either soluble or total % organic C) may be a good rapid assessment tool for estimating denitrification potential for use in catchment scale models.

Within each site, the greatest rates of denitrification were measured in surface soils, followed by in-stream sediments, with the lowest rates in mid and deep soils. Across the three regions, there was a general pattern that VIC denitrification potential rates were greater than those for SEQ, which were in turn greater than WA. High rates in VIC may be associated with high nitrate concentrations and moisture conditions that are favourable for the microbial community, while the very sandy soils of WA may create a less favourable environment in terms of moisture, especially in the dry season. VIC sites have the capability to remove substantial quantities of nitrate due to the high rates measured and the proximity of the groundwater table to the soil surface, compared to deep water tables present in SEQ. While perched groundwater was close to the soil surface in WA, both in-stream and riparian soil denitrification potential rates were low in comparison to the other two regions.

www.rivers.gov.au

Denitrification is the conversion of nitrate to nitrogen-containing gas. It is a biological process carried out by microbes in conditions of low or no oxygen. These microbes require organic carbon as a source of fuel for carrying out denitrification. This process can effectively remove nitrate, as it is converted to a gas that can diffuse out of the ecosystem.

Contributing to catchment water quality models

Rates of denitrification potential were obtained for eight types of soil/sediment at 16 sites across the three regions, providing values that are useful in modelling a wide range of conditions. The riparian soil values obtained have been included as part of a look-up table of rates of denitrification potential for use in the Riparian Nitrogen Model (RNM), both within the catchment-scale water quality model, E2 (www.toolkit.net.au) and as a stand-alone tool. The RNM allows users to estimate the amount of nitrate removed by denitrification in riparian buffers. In addition, the results of this project provide evidence for relationships between denitrification potential and influencing factors that can feed into models of nutrient cycling and water quality at a range of scales. These relationships include decreasing denitrification potential and soil organic carbon concentration with depth and increasing denitrification potential with increasing background nitrate concentrations.

New guidelines for riparian zone management

The findings from this project and two Cooperative Research Centre (CRC)-funded projects (Nitrogen and carbon dynamics in riparian buffer zones and Modelling and managing nitrogen in riparian zones to improve water quality jointly funded by the CRC for Coastal Zone, Estuary and Waterway Management and the CRC for Catchment Hydrology) were used to propose guidelines for the management of riparian lands with a focus on increasing the potential for denitrification and thereby reducing nitrogen loads entering surface water bodies. The two main guidelines are:

1. Maintain and/or increase organic carbon levels in riparian soils; and
2. Identify riparian areas with the greatest potential to support denitrification to target for protection or rehabilitation.

While these guidelines can enhance nitrogen removal by riparian zones, it should be emphasised that overall nutrient management should aim to minimise off-site movement at the source. The guidelines and further information can be found in the following publications. ■

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New riparian management guidelines target sub-surface nitrate — an 8 page booklet summarising the technical report, www.coastal.crc.org.au/pdf/Riparian_Booklet.pdf

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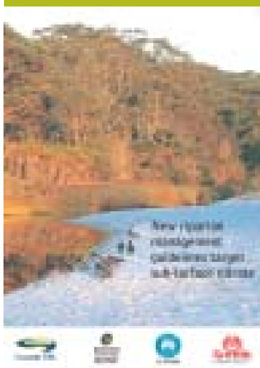
Collecting soil samples for measuring denitrification potential outside the riparian zone at Sandy Creek, Qld. Photo Carol Conway.

RESOURCES



See references for where to download these two publications.

NEW IN 2007

This project will be featured in a River Contaminants Program publication summarising research results.

Management issue 7: Valuing ecosystem services

By Siwan Lovett

Siwan Lovett is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

Ecosystem services are the benefits to humans that come from plants, animals and micro-organisms in nature interacting together as an ecological system, or 'ecosystem'. In Phase 2 of the National Riparian Lands R&D Program we did some work on defining the range of ecosystem services provided by riparian areas and, in so doing, highlighted the importance of these parts of our 'river landscapes' as supporting a diversity of ecological processes.

When talking to land managers about the need to protect and maintain riparian areas it is often useful to discuss the 'ecosystem services' listed below. You can also talk about managing riparian areas for 'multiple benefits' which is sometimes an easier way for people to understand the range of environmental, ecological and social 'services; riparian lands provide. ■

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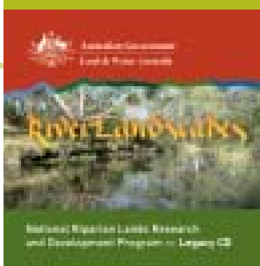
Healthy ecosystems. Improved water quality. Denitrification.
Decreased erosion. Maintaining river courses. Ecotourism.
Maintaining biodiversity.

Photo John and Sue Holt.

Decreased algal growth. Maintaining fish stocks. Recreation.
Shelter effects. Lowered water tables. Retention of nutrients.
Opportunities for diversification. Increase in capital values.
Decrease in pests. Cultural and spiritual fulfilment.

RESOURCES



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Management issue 8: Riparian widths for different management objectives

By Phil Price

Phil Price is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

The width of land identified for fencing, replanting or other treatment within a riparian rehabilitation project is likely to be determined by state or local legislation and regulations, by the management objective(s) to be achieved, by catchment position (are you on a first or fifth order stream), and by the site characteristics (slope, aspect, land use etc.). To this could be added the amount of funding available! This article discusses eight different management objectives, and their influence on the width needed to achieve them.

1. If the objective is to **clear land for agriculture or urban development**, where the aim is to minimise the effects of vegetation clearance and soil disturbance, width will be determined by state/territory regulations, the general prohibition on such activity within 20–200 m of a designated watercourse, and the need to obtain development/planning consent.
2. If the objective is **agricultural production**, where the aim is long-term, sustainable profit, a width of at least 30 m is suggested for agroforestry plantings (with caution needed in harvesting trees within 10–40 m of bank top), 10–30 m for an effective, multi-species windbreak, 30 m for a spray drift buffer, a 10 m grass filter strip between intensive production such as cropping and the stream (this can be grazed with care), and at least 5 m upslope from the top of the bank fenced off from grazing.
3. If the objective is **grazing domestic stock**, where the aim is to control stock access to riparian areas, the waterway should be fenced off with the width determined by the grazing regime and stocking rate/mob size to be used to optimise pasture composition and animal production. An alternative supply of clean drinking water is required with benefits to growth rate and disease control. Provision of water points, shade, and supplements can be used to influence animal behaviour where fencing is impractical. Channel should be fenced at least 5 m upslope from the top of the bank, more if the area is prone to flooding.
4. If the objective is to **maintain or improve water quality**, and the aim is to filter out solid contaminants before they reach the stream, a grass filter strip at least 5–10m wide is required, or 10 m or more of native vegetation. The exact width needed depends on slope, likely sediment load and depth of overland flow (see 'Designing filter strips to trap sediment and attached nutrient', *River and Riparian Land Management Technical Guide no. 1* for details), stock should be excluded or grazing managed with special care to maintain full ground cover.

Photos (left to right): Roger Charlton, Ian Prosser, Peter Hairsine.


5. If the objective is to reduce or **prevent streambank erosion** caused by sub-aerial, scour, or mass failure processes, the aim is to cover, reinforce, and dry the bank soil. Aim for complete vegetation cover for the entire bank height plus 5 m upslope from the top plus an allowance for initial continued erosion. In practice this means a width of 5–15 m upslope from the top of the bank, generally equivalent to about half the channel width. Exclude stock, and replant this area if necessary.
6. If the objective is to **control light level and water temperature**, to maintain or return to more natural conditions, the key aim is to ensure sufficient shade of the stream. High light (especially in combination with increased nutrient levels) can lead to excessive growth of algae and macrophytes, and without shade stream water temperature can rise by 3–5°C and be lethal to or affect the life cycle of many in-stream animals. For channels less than 10 m wide, 75% of natural shade level should be achieved, generally requiring one to three tree widths and 5–20 m of native vegetation.
7. If the objective is to **maintain healthy aquatic ecosystems**, the aim is to provide adequate food inputs (leaves, twigs, fruit, insects) and habitat (large pieces of wood and overhanging roots for flow diversity and protection from predators). This will require: *(continued over)*

native plant species, one to three tree widths and 5–20 m of natural vegetation.

