Australian Government
Land & Water Australia

RipRap

RIVER AND RIPARIAN LANDS MANAGEMENT NEWSLETTER

TOOLS AND TECHNIQUES for river management

There is growing emphasis on regional management for rivers, with an expectation being placed on catchment management authorities and other regional groups to take on the responsibility of planning and managing their natural resources for the long-term. The shift to a regional model poses several challenges for organisations like Land & Water Australia, as the research we invest in, and the information we produce must be relevant, accessible and meet the particular needs of regional groups. This edition of *RipRap* highlights some tools and techniques that have recently been developed with these challenges in mind.

continued page 3

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CONtents

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

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RIParian lands:

WHERE LAND AND WATER MEET

From the Editor

Land & Water Australia's National Riparian Lands R&D Program, National River Contaminants Program and National Rivers Consortium are now entering their final year of investment, and this edition of *RipRap* is starting the process of translating the research undertaken into practical and useful tools and techniques for people working in river and riparian management. This edition provides information about new Rapid Appraisal of Riparian Condition tools; stream temperature guidelines; and how to extend the use of tools such as SedNet so that they can assist catchment communities decide where to invest limited resources. We also feature some new web-based products that enable you to explore how rivers function, as well as how to predict stream roughness coefficients for Australian river conditions. In developing these tools and techniques we have tried to be innovative and keep the needs of the user foremost in our minds. We hope you find this edition useful, and encourage you to contact us if you have any ideas about how we can further improve the communication and distribution of our research.

* Land & Water Australia has moved offices. The postal address is unchanged New telephone is **02 6263 6000** and new facsimile is **02 6263 6099**.

TOOLS AND TECHNIQUES for river management

By Ian Prosser
and Siwan Lovett

For its natural resource management programs, the Australian Government recognises more than 60 regional authorities as well as additional State government authorities operating at the catchment level. These organisations are charged with setting and meeting ambitious targets of improved river health, as well as a host of other land and water management objectives. The move to a regional level recognises that local action is not enough to solve larger scale problems. We now know that problems such as habitat degradation, flow modification and water quality, require larger-scale strategic investment, with explicit account of the catchment and regional benefits of work being done at the local river reach.

This shift in responsibility to the regional level provides communities with potentially more responsibility than they have ever had before in managing their natural resources. However, it also brings with it considerable challenges. Asking a community to come together (largely voluntarily) and develop a technically competent catchment land and water management plan, with detailed analyses of problems and priorities, requires that the regions have good access to scientific data and its interpretation, and to people skilled, willing and able to participate. However, in many parts of Australia this is not the case. Different groups may have quite different visions for the catchment, the process of collating data and reaching agreement on priorities is often ill-defined, and people with the requisite skills hard to find. Many regional groups are newly formed, and are dealing with unfamiliar government programs and reduced State agency capacities. These groups have limited resources and capacity to manage the large problems they face. It is also the case that even when research is available to assist decision making, it often requires people with considerable skill to apply it to particular regional situations.

When thinking about these challenges, Land & Water Australia's Rivers Arena committed itself to continuing to produce research in ways that make it relevant and accessible to regional groups, but to also try and play a more active role in supporting regional communities. Over the next 12 months we will be taking our research into the community by providing training to intermediaries (e.g. local catchment management authorities) so that they can use the tools and techniques being produced and pass those skills onto others in their region. Each of our research projects is also tasked with making their findings accessible and relevant in a regional context, and this edition of *RipRap* builds on earlier products such as the *Rehabilitating Australian Streams* CD ROM and the *Riparian Management Technical Guidelines*, that aim to put the techniques into the hands of those doing the work. In this edition we cover the basic principles and key management strategies required to optimise river restoration efforts when considering stream temperature, stream roughness coefficients and riparian condition. We also highlight a new educational tool that enables people to explore how river and riparian environments function, by choosing the topics that interest them and going at their own pace. We hope that you find this edition of *RipRap* useful, and if you are interested in being involved in our regional workshops, or have ideas about how we can better communicate with regional groups, please contact Penny Cook or Dianne Flett at Land & Water Australia on 02 6263 6000.