8. If the objective is to **maintain or enhance wildlife**, with the aim of providing food, habitat, and shelter for native species, care should be taken to minimise edge effects and to meet the special requirements of rare or endangered species. This will require native plant species, and a width of up to 100 m for a self-regenerating plant community. Considerable benefit can be obtained from a 20 m corridor with 50–80 m islands of native vegetation where it is too expensive to fence along the stream bends.

Ideally, it is possible to manage riparian areas to achieve multiple objectives. Place any fencing at least 5 m upslope from the top of bank, incorporate a 10 m grass filter strip between the stream and area of intensive land use, include 20 m or three widths of native trees/shrubs along the top of the bank (as well as ensuring the bank itself is fully vegetated. This will achieve most of the management objectives listed, and you can do the lot in 20–30 m, and still graze it (with care!). ■

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Photos: (left) Phil Price, (right) John Dowe.

Peri-urban CD-ROM

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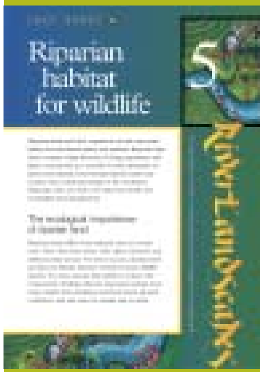
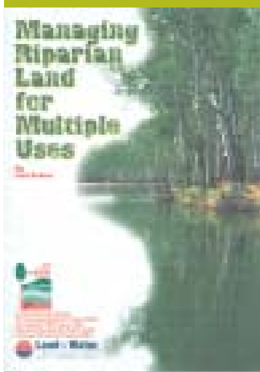
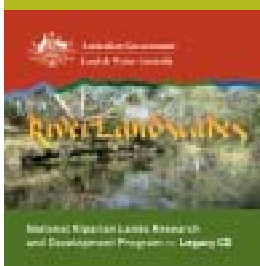






Resources are available from www.**rivers**.gov.au

Management issue 9: Impacts of livestock grazing in riparian zones — can they be reversed?

By Amy Jansen and Ian Lunt

Many studies have shown that livestock grazing has negative effects on the function and biodiversity of riparian ecosystems (e.g. Fleischner 1994; Belsky, Matzke & Uselman 1999). We have done a number of studies in the riparian zone of the Murrumbidgee River in western New South Wales, showing that grazing and associated land management practices have had negative impacts on ecological condition (Jansen & Robertson 2001a), terrestrial bird communities (Jansen & Robertson 2001b), wetland frog communities (Jansen & Healey 2003), ant communities and seed predation rates (Meeson, Robertson & Jansen 2002) and herbaceous plant communities (Jansen & Robertson 2005).

While it is often necessary to exclude grazing from riparian zones to achieve any restoration of their function and biodiversity (e.g. Thompson et al. 2003), this is not always possible. It also may not be necessary, particularly in areas of less intensive grazing. Our collaborators, State Forests of New South Wales, decided to implement rotational grazing on all of their leasehold riparian river red gum forests. They proposed that low levels of grazing, for only a part of the year, would not cause any additional impacts on these floodplain forests, and may actually aid in controlling weeds and promoting the growth of native perennial species. We worked with State Forests to establish experimental areas within several forests to test this idea. Two experiments were established: a short-term, large-scale one across several forests on the Murrumbidgee and Edward Rivers, and a long-term, small-scale one in Millewa Forest, on the Edward River.

In both experiments, grazing exclusion plots and unfenced plots were set up to compare the effects of different grazing regimes with recovery from grazing in previously continuously grazing areas. We examined effects on herbaceous plants in both experiments, and also on ant communities in the large-scale experiment. Plant communities were sampled using quadrats, with cover of all herbaceous species recorded, while ant communities were sampled in small pitfall traps, with the ants collected after 48 hours.

Large-scale experiment

This experiment was established in 2001, with five fenced and unfenced plots (each 1 hectare in area) in each of three forests. Plant and ant communities were assessed in spring of each year until 2004 (except 2002 during the severe drought). Figures 1 and 2 show plant and ant community ordinations at one of the sites (results for all three sites were similar). Each point represents a plot, fenced or unfenced, and plots with similar communities are close together in the figures while plots with very different communities are far apart. These figures show that while there were changes from year-to-year in the plant and ant communities, no differences developed over time between the fenced and unfenced plots at any site, for either plants or ants. It seems likely that the stocking rates adopted by State Forests for these sites, and particularly the extremely low stocking during the drought in 2002, may be so low that there is no difference in impact between grazed and ungrazed sites.

Figure 1. *Plant communities in fenced and unfenced plots in Cuba State Forest.*

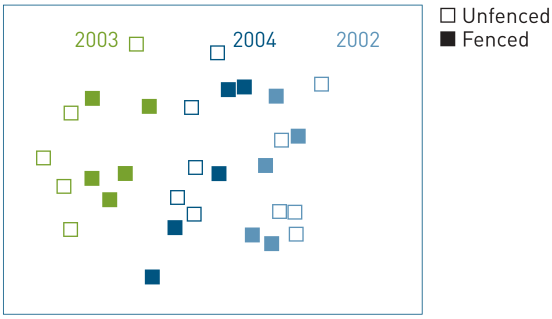
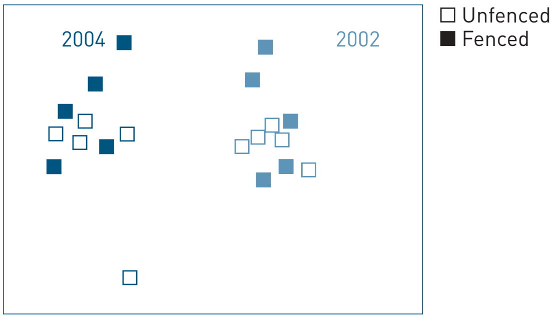


Figure 2. *Ant communities in fenced and unfenced plots in Cuba State Forest.*



In autumn (Photo 1, left), grazing impacts on vegetation cover outside the fence are evident. However, by the next spring (Photo 2, right), these effects have disappeared. Photos Amy Jansen.

Long-term experiment

This experiment was established by NSW State Forests in 1990. Fifteen paired fenced and unfenced plots (each 10 m x 25 m in area) were established in different parts of Gulpa Island State Forest. Plant composition was assessed each spring in six of the following 12 years (until 2002). Figure 3 shows the plant community ordination over eight years from the beginning of the experiment (plant communities were sampled again in 2002 but, due to the drought, were off the scale of this plot).

As was found in the short-term experiment, plant cover and composition varied greatly between years, but we found little impact from excluding grazing stock. In one year, the cover of annual species was slightly (but significant statistically) lower in the grazed plots than in the ungrazed plots (67% versus 78%), and in another year, there were slightly more annual species in quadrats in grazed than ungrazed plots (5.4 spp. versus 4.2 spp.). Both of these effects were very minor. Similarly, species composition differed significantly between grazed and ungrazed plots in two of the six years, but this was due to relatively small differences in the abundances of common exotic annual species, with species such as *Avena barbata* and *Bromus diandrus* being more abundant in ungrazed plots and *Vulpia* species being more abundant in grazed plots. Importantly, all of these small differences were transient. We found no evidence that grazed and ungrazed plots were becoming more different over time, as we would expect if ungrazed plots were slowly but steadily recovering from previous stock grazing.

The lack of responses to grazing exclusion could be due to a number of factors, including low stocking levels, dry conditions in many years, competition from dense stands of *Eucalyptus camaldulensis*, the degraded initial condition of the experimental area, and shortages of seeds of native species. A seed bank study at the same sites by Honours student, Sally Kenny, found that the soil seed bank did not contain seeds of many extra native species that weren't recorded in the standing vegetation (Kenny 2003).

Conclusions

The main conclusion that can be drawn from these results is that stocking rates and grazing regimes used in State Forests in floodplain forests in the Riverina in recent years are unlikely to cause any more degradation of riparian habitats than has already occurred. However, there is also no evidence that riparian habitats are likely to rapidly recover from past grazing-induced

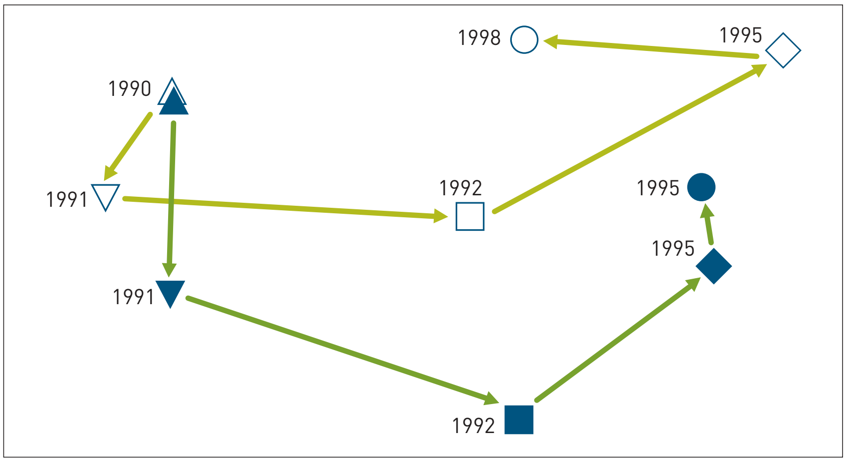


Figure 3*. Plant communities in grazed and ungrazed plots in Millewa State Forest. Each point represents the average composition of 15 plots. Open symbols represent grazed plots and filled symbols represent ungrazed plots.*

damage, either under light grazing or with total exclusion of grazing.

However, these conclusions must be must be tempered by a number of issues. Firstly, much of the large-scale experiment was conducted in an abnormally dry (drought) period, and more dramatic vegetation changes may be expected in high rainfall periods. Secondly, the long-term experiment was in a relatively dry and highly degraded area where the understorey was dominated by exotic annual species. Different outcomes may have been found if the experiment had been conducted in more intact and more productive parts of the forest.

Thirdly, these findings apply to the floodplain area and not to riverbanks; grazing on riverbanks may contribute to long-term erosion and changes to instream ecosystems. Finally, the grazing strategy adopted by NSW State Forests had excluded stock from many sensitive parts of the floodplain, including wetlands and other key environmental assets. These assets may be far more easily degraded than the parts of the environment than we studied here.

Finally, the key output from this work has been the incorporation of findings into the *Stock and waterways: a manager's guide* publication, as well as a chapter in the *Principles for Riparian Lands Management* book. ■

For further information

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Further reading

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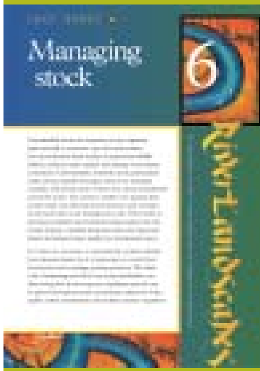
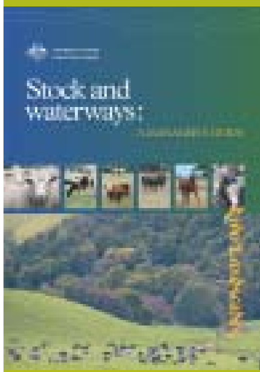
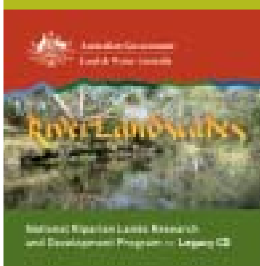
Photo Mike Wagg.

RESOURCES







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Management issue 10: Monitoring and evaluation

By Phil Price

Phil Price is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

Photos (below) Monika Muschal, (opposite) Michael Askey-Doran.

Monitoring is the collection of information to demonstrate continuity or change (for example following treatment or over time), and **evaluation** is the assessment of whether aims, objectives or preferences are being achieved. The purpose of the evaluation will in general guide the type of monitoring required.

Monitoring and evaluation (M&E) should be considered as integral components of any riparian land management project or program, and be funded and resourced accordingly. It is often claimed that 'you cannot manage it if you cannot measure it', and it is difficult to be confident that management is effective if there is no supporting evidence. As well as helping to show whether management is achieving its objectives, M&E also provides a basis for adaptive management and continued improvement, and can assist in identifying priorities when resources are limited.

Despite this, the history of river and riparian management in Australia has involved little or no effective M&E activity, even for programs that involve the expenditure of substantial public funds. M&E activities can be long-term and expensive, and should be designed to match the scope and scale of the riparian management itself. There are also pitfalls to be avoided. To be effective, M&E must have a defined purpose and clear objectives, otherwise it will be difficult to decide what data should be collected and how often over what period. There should be an effective link between the program and the decisions it is to influence, for example through public reporting of the results and presentation to users. The design of the program must have the potential to detect changes and differences at the spatial and temporal scales anticipated. The attributes to be measured must reflect the outputs and outcomes to be achieved by the project, preferably linked via knowledge of riparian zone functions. There should be consistent and reliable protocols for measurement. Finally, the program must be funded adequately — there is little to be gained from inadequate M&E.

Riparian management projects, including on-ground works, can be evaluated at two levels. The first is what might be called project or **output** evaluation. This type of evaluation is used to show whether the project is following its agreed (or contracted) schedule, whether key stages have been completed (milestones), and whether it is delivering or has delivered its outputs (specified products or services). This follows the standard form of project evaluation, primarily for purposes of accountability and reporting. There is a large literature available about how to undertake this type of evaluation, and what sort of things to measure and record (what to monitor).

This type of evaluation is straightforward, and should be considered as part of the minimum requirements for good project management. However, it tells us little about whether the project achieved its purpose and wider objectives, i.e. the **outcomes** sought. To do this requires a different approach to evaluation, one that is capable of measuring over time whether the required changes in condition (e.g. less bank erosion, lowered water temperature, increased in-stream habitat) have been achieved, and, just as importantly, whether they are the result of the project and the work undertaken. This type of evaluation is more complex and difficult, and as a result is rarely undertaken. The difficulties include the long time and large spatial scale often needed to demonstrate change in river characteristics, low signal to noise ratio in Australia's highly variable climate, continuous measurement required to capture periodic but unpredictable events, lack of baseline data when the project is initiated, and separating the effects of multiple variables.

These problems help to explain the paucity of good evaluations of riparian management projects. The size of many projects does not warrant the expense of effective evaluation, but without such assessments it will be difficult to learn from past successes and failures in order to improve the effectiveness and efficiency of future projects. Evaluation, and the associated monitoring, must be incorporated into project design; it is rarely possible to return to past riparian projects and assess their success in achieving outcomes.

One means of resolving this problem is to identify a small number of indicators of riparian condition (including surrogate indicators) that can be assessed easily and cheaply. These may not be suitable for all components of riparian

You cannot manage it if you cannot measure it.

management, but they can demonstrate at least the trend of changes following treatment, and they may be suitable for repeated assessment by non-technical people who have completed a short period of training. They may also enable some level of statistical analysis of the monitoring data to test for operator error and repeatability. This is where the rapid appraisal of riparian condition assessment methods (the RARC and TRARC, see pages 42 and 44) developed by research teams working on the National Riparian R&D Program may be very useful.

For monitoring, statistically designed comparison of treated and control sites over an adequate timescale is the best option, but in practice has been uncommon. For many riparian rehabilitation projects, the emphasis will be on measuring change from the initial condition considered to be degraded or unsatisfactory, to one considered closer to natural or at least preferred. In the absence of a matching but untreated control site, comparison to an adjacent reference site is valuable to help distinguish treatment effects from natural background variability (the signal to noise issue).

Where no comparison with other sites is possible, the collection of adequate baseline data from the project site before treatments are imposed is essential. Some type of before-after-control-impact (BACI) sampling design should be considered, with randomised or gradient sampling to take account of local spatial variability. BACI monitoring systems are commonly used in environmental impact assessments, and for detecting the impacts of anthropogenic change. The length of the 'before' monitoring should be sufficient to provide information about the scale and direction of natural variability, and to capture the effects of significant natural events such as flood flows. In practice this is difficult due to the timing and funding processes for most riparian projects, although use may be made of local knowledge, oral histories, and past photographs or imagery.

Where even adequate BACI monitoring is not possible (this includes many on-ground riparian projects), effort should be made to collect monitoring data from randomly selected locations within the treated zone (helps reduce effects of

spatial variability) and data collected periodically over as long a time period as possible (to reduce effects of temporal variability). Rapid assessment tools for monitoring riparian condition (RARC/TRARC) have been developed to meet exactly this need.