Photo below and front cover: CSIRO Sustainable Ecosystems.

DEVELOPMENT and application of a method for the

by Amy Jansen,
Alistair Robertson,
Leigh Thompson
& Andrea Wilson

Riparian habitats are where terrestrial and aquatic ecosystems meet. They are vital sites in a catchment, supporting high levels of biodiversity and being critical in controlling flows of energy and nutrients between terrestrial and aquatic ecosystems. Being at the boundary of terrestrial and aquatic ecosystems means that riparian areas are powerful indicators of catchment quality. Human settlement has always been focused on rivers and is often a major determinant of riparian structure and function. One of the biggest impacts on riparian areas has been the introduction of domestic stock, with grazing being the major land use over 60% of Australia's land surface. Stock concentrate around water sources, which means riparian and wetland habitats, as well as those around artificial watering points in pastoral regions, suffer greater impacts from domestic and feral grazing herds than dryland areas. These impacts have led to extensive loss of ecological condition in riparian areas in Australia.

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. Within this context a need was identified 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.

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.

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, as defined by Naiman & Decamps (1997) (see Table 1 opposite). Some of the indicators chosen reflect a variety of functions, e.g. 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 Rapid Appraisal of Riparian Condition (RARC) index is made up of five sub-indices, each with a number of indicator variables (see Table 2 overleaf). 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.

Applications of the RARC index

The RARC was initially developed as a tool to determine the impacts of grazing management practices on riparian condition, and to identify those practices which resulted in minimal impacts. We have now tested this approach in three areas of south-eastern Australia: on the Murrumbidgee River between Gundagai and Hay in NSW; in West and South Gippsland, Victoria; and in the Goulburn-Broken catchment also in Victoria. In all three regions, we examined the relationship between stocking rates and riparian condition, with Figure 1 (overleaf) showing our results. Clearly, riparian condition declined with increased stocking rates, across all regions and a large range of stocking rates. Given

Rapid Appraisal of Riparian Condition

***Table 1**: Functions of the riparian zone at different levels of organisation, the components of the riparian ecosystem which perform those functions, and the indicators of the function used in this study.*

Functions	Components	Indicators
Physical		
Reduction of erosion of banks	Roots, ground cover	Vegetation cover*
Sediment trapping	Roots, fallen logs, ground cover	Canopy cover, fallen logs, ground cover vegetation, leaf litter cover
Controlling stream microclimate/ discharge/water temperatures	Riparian forest	Canopy cover
Filtering of nutrients from upslope	Vegetation, leaf litter	Ground cover vegetation, leaf litter cover
Community		
Provision of organic matter to aquatic food chains	Vegetation	Vegetation cover*, leaf litter cover
Retention of plant propagules	Fallen logs, leaf litter	Fallen logs, leaf litter cover
Maintenance of plant diversity	Regeneration of dominant species, presence of important species, dominance of natives *vs* exotics	Native canopy and shrub regeneration, grazing damage to regeneration, reeds, native vegetation cover*
Provision of habitat for aquatic and terrestrial fauna	Fallen logs, leaf litter, standing dead trees/ hollows, riparian forest, habitat complexity	Fallen logs, leaf litter cover, standing dead trees, vegetation cover*, number of vegetation layers
Landscape		
Provision of biological connections in the landscape	Riparian forest (cover, width, connectedness)	Vegetation cover*, width of riparian vegetation, longitudinal continuity of riparian vegetation,
Provision of refuge in droughts	Riparian forest	Vegetation cover*
* Vegetation cover = canopy, understorey and ground cover		

***Photo 1**: A site in excellent condition on the Edward River (RARC score = 50; note continuous canopy of native trees, standing dead trees and fallen logs, native shrub understorey, reeds and regeneration of canopy trees).*

***Photo 2**: A site in very poor condition on the Murrumbidgee River (RARC score = 13.2; note discontinuous canopy, lack of shrubs, small amounts of leaf litter, lack of native ground cover and reeds, little regeneration of canopy trees).*

For further information

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Table 2: Sub-indices and indicators used in the Rapid Appraisal of Riparian Condition.