Good information about different types of indicators for monitoring change in riparian areas and rivers is available in the literature. The key issue is to make sure the indicators provide sufficient information to be able to answer the evaluation questions with confidence. A final point about indicators is that you do not have to measure everything. A small number of well-chosen indicators can be quite sufficient to indicate the direction and size of change over time, and for many purposes this will be all that is required. It is generally far better to focus limited resources on measuring thoroughly a few carefully selected indicators, than to attempt to cover all possible factors but with less replication or limited frequency. ■

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RiverLandscapes

Principles for Riparian Lands Management

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The no frills free national riparian research and development workshop

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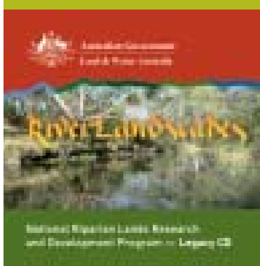

Resources are available from www.**rivers**.gov.au

Management issue 10: Development and application of a method for the Rapid Appraisal of Riparian Condition

By Amy Jansen, Alistar Robertson, Leigh Thompson and Andrea Wilson

Given the critical role of riparian areas within catchments, and their extensive degradation in Australia, there is a need for improved management of these areas. A baseline for improved management must be an understanding of current condition*, and the factors which determine this. We felt that there was a need for a rapid method of measuring riparian condition, both to enable assessment of a large number of sites in a catchment and to investigate relationships with current management practices. This project focused on developing a rapid method which could be used at a large number of sites and was responsive to changes in grazing management.

Rapid Appraisal of Riparian Condition (RARC)

Assessment methods incorporating indicators of geophysical and biological properties and processes are likely to provide reliable estimates of ecological condition in riverine ecosystems. Ladson et al. (1999) described an index of stream condition based on 18 indicators that measure alterations to the hydrology, physical form, streamside vegetation, water quality and biota of streams. This project used a similar approach, and chose indicators to reflect functional aspects of the physical, community and landscape features of the riparian zone. Some of the indicators chosen reflect a variety of functions, for example, different aspects of vegetation cover can play a role in reducing bank erosion, providing organic matter and habitat for fauna, and providing connections in the landscape. The RARC index is made up of five sub-indices, each with a number of indicator variables.

Photo 1*. A site in excellent condition (RARC score = 41).*

1. Habitat continuity and extent (HABITAT)
2. Vegetation cover and structural complexity (COVER)
3. Dominance of native versus exotics (NATIVES)
4. Standing dead trees, fallen logs and litter (DEBRIS)
5. Indicative features (FEATURES)

Each sub-index is scored out of 10, with a total possible score of 50 representing best condition. Photos 1 and 2 show contrasting sites in excellent and very poor condition. The RARC has now been in use across Australia for a couple of years, and has proved to be an extremely popular assessment method. It has been modified it for riparian environments in the tropics (see next article), South Australia and Tasmania, and we are currently in the process of developing a RARC for the New South Wales tablelands region. These three 'regional RARCs' make it easy for people in these areas to pick up and use the assessment method, as the descriptions of riparian areas, photographs and data (most people undertake at least 20–30 assessments using the original RARC and use the information gathered in this process to then modify the assessment method to meet their regional characteristics) relate directly

> ****Condition** refers to the degree to which human-altered ecosystems diverge from local semi-natural ecosystems in their ability to support a community of organisms and perform ecological functions.*

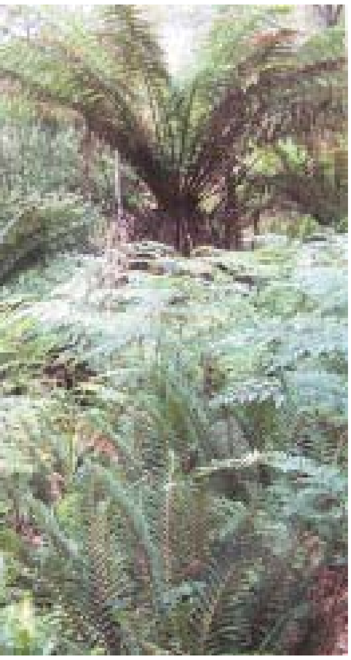

Photo 2. *A site in very poor condition (RARC score = 10). Both photos Robyn Watts.*

to them. For more information on how to 'tailor' the RARC visit www.rivers.gov.au and select 'tools and techniques'.

Concluding comment

The RARC is a general tool for assessing riparian zone function and biodiversity. It shows clear relationships with more detailed measures of biodiversity and function in catchments where this has been tested. It is also simple to use, easily taught to new users, and shows good inter-observer reliability. It is freely available and has been updated in our *River and Riparian Management Technical Guideline* series. The South Australia and Tasmania regional RARCs are also now available in hard copy (CanPrint on freecall 1800 776 616) and via www.rivers.gov.au ■

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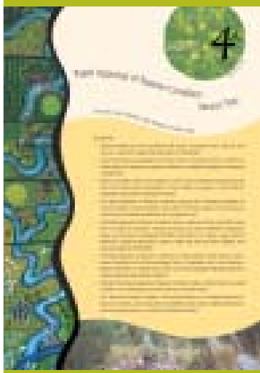

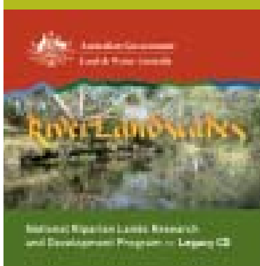

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Management issue 10: Development and implementation of the Tropical Rapid Appraisal of Riparian Condition (TRARC) method

By Ian Dixon, John Dowe, Michael Douglas and Damien Burrows

Tropical rivers are an important and dynamic feature of northern Australia's vast savanna landscape, providing valuable cultural, economic and ecological contributions to the region. Riparian zones (or riverbank habitats) are widely acknowledged as important elements of the landscape because they influence the flow of energy and nutrients across the terrestrial and aquatic ecosystems, perform functions that help to maintain aquatic ecosystems and provide a range of ecosystem services. For example, riparian vegetation slows water flow and helps stabilise stream banks; provides food, shade and habitat for terrestrial and aquatic plants and animals; and filters sediments, nutrients and pollutants before they enter the stream. Being located at the interface of the terrestrial and aquatic ecosystems, riparian zones are potentially valuable indicators of catchment condition. They are also the focus of much activity related to development of the region, including grazing, agriculture and tourism, which add pressure to an ecosystem already vulnerable to weed invasion, over-grazing, feral animals, fire and erosion.

Long thin riparian strips through the vast savanna landscape, Ord River catchment, Western Australia. Photo Ian Dixon.

As development of northern Australia increases, there is a growing need for land managers to better understand the condition of riparian zones to ensure effective management practices. It is recognised that a user-friendly tool to assess and monitor riparian condition would support land managers in directing management programs and to monitor their effectiveness over time. The Tropical Rapid Appraisal of Riparian Condition (TRARC) is a user-friendly tool designed for land managers to quickly assess the condition of riparian zones. It has been specifically developed for riparian zones in tropical savannas and has been tested with land managers in a selection of catchments in the Northern Territory, Queensland and Western Australia by researchers from the Tropical Savannas Cooperative Research Centre and the Australian Centre for Tropical Freshwater Research.

The TRARC

The TRARC methodology was first developed at a workshop held at James Cook University, Townsville, in October 2003 where riparian ecologists agreed on a framework for developing a rapid assessment method for tropical regions in Australia.

The workshop, hosted by the Australian Centre for Tropical Freshwater Research (James Cook University, Townsville), was attended by representatives from a number of organisations, including the Tropical Savannas Cooperative Research Centre (Charles Darwin University, Darwin), CSIRO and departments within the Northern Territory and Queensland Governments. The workshop participants determined which habitat indicators would be important to measure in savanna riparian zones and how best to measure them. Methods were formulated to provide a balance of accuracy, time, cost and ease-of-use (Dixon et al. 2005). The approach developed in this workshop was similar to the Rapid Appraisal of Riparian Condition method of Jansen et al. (2004), thus giving it considerable comparability to the methods currently being developed for south-eastern Australia. The TRARC method developed from that workshop was trialled in both the Northern Territory and Queensland. Further cooperation and communication between Australian Centre for Tropical Freshwater Research and Tropical Savanna CRC resulted in minor alterations to the method that was developed at the workshop, and a slightly modified version and its assessment protocols were considered to be at a stage at which the method could be used more extensively and comparably across a wide geographical area (Dixon et al. 2005; Dowe et al. 2004). The final version of TRARC (Dixon et al. 2006) is the result of adjustments made from trialling projects, with intense use in the Burdekin River Catchment, across the Top End and in northern Western Australia.

The TRARC method is intended as a rapid appraisal technique and, therefore, focuses on what are considered to be the most important elements from which ecological condition can be estimated. The TRARC scores a number of simple vegetation attributes in the riparian zone, and thus provides an overall score that is intended to rank the 'ecological condition' of the site. Sites are scored 0 to 100, with the greater the score the greater ecological integrity of that site. Management issues can be derived from such assessments. The scoring system is composed of five components: vegetation cover; woody debris; weediness; native regeneration; and disturbance. In addition, supplementary data record the types and levels of erosion; geomorphologic attributes; stream and riparian zone dimensions; position and influence of fences and water points; and population structures of the dominant native species and weeds.

The TRARC is currently designed for site-scale (less than 10 km of river length) assessments of the current condition of a riparian zone. Repeated measurements over time can help land managers to monitor the outcomes of management practices such as riparian fencing or weed management. It is also anticipated that use of the TRARC will encourage discussions between land managers and scientists about how best to manage and monitor savanna riparian zones.

Implementation of TRARC

The TRARC has been trialled and implemented in a number of projects. The condition, characterisation and distribution of riparian vegetation have been assessed at over 200 sites throughout the Burdekin River and Haughton River/Barratta Creek catchments using the TRARC method (Dowe 2004).

Most recently, it has been used in the Ord River catchment as part of the National Action Plan for Water Quality and Salinity (Western Australian and Commonwealth Governments). Led by the Department of Environment and Conservation and the Ord Irrigation Cooperative in Kununurra, researchers from Charles Darwin University spent five weeks 'TRARCing' the rivers and creeks throughout the catchment to trial the method and modify the methodology to be suitable for the East Kimberley region. These trials also collected base-line data for land managers to use as potential monitoring sites. A total of 116 sites were assessed at 29 locations upstream of Lake Argyle and around Kununurra. Modifications to the TRARC methodology considered the lower canopy cover and different weed species in the trialled areas. Results will be available in December and training sessions in the modified Ord-TRARC will commence in the 2007 dry season.

Applying the TRARC in the Walsh River, North Queensland. John Dowe (middle) from the Australian Centre for Tropical Freshwater Research (James Cook University) training Deb Eastop (left) and Fiona Barron (right) from the Mitchell River Watershed Management Group. Photo Ian Dixon.

Brad Halasz (left) and Ian Dixon (right) from the Tropical Savannas CRC (Charles Darwin University) trialling the TRARC in the Ord River catchment. Photo Ian Dixon.

Summary

The TRARC provides savanna land managers with a simple and consistent way of assessing the features of the riparian zone that are likely to affect its ecological function and to identify management actions that can maintain or improve the condition of the riparian zone. Undertaking TRARC assessments encourages land managers to spend time in their riparian zones, identifying current or potential threats and to consider the effects of their management practices. ■

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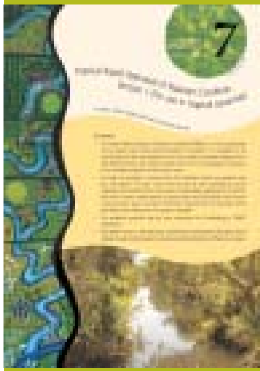

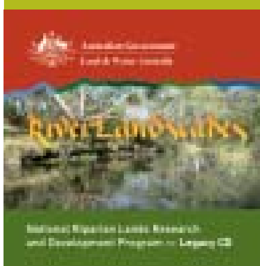

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Management issue 11: Overcoming constraints to implementation of sound riparian management

By Siwan Lovett

Siwan Lovett is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

Despite the fact that we know better managing riparian areas is important environmentally, there are still a number of constraints that prevent or hinder people from implementing recommended practices. Many of these are due to economic, social and cultural factors. In Phase 2 of the National Riparian Lands R&D Program we have undertaken a range of different activities to explore the 'human' element of riparian management, and these are summarised in the following four articles. ■


Photo Jan Snape.

Team 'Riparian' negotiating the hindrance of muddy ground.

Management issue 11: The 'Capacity Assessment Tool for riparian rehabilitation'

By Don Thomson

The 'Capacity Assessment Tool for riparian rehabilitation' was first introduced to *RipRap* readers in 2003. Since then it has been tried, tested, reviewed and renewed!

The 'Capacity Assessment Tool for riparian rehabilitation' (CAT) was an outcome of a research project commissioned by Land & Water Australia in 2002/03 'Assessing community capacity through riparian restoration'. That project was instigated to assess whether Land & Water Australia's National Riparian Lands R&D Program 'Demonstration and evaluation' projects had built 'capacity', within the communities that embarked upon them for long-term changes in their approach to river and riparian management. The CAT is based on the experiences of a wide range of people who were involved in establishing and managing the 'Demonstration and evaluation' projects, which were set up between 1996 and 2000.

What we found is that 'capacity' is very much about the skills and knowledge of individuals and their perceptions and values, the social networks and relations, including feelings of trust and reciprocity and support and cooperation within and between institutions and between individuals. Issues of governance, administration, consistency, continuity, and the availability and accessibility of financial and other resources, are also important. The physical and natural capital of the region can also play a large role in determining the level of capital of other forms required to successfully manage riparian lands — that is, social and human capital.

We distilled these common themes into a set of enabling and constraining 'dimensions', which were used as a framework for a 'capacity assessment tool' that would be widely applicable (see Table 1 overleaf).

In a regional natural resource management (NRM) delivery context, this means shifting the focus from 'building the capacity of communities' to change their practices, to 'what are the capabilities of agencies/regional bodies to influence change among diverse communities within variable and diverse spatial and temporal contexts'.

How is the CAT used?

The tool can be used to assess 'capacity' at any geographic scale and across a wide range of riparian and river health programs. However, the tool does need to focus on a particular program or project. The main proviso is that users have at

Table 1: Dimensions of capacity included in the 'Capacity Assessment Tool'

Theme	Dimension
1. Context	Economic conditions, community cohesion and support, awareness of water quality/quantity issues, setbacks, community networks, community negotiation structures, complexity & cost of works.
2. Values and perceptions	Values, shared vision, skills in working with diverse values and perceptions, awareness, open mindedness and learning, perceptions of solutions, ownership of problems and solutions.
3. Communications and empowerment	Data availability, communications — targeting, communications — mechanisms, consistency of communications, cooperation between agencies, empowerment, inclusiveness.
4. Program design	Roles and responsibilities, financial security, program consistency, institutional consistency, flexibility, forward planning, transparency.
5. Program delivery	Decision-making, consistency of key people within agencies, personality of key people within agencies, skills and experience of key people within agencies, community 'champions', monitoring and evaluation, institutional capacity.

Photos (left) Nadeem Samnakay, (right) Jenny O'Sullivan

least some knowledge of the conditions of their selected geographic area and of the program/ project and what it aims to achieve. Anyone living or working in an area should have sufficient knowledge to complete the tool without needing to do further research. Referring to relevant data, reports, etc. can enhance the 'accuracy' of the tool, for example, if there has been some social research on attitudes, values and drivers and barriers to change in the focus region, this can be used to inform your responses to key sections of the assessment.

However, the tool does not rely on accurate information. Sometimes the user's perceptions of the situation are just as important and valid. This feature of the tool is actually one of its strengths, because the tool can be used to compare different peoples' or groups' perceptions of current conditions and trends across 35 important dimensions of capacity. By using the tool with groups, or comparing responses of individuals or groups over time, the CAT can be used as both a facilitation tool to elicit perceptions, and a monitoring and evaluation tool.

For each of the 35 'dimensions' of capacity, the user selects one of three 'statements' based on the degree to which it 'best' describes the current condition of their region/catchment and their community/NRM institution. Users then select one of three 'trends' describing how conditions are changing for each dimension — either static, declining or improving. Weightings can be applied if users believe some dimensions are more important than others at that time and place, or a default set of weightings, based on the original research on the five case-study regions. Weightings can also be applied depending on the life-stage of the project/program, because at some stages in a projects life-stage some dimensions are more important than others.

It takes between half an hour to an hour to step through the tool, depending upon your familiarity with the tool, the extent to which you want to adjust weightings, and whether or not you need to refer to other data sources to inform your responses.