Sub-index	Indicators
HABITAT (Habitat continuity and extent)	~ Width of riparian vegetation ~ Longitudinal continuity of riparian vegetation
COVER (Vegetation cover, structural complexity)	~ Canopy (greater than 5 metres tall) ~ Understorey (1–5 metres tall) ~ Ground (less than 1 metre tall) ~ Number of layers
DEBRIS (Standing dead trees, fallen logs, leaf litter)	~ Leaf litter ~ Standing dead trees (greater than 20 centimetres diameter at breast height) ~ Fallen logs (greater than 10 centimetres diameter)
NATIVES (Dominance of natives *vs* exotics)	~ Canopy (greater than 5 metres tall) ~ Understorey (1–5 metres tall) ~ Ground (less than 1 metre tall) ~ Leaf litter
FEATURES (Indicative features)	~ Native canopy species regeneration ~ Damage to regeneration ~ Native shrub/sub-canopy regeneration ~ Reeds

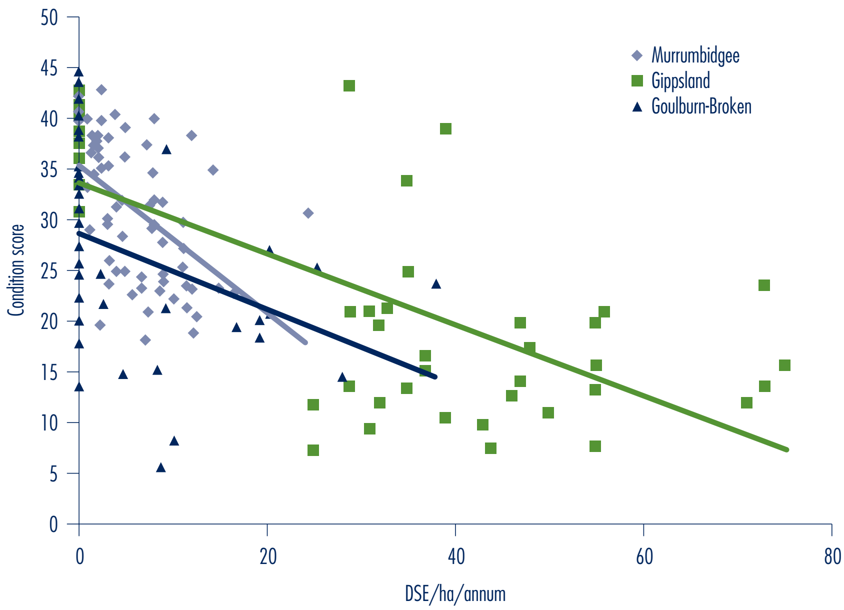

***Figure 1**: Condition scores in relation to stocking rates (DSE/ha/annum) for three regions: Murrumbidgee River, West and South Gippsland, and upper and mid-Goulburn-Broken catchment.*

the large number of sites in poor condition in all catchments, this suggests that stocking rates commonly used on private properties are too high to maintain riparian zones in good condition.

Why is the RARC a useful tool?

What does riparian condition tell us about the biodiversity and functioning of riparian zones?

The RARC has been tested against more detailed measures of the biodiversity and functioning of riparian zones in the Murrumbidgee and Gippsland regions. There was a significant positive relationship between litter decomposition rates in the soil and the COVER sub-index of the RARC score in both Summer (r = 0.50, $p < 0.05$) and Autumn (r = 0.78, $p < 0.01$), indicating that decomposition rates were higher where there was more vegetation cover in the riparian zone of the Murrumbidgee River.

There were highly significant relationships between bird communities and all sub-indices, as well as the total RARC score (r = 0.68, $p < 0.0001$), indicating that riparian bird communities varied according to the condition of the riparian zone of the Murrumbidgee River. Of particular significance (r = 0.74, $p < 0.0001$) was the DEBRIS sub-index (scoring for leaf litter, fallen logs and standing dead trees), indicating that retention of leaf litter and woody debris in riparian habitats is crucial to the survival of riparian bird communities. Many of the species most dependent on these features (e.g. Brown Treecreepers) are threatened or declining throughout the agricultural regions of southern Australia. In Gippsland, there was also a significant relationship (r = 0.59, $p < 0.0001$) between bird communities and the total RARC score, indicating again that riparian bird communities varied according to the condition of riparian zones in Gippsland.

r = correlation coefficient (indicates the strength of a relationship

p = significance (where $p < 0.05$ indicates a significant relationship)

Given the importance of riparian zones in supporting high levels of regional biodiversity, and the links between riparian condition and biodiversity demonstrated here, the RARC is a useful tool for assessing riparian condition and hence biodiversity and functioning of riparian zones.

Inter-observer reliability testing of the RARC

Ten people participated in a RARC training workshop in November 2003, including three already trained in the method. As part of the training, 11 sites were each visited by three to four observers. Each observer independently scored riparian condition at each site, so that pairs of scores for each site could be compared as shown in Figure 2. It can be seen that most scores fell within two points of each other, and the maximum difference between the scores of different observers at the same site was five points, or 10% of the total possible score. This suggests very good inter-observer reliability, with even minimal training (half a day).

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 now freely available as the fourth in our *River and Riparian Management Technical Guideline* series, contact CanPrint Communications on 1800 776 616 or download it from the website www.rivers.gov.au.

If you would like further information about the method, are are interested in attending a training workshop, please contact:

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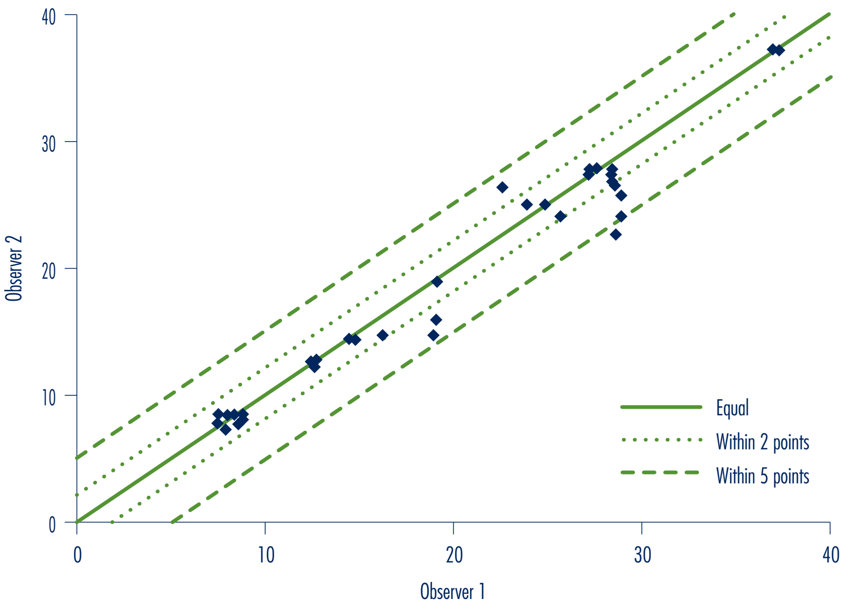

Figure 2*: Scores obtained for the RARC by pairs of observers at the same sites.*

TRIALLING of the Tropical Rapid Appraisal of Riparian Condition method

By John Dowe, Ian Dixon and Michael Douglas

Background

Riparian zones are vital elements of the savanna landscape. Their contribution to biodiversity, cultural values and the economy is disproportionate to the small area they occupy. They are important for maintaining water quality, stream geomorphology and the biodiversity of the stream and surrounding savanna. However, savanna riparian zones are highly vulnerable to the effects of disturbances such as weed invasion, feral animals, fire and overgrazing. Threats to riparian health are compounded by the fact that riparian zones are the focus for much activity related to the development of northern Australia (such as grazing, agriculture and tourism) and the concentration of use in these habitats is likely to increase in the future. Consequently, there is a growing need for practical techniques for assessing and monitoring the condition or health of savanna riparian zones.