Conclusion

The review found that the CAT was basically a sound tool that, because of its flexibility, had very wide application. Users are seeing the potential of

the tool as a *process tool* as much as anything, and this is heartening because that was the original intent.

The tool has also achieved its objective of shifting the focus of users from 'building the capacity of communities' to that of understanding the capabilities of NRM bodies to work with diverse communities, in diverse and changeable contexts, to influence desirable outcomes.

Improvements have been made to facilitate better data storage and management. Further development of the tool to enable better time-series analysis to be undertaken would facilitate simpler comparisons of assessments undertaken for specific projects over time. Additional future improvements could include having the capacity to compare different peoples' or groups' assessments of a project/program/region at the same point in time. An ability to plot changes in condition and trend over time would be a valuable addition to a future version.

The architecture of the new CAT allows the statements to be updated and/or changed to encompass other issues. This means that developing a CAT for broader NRM programs could be more easily facilitated by changing the statements. There is obviously some more research required to ensure that this is a valid and useful thing to do, but the review of the CAT has revealed that there is probably demand for such a tool among NRM practitioners.

Since posting the new version of the tool onto the Rivers website in April 2006, there has been a further 43 downloads, including 15 from international users, from countries as diverse as Uganda, Canada, Vietnam, Ghana, Brazil, Ethiopia and the UK.

We sincerely hope that the CAT is proving a useful tool and helping program developers and managers improve the effectiveness of their efforts in achieving positive resource condition change. ■

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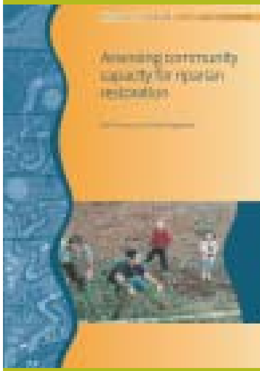

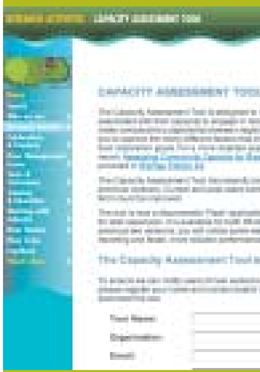

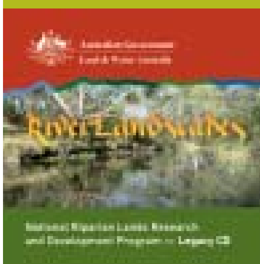

Resources are available from www.**rivers**.gov.au

Management issue 11: Connecting communities

By Siwan Lovett

Siwan Lovett is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

In July 2004, I travelled to Canada to study a range of different organisations working in river management. The focus of my study was on 'capacity building' and 'knowledge exchange' techniques, with a particular emphasis on how science was used in community based decision-making. Studying another country's approach to the same issue enabled me to gain new perspectives and provided opportunities to import new ideas and adapt them to local environments.

Overall, I found that the strengths of one country are the weaknesses of the other, thereby creating ample opportunity for learning from each other. Canada's strengths are in engaging communities, initiating action, celebrating, and using art, culture, history and drama as ways of 'knowing' a river. Australia's strengths are technical rigour, a greater level of institutional coordination and the involvement of communities who are building capacity to make strategic long-term decisions about the future sustainability of their river and environs.

I believe that in Australia we need to rethink some of the technically based demands we are placing on community groups, and replace that with ways to celebrate and encourage involvement at a range of different levels, not just in formal committee structures. We also need to continue exploring ideas around different ways of 'knowing' a river and placing equal value on 'scientific' and 'experiential' knowledge in our decision making processes (see Working with industry, page 53).

I benefited enormously from visiting Canada, and I have shared my findings through a Report, as well as dedicating *RipRap*, edition 27 to the theme of 'Connecting communities'. I have also made several presentations at conferences over the past two years, where I have tried to highlight the importance of integrating the social, cultural and biophysical factors that impact on people making decisions about whether or not to undertake riparian restoration

I believe that those working in river management now recognise that improving river and riparian management is all about working with people, and we are spending more time on this topic. However, social aspects of river management are often talked about as important, but still end up as an 'add on' to a project, or funded separately. We need to rethink this approach and merge the social and biophysical so that integrated solutions to the issues we are facing can be developed. Just as we have developed many different biophysical techniques to understand our environment, we need to use a range of different approaches to connect with communities. *RipRap*, edition 30 on 'Knowledge and adoption' provides plenty of insights for people on how people across Australia are tackling this issue. ■

Photo Tom Clarke.

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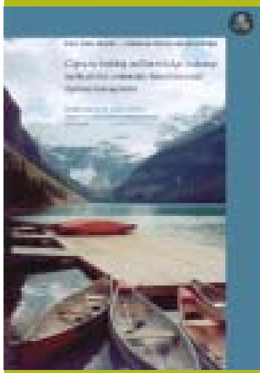

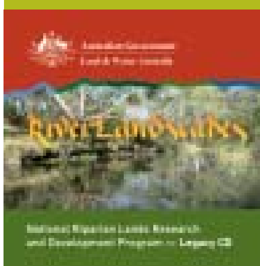

Resources are available from www.**rivers**.gov.au

Management issue 11: The application of environmental justice to stream rehabilitation

By Mick Hillman

The overall aim of this PhD project was to identify some key issues and challenges in developing an environmentally just and fair approach to river rehabilitation using the Hunter Valley as a case study. The term' environmental justice' has four components — distributive (who gets what); procedural (how decisions are made); relational (informal processes and relations between stakeholders); and ecological (justice *towards* the environment). These are discussed .

Distributive justice

A range of tensions have occurred over: the allocation of resources for rehabilitation work; differing criteria used for priority-setting across time and place and between stakeholder groups; the absence of any transparent or agreed upon criteria used in 'official' decision-making; and problems in the use of ecological assessment tools, which is often seen as a purely 'technical' issue but in reality is an ethical and political process.

Procedural justice

Historically, a very limited range of 'stakes' have been included in river management in the Hunter Valley. Attempts to broaden the base through total catchment management have been viewed in government policy circles as a 'failure', leading to a move away from stakeholder towards expert-based management. This reflects a tension between the need for just process and the need to 'deliver' on-ground outcomes.

Photo Andrew Brooks.

Relational justice

Ideas of the use-value and health of a river underpin ideas of what is fair and just in river management. Changes to the scale and institutional framework also affect the relations of knowledge and power between sections of the community. Transitions from one system to another need to be carefully managed to avoid loss of valuable resources, particularly skills, knowledge and trust.

Ecological justice

Attitudes towards 'the river' have framed distributive and procedural issues — understanding how this operates is a key to developing a just and strong form of sustainability. Failure to engage with the scaled and variable nature of the biophysical environment has been a source of ongoing mismanagement and injustice.

From a river management point of view this research showed that it is vital to recognise and engage with **all** the above issues and elements of justice.

Summary of implications for rehabilitation practice

In summary, there are a number of key principles emerging from this research that form part of a just approach to stream rehabilitation.

1. Rehabilitation is more than an instrumental means of achieving biophysical outcomes. Rather, it is a mix of *outcome and process*. Both are essential to a sustainable program of river rehabilitation.
2. Rehabilitation starts from a *transdisciplinary* perspective rather than attempting to integrate biophysical and social goals and knowledge at some later stage in the process.
3. Just practice needs to *integrate a diversity* of tasks, roles, values and purposes that create tensions between practitioners or for an individual practitioner. Such tensions are a sign of effective practice rather than any indication of inadequacy or failure.
4. Just practice is made up of a wide range of academic, technical and practical skills,

knowledge and values. An understanding of practice must be more than skills used and tasks undertaken. It must also make reference to purpose and values in a practical context.

5. Just practice recognises the social, historical and geographical *context* in which river rehabilitation takes place. It is situated and grounded rather than generic and abstract and cannot be captured in one categorical 'one size fits all' fashion. This involves identifying similarities and differences between situations and differing perspectives between members of the river community.
6. Just practice links knowing and doing in a reflective *praxis* — one is not the application of the other. Failure to apply this results ultimately in an *ad hoc* approach both to knowledge generation and to on-ground works.

Photo John Koehn.