Techniques to determine the ecological integrity of waterways and associated riparian zones have been developed to provide information that assists in land management, ecological restoration and rehabilitation (Karr 1999). Many of these techniques are framed around scoring systems, in which it is assumed that the natural, fully integrated 'healthy' system will score high marks and that less natural and less healthy systems receive correspondingly low scores. In Australia, there has been the recent development of rapid appraisal techniques that enhance the accumulation of data on the condition of the riparian zones in many localities, and with an emphasis being on 'rapid', i.e. for surveys to be completed and results to be presented in a shortened time-frame. The advantage of rapid appraisals is that they can be completed by an individual with limited scientific knowledge, and can facilitate programs to provide immediate assistance to land management, restoration and rehabilitation. There can be both environmental and economic advantages in implementing such programs.

Rapid appraisal of riparian condition methods have been developed for river systems in southeast Australia and the moist areas of eastern Queensland. However, for river systems in the seasonally dry/monsoonal areas of tropical Australia, these methods have proved not to be totally suitable, and a more appropriate method for such areas has been developed by the Tropical Savannas Co-operative Research Centre (Charles Darwin University, Australian Centre for Tropical Freshwater Research, Townsville, and CSIRO – Sustainable Ecosystems). This article introduces the Tropical Rapid Appraisal of Riparian Condition (TRARC) method, and presents the results of a testing of the method at 34 sites within the Burdekin River catchment. The TRARC is designed to complement the RARC described on page 4 of this edition of *RipRap*.

Tropical river systems

Are there fundamental differences between river systems in southern Australia and northern Australia that should be considered in the study of riparian zones? The rapid assessment of riparian condition (RARC) method proposed by Jansen & Robertson (2001) was developed for the multi-use impact sites of rivers in south-east Australia, and has been used at sites on the Murrumbidgee, Murray, Goulburn and LaTrobe Rivers (Jansen et al. 2004). Jansen et al. (2004) concluded that their method "is a good indicator of the biodiversity and functioning of riparian zones". Werren & Arthington (2002) proposed a method aimed at providing a standard riparian assessment of Queensland streams. This method was based on a strong theoretical framework for the examination and scoring of perennially flowing streams in the moister areas of eastern Queensland (Werren 2002). Neither the Jansen et al. (2004), nor the Werren & Arthington (2002) methods has proven to be totally effective in dealing with the rivers in the seasonally dry/monsoonal areas of tropical Australia, primarily because they did not account for some of the key characteristics that distinguish these systems from those elsewhere. Some of the factors that may distinguish river systems in seasonally dry northern Australia

in the Burdekin River catchment, northeast Queensland

from those in southern Australia and eastern Queensland include:

~ pronounced effects of seasonality on the vegetation;
~ predictable and regularly recurrent fire events;
~ unpredictable but recurrent high impact flood events;
~ greater diversity in biotic influences;
~ lower diversity in land-use patterns, (generally dominated by cattle grazing); and
~ lower occurrence of exogenous impacts.

Notwithstanding that there should be a different approach to riparian condition appraisals based on the factors listed above, the basic indicators to be measured and used in condition appraisals remain similar to those used in the established schemes (for example, see page 5 of this edition of *RipRap*).

Tropical Rapid Appraisal of Riparian Condition (TRARC)

The Tropical Rapid Appraisal of Riparian Condition (TRARC) is used to score a number of readily observable attributes of the vegetation in the riparian zone, to provide an overall score that is intended to comparatively grade the 'ecological health' of the site. Total scores are calibrated at 0–100, with higher scores indicating 'healthier' sites. Additional geomorphologic and topographic features are also recorded. The basic scoring system is composed of the following elements:

~ riparian width and linear continuity;
~ percent cover of canopy, understorey and ground cover vegetation;
~ presence of woody debris and standing dead vegetation;
~ indigenous species regeneration; and
~ presence of weed species.

In addition, supplementary data records the following:

~ slumping, gullying and sheet erosion;
~ location of fences and water points;
~ number of cow pats (as an indicator of stocking rates);
~ water permanency;
~ dominant tree population structure; and
~ dominant weed population structure.