7. Rehabilitation programs should aim for '*industrial justice*' both in transitional phases and in the development of more secure quality jobs in the rehabilitation field as a distinct area of work. This is restricted at present by dependence on grant funding, frequent institutional changes, high dependence on volunteer labour, separation of research and application and a lack of recognition of skills.

Conclusion

Substantial gains have been made in efforts to rehabilitate our rivers following a long period of neglect and damage. New scientific approaches to assessment and intervention have been matched by more flexible and participatory management approaches. However, it is too early to talk about a 'new era' as many problems remain. From a justice perspective, there is still a lack of clarity and progress in dealing with the balance of outcome and process, and of recognising how the particular characteristics of a catchment shape what might be called 'fair'. This research has confirmed the view that we are unlikely to reach a consensus on what is just and equitable in policy and practice — but given that, it is vital that the means to debate these differing ideas are readily available to all. These are difficult and challenging issues, but dealing with them is essential to creating a genuinely sustainable form of river management — that is, sustainable both in the biophysical and human dimensions. ■

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Management issue 11: Working with industry

By Siwan Lovett

Siwan Lovett is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

Industries that wish to be leaders in the field of environmental management are seeking improved measures against which to base their performance, and to respond to community expectations. Over the past few years, the National Riparian Lands R&D Program has worked with several different agricultural commodity groups to provide information, guidelines and demonstration sites that show how economics and environmental outcomes can be met on-farm. This work is providing the basis upon which Environmental Management Accreditation Systems can be developed to 'slot' into commodity specific Best Management Practice guidelines and manuals. The following articles highlight four projects where we have successfully worked with industry to improve river and riparian management on-farm.

Managing riparian lands in the sugar industry guideline

Photo Canegrowers.

The Sugar Research & Development Corporation and Land & Water Australia co-funded the development of a guideline for the sugar industry that focuses specifically on riparian management on cane farms. Key sugar industry, research and government departments were involved in the project, as well as an important group of cane growers who worked with the research team to define the issues to be covered and ensured that the guideline met their industry's needs. The guideline is intended for use by extension officers and those working with cane growers to develop more sustainable management practices on-farm.

For further information and to download a copy www.rivers.gov.au

Managing riparian lands in the cotton industry guideline

Photo Guy Roth.

Cotton is an important industry to Australia that generates a large export income. Cotton growers often own properties that adjoin larger rivers, with the ownership and management of riparian lands being the responsibility of the landholder in most cases. Riparian land is important for the management and control of off-farm impacts, such as chemicals, sediment and fertilisers. Riparian lands and adjoining floodplains are also often important for biodiversity because they are fertile, provide access to water, support a greater variety of species and provide corridors for the movement of wildlife. The Cotton Research & Development Corporation, CRC for Cotton, Land & Water Australia and cotton growers have worked together to produce this riparian management guideline for the cotton industry. It cover a range of topics, with case studies demonstrating how the management practices recommended in the guideline can be applied on-farm. ■

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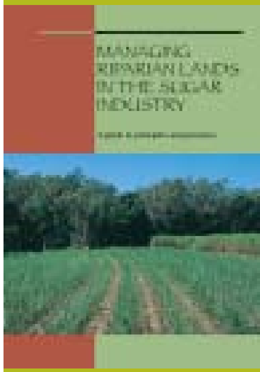

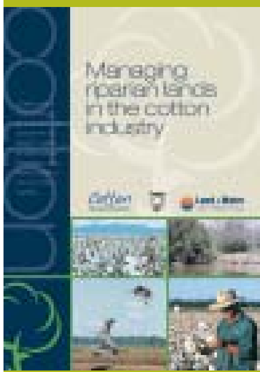

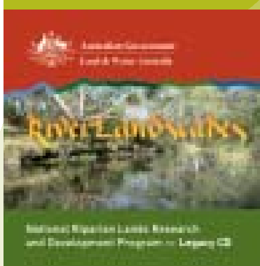

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Management issue 11: The Gippsland Dairy Riparian Project or "GipRip"

By Jenny O'Sullivan

GipRip is a collaborative project aimed at equipping Gippsland dairy farmers with the tools to understand, develop and implement sound riparian management practices. Since 2002, more than 30 km of waterways have been fenced off, extensive areas of riparian land have been de-willowed and/or revegetated, and strategies implemented to reduce effluent and nutrient runoff.

Significantly, a recent Dairy Australia report indicates a notable increase in the number of Gippsland dairy farmers fencing off riparian land, and reveals that more dairy farmers are engaged in natural resource management (NRM) activities in Gippsland than anywhere else in Australia. GipRip has also been recognised for the role it has taken in fostering cooperative relationships between dairy farmers, NRM professionals and researchers. As well as helping to identify and measure the impacts of dairy farming on riparian health, and formulate strategies to minimise those impacts, these relationships are creating the framework for future works designed to improve catchment health generally.

GipRip uses a multi-faceted, "Tell, show, do" approach that aims to motivate and engage farmers as follows:

Inform (**Tell**) the industry about sound river riparian management.

Train members of the community in different aspects of sound riparian management (e.g. learning groups, river walks, Gippsland River Forum and WaterWatch) to explore current knowledge and understand how Gippsland dairy farmers can minimise the impact of farming on riparian areas).

Establish demonstration sites (**Show**) to develop best practice management systems for local conditions, in conjunction with local farmers.

Measure and evaluate impacts of changed practices on both productivity and the health and sustainability of natural resources.

Record costs and benefits of changed management practices and undertake cost benefit analysis to demonstrate effects on productivity, water quality, animal health and other environmental issues (**Do**).

Maintain a written record of the project from inception to provide a guide for other producers.

Photo Jenny O'Sullivan.

How GipRip has achieved results

The key to the success of the GipRip project is local knowledge and input. GipRip has established two demonstration sites, and formed four learning or syndicate groups where local farmers and researchers are encouraged to work together to:

- identify the impact dairying has on the site's waterways,
- determine the priorities and processes for change, and
- make the changes on the site.

Researchers from the University of Melbourne have set up monitoring equipment at Willow Grove to study the environmental impacts of dairying (measuring nutrient levels, water temperatures and biodiversity, for example), and the effects of better management practices such as willow removal, fencing off and revegetating. The results of this research are shared regularly with farmers, industry representatives and NRM specialists both on-site, at workshops, river forums and via newsletters.

In conjunction with the research and demonstration sites, GipRip runs a structured learning program targeted mainly at dairy farmers occupying riparian land along four waterways in the West Gippsland Catchment. Many of the products shared with dairy farmers came from the work being undertaken in the National Riparian Lands R&D Program, with the fact sheets and *RipRap* very popular. Members of these learning groups are encouraged to work together to explore issues relevant to their waterway management, and to develop goals and action plans to improve their management practices.

GipRip's legacy

Using knowledge derived through GipRip, members of the learning groups have taken significant steps towards achieving sustainable riparian management. Since 2003, GipRip participants — with the West Gippsland Catchment Management Authority, researchers from the University of Melbourne, Victorian Department of Primary Industries and Landcare — have worked together to remove willows from, and fence off,

The experience of the dairy farmers involved is valued and recognised, and one of the first projects was to capture some of this knowledge with the 'Dairy farmers going with the flow' oral history CD-ROM. This was developed by Louise Darmody on behalf of the National Riparian Lands R&D Program.

Photo Jenny O'Sullivan.

www.rivers.gov.au

almost 34 km of waterways within the catchment. Extensive replanting of native vegetation has been carried out, banks stabilised, and projects to reduce effluent and nutrient run off are being considered. Snapshots of improved river health, including an increase in biodiversity, are already visible in some areas.

The GipRip project has been recognised for the way in which it has fostered collaborative partnerships to improve stewardship of Gippsland's natural resources. The 2006 Gippsland Integrated Natural Resources Forum Report Card refers to the "continued excellent work to reduce off-site impacts of the MacAllister Irrigation District on the Gippsland Lakes" which has been carried out through GipRip.

A lasting legacy of the GipRip project is the model it provides for future NRM projects. The prevailing view is that the skills, partnerships and experiences derived through the program will carry over into other environmental projects, particularly as many of the individual projects are now being wound up and fed into the broader Landcare network.

The projects commitment to changing community behaviour has paid dividends. A recent Dairying Australia survey reveals that more than 80% of Gippsland dairy farmers are involved in NRM activities. This is a 24 point increase since 2000, and is the highest rate for dairy farmers anywhere in Australia. In addition, the proportion of Gippsland's dairy farmers who have fenced off all their waterways has risen significantly from 19% in 2000, to 34% in 2006. Similarly, the proportion of Gippsland's dairy farmers who have fenced off some of their waterways has risen from less than 60% in 2000, to 73% in 2006, with 13% saying that they plan to fence off at least some of their waterways over the next two years.

While the GipRip project was always intended to finish in 2007; its success has resulted in recent discussions to explore the possibility of extending its reach into the Port Phillip and East Gippsland catchments. ■

This project was developed by GippsDairy and Land & Water Australia. Key funding comes from GippsDairy using milk levy money collected by Dairy Australia to fund its Dairy for Tomorrow initiatives. The Natural Heritage Trust has also contributed Enviro-funds for individual projects carried out through the GipRip program. The West Gippsland CMA has contributed fencing materials, labour and plants for many GipRip projects. Other on-ground works have been funded by farmers, Landcare and the West Gippsland CMA as part of their river works program.

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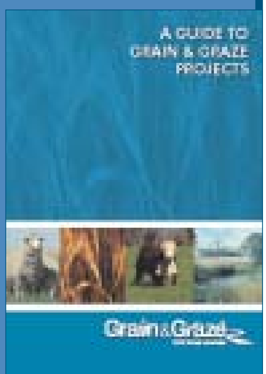
A guide to Grain & Graze projects

The Grain & Graze Program invests in research to improve on-farm profitability while better managing natural resources such as water, soil and biodiversity. The Grain & Graze Project Guide provides a brief description of the program's four national projects and 57 regional projects.

An important part of Grain & Graze's strength is the direct involvement of farmers. Thousands of farmers are gathering information and testing new farming practices on more than 100 research and demonstration sites across Australia.

Working across nine regions, Grain & Graze is collaborating with more than 65 organisations, including a large number of producer and landcare groups, research providers and catchment management authorities.



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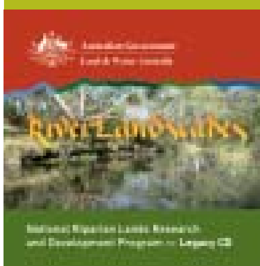

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Management issue 11: Land, Water & Wool

By Siwan Lovett

Siwan Lovett is just one of the presenters at **The no frills free national riparian research and development workshop** on 14 February 2007

Edition 30 of *RipRap* featured a detailed article about Land, Water & Wool, a joint Australian Wool Innovation Ltd and Land & Water Australia Program. It is a Program that aims to provide the wool industry with the knowledge, tools and enthusiasm to minimise its environmental impact while enhancing productivity. The Program is coming to an end (March 2007) and we are now disseminating research results.

In the LWW–Rivers and Water Quality Sub-Program we have developed a range of products to meet different end-user needs (see the resources). Perhaps the most valuable part of the Program, however, has been the development of the 'Five P' framework. Over the past 18 months I have been sharing this approach at a number of different forums, and I have been overwhelmed by the response of people to such a simple idea. The Five Ps stand for: Profit, Proof, People, Place and Promise and highlight the full range of factors that impact on natural resources management decision making. It is a framework that can be applied at a number of different levels by people working in catchment management and with rural industries. *RipRap*, edition 30 on 'Knowledge and adoption' has a comprehensive article on the Five Ps, and they are briefly covered again here.

Land, Water & Wool project activities mainly take place within seven sub-programs, being:


Sustainable grazing on saline land


Native vegetation and biodiversity


Rivers and water quality


Managing pastoral country


Managing climate variability


Future woolscapes


Benchmarking

www.**landwaterwool**.gov.au

Profit

When we use the term profit, it tends to be given a very narrow interpretation that, in general, relates to how much money is being made from a particular activity. When you go to the dictionary, however, it is defined as 'advantage', 'benefit' or 'gain', a much broader way of thinking about the term. When working with woolgrowers it is clear that although economics is an important motivator for action, it is often a desire to be able to leave their property in better condition than when they took it over, or to restore a part of the creek that is special as a place for the family to gather, that is motivating their desire to do something. Profit in this sense, means far more than a commercial transaction or a decision based purely on business principles — it is about the range of benefits that can accrue from a decision, whether they be at an individual, family or community level.

Proof

High quality, technically rigorous science that is able to be applied is fundamentally important for good natural resources management decision making. Without good science underpinning management recommendations, there can be little confidence for the end-user that the required outcomes will be achieved. Importantly, scientists working on the Land, Water & Wool — Rivers and Water Quality Sub-program know that their work has to have practical application, so proof when used in this context, is to provide certainty to woolgrowers that the tools, techniques and guidelines that are developed, are done so on the basis of excellent science.

People

When it comes down to it, managing our natural resources is all about people and how we interact with our environment. However, we don't tend to spend a lot of time on this topic as we are all too busy managing the day-to-day issues that capture our attention. By mixing social scientists with biophysical scientists, the Land, Water & Wool — Rivers and Water Quality Program has been fortunate in developing a team of people with different skills, but who work well together and who are committed to getting the best outcome possible for end-users. Considerable effort has been made by those managing the Program to 'look after' the woolgrowers working on demonstration sites, and the general wool community, so that relationships are maintained and recognised as being fundamental to meeting the objectives the Program has set out to achieve. Oral histories have been used to chart the stories of woolgrowing families, photographic exhibitions, workshops, field days and opportunities for people to meet and share experiences have been created over the life of the Program to provide people with the opportunity to express themselves.

Place

When you ask someone what motivates them to change their behaviour it generally comes down to a feeling, for example, wanting to leave their 'place' in good condition for future generations, or wanting to preserve the special 'place' where they went fishing with their Dad. Emotion is what drives us to do most things, yet it is often not talked about and few resources are allocated to taking the time to understand the socio-cultural context within which someone is located. Without this understanding it is difficult to develop guidelines, management recommendations or tools that will be used. Trust and confidence take a long time to build, and asking someone to change their behaviour overnight is difficult when there may be no immediate benefit to them. The Land, Water & Wool — Rivers and Water Quality Sub-program has tried to create a 'place' for people to turn to for advice and assistance by providing excellent tools and materials, and by employing local project coordinators, who will stay on in the community long after the project has finished. Local people have been trained in the use of new techniques so that they can pass those skills on to others in the region. In this way, we have tried to ensure that the 'places' we have been working in can continue to undertake river restoration work with others in their local community, rather than looking to outsiders to do that work for them. The Sub-program has also 'placed' people in a network that they can remain a part of after the research project ends. This helps to ensure continuity of support for those that have been involved.

Promise

This final 'P' is the most difficult to describe, yet it is about valuing the relationships between people that generate trust, confidence and a desire to work together. Promises have been made to local woolgrowing communities involved in the Land, Water & Wool — Rivers and Water Quality Sub-program that we will listen, empathise, work together and leave something behind when we go. We are committed to ensuring we deliver this promise and examples have been given in this paper to demonstrate how we are doing this (oral histories, employing local project coordinators, training local people in new skills etc.).

Both sheep photos Australian Wool Innovation.

We have found that using the Five P framework makes it clear that each 'P' is equally important. In natural resource management there is a tendency to focus on the first two (Profit and Proof) with much talk, but few resources allocated to the other three. By considering the Five Ps, the experience of the Land, Water & Wool — Rivers and Water Quality Sub-program is better understood as being the result of a range of different factors and experiences, and not dominated by one 'P' over another. The Five Ps is an attempt to explicitly recognise the importance of considering the biophysical, economic, social and environmental together, rather than as separate parts of a puzzle. We believe the reason people relate well to the Five Ps is because the framework demystifies a lot of the jargon used in natural resources management and places the individual at the centre of the issue, rather than on the periphery.

Land, Water & Wool has a number of activities over the next few months that you might like to get involved in. I encourage you to regularly visit the website www.landwaterwool.gov.au to keep in touch. ■

For further information

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RiverLandscapes

Thank you to all

Well, you have reached the end of this *RipRap*, our biggest yet. When I look through this edition I am so proud of all the work we have done over the past 13 years, with so many fantastic people. A big 'Thank you' to all the researchers, the groups who have been involved in demonstration sites, and to all those people across Australia who have supported our Program, including the LWA Board and staff, and our funding partners.

RESOURCES www.landwaterwool.gov.au

These resources are available from www.**landwaterwool**.gov.au and also from www.**rivers**.gov.au/lww

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