The supplementary data sheets do not directly contribute to the TRARC score system, as most of the data collected are either descriptive or qualitative. These data are most appropriately used for the characterisation of sites, based on single characters (e.g. dominant tree species) or small suites of characters.

Methods used in the preliminary study

The base criteria for scoring the TRARC method were developed during the Tropical Savannas CRC Riparian Health Workshop conducted in October 2003 at James Cook University, Townsville. The method was then applied to riparian vegetation adjacent to 34 permanent waterholes in the Burdekin River catchment. At each waterhole site, a single 100 metre transect was laid out parallel to the stream flow, with the midpoint positioned adjacent to the centre of the water body. In cases where the water body exceeded 100 metres in length, a representative section of bank was chosen. Transects were placed most commonly at 5 metres from the stream flow edge but where access was restricted or the riparian zone was relatively wide, transects were laid up to 20 metres from the stream edge. The transect was traversed on foot and indicators appropriately scored on the data sheets. The time taken to complete each survey varied between 50 and 90 minutes per site, depending on the topography, complexity of the site, and density of vegetation. Cow pat frequencies were used to estimate stocking rates.

Results

The allocation of scores and ratings for the 34 sites is provided in Table 1. The greatest number of sites, 13 (38.2% of total), was in the 'average' category, but the results were significantly biased toward the 'very poor' and 'poor' categories in which 7 (20.6%) and 11 (32.4%)

Rating	Score	Number and percentage of sites with rating (n=34)	
very poor	<50	7	(20.6%)
poor	50–59	11	(32.4%)
average	60–69	13	(38.2%)
good	70–79	3	(8.8%)
excellent	80–100	0	

***Table 1**: The allocation of ratings and scores to the 34 sites used in the preliminary TRARC study in the Burdekin catchment area.*

sites were respectively allocated. Only three (8.8%) of the sites were in the 'good' category and there were no sites in the 'excellent' category. The site with the highest score was an anabranch of the Cape River (Figure 1). The site with the lowest score was a water hole on the upper Basalt River (Figure 2).

A range of data was collected, with detailed analyses undertaken of tree species, weed species and the impact of stock. The impact of stock was measured by the relationship between the number of cowpats at each site and the corresponding TRARC scores for those sites (Figure 3). The results indicate that with an increase in the number of cowpats there is a corresponding decrease in the TRARC score.

***Figure 1**: A survey site on an anabranch of the Cape River was the highest scoring site in the preliminary study, with a score of 77 and allocated to the 'good' category. The dominant tree species was* Melaleuca fluviatilis, *and the dominant weed species was* Cryptostegia grandiflora *(rubber vine). Photo was taken 29 November 2003, prior to the commencement of the wet season.*

***Figure 2**: A survey site on the upper Basalt River was the lowest scoring site in the preliminary study, with a score of 39 and placed in the 'very poor' category. The dominant tree species was* Eucalyptus camaldulensis *and the dominant weed species was* Brachiaria mutica. *Photo was taken 22 January 2004 following the commencement of the wet season.*

Discussion

Rapid appraisal methods, by their very nature, can provide only a 'snap shot' of the condition of vegetation in the riparian zone. There are restrictions on time, on the amount of data that can be collected, and are confined to examination of a site on a single day of a year. Survey sites can be strongly influenced by seasonal changes, fluctuations in stocking rates, and the 'natural' flow of plant dispersal, establishment, growth and senescence, and indeed may not be representative of the site over an extended time frame. However, if the key components of riparian health can be documented in a comparative and consistent manner, then an appropriate and useful appraisal of the site is possible.

This trial of the TRARC method has attempted to recognise weaknesses and strengths in the method. Based on the results of 34 sites, the scores for the sites are strongly biased on the 'negative' side of the average of 59 [out of 100], and overall indicate that the riparian zones within the Burdekin River catchment are in relatively poor ecological health. However, with a change in the weighting of some indicators, the scoring average may be readily shifted to the positive side of the scale, and another conclusion may be drawn. The qualitative indicators recorded on the supplementary data sheet, indicate that the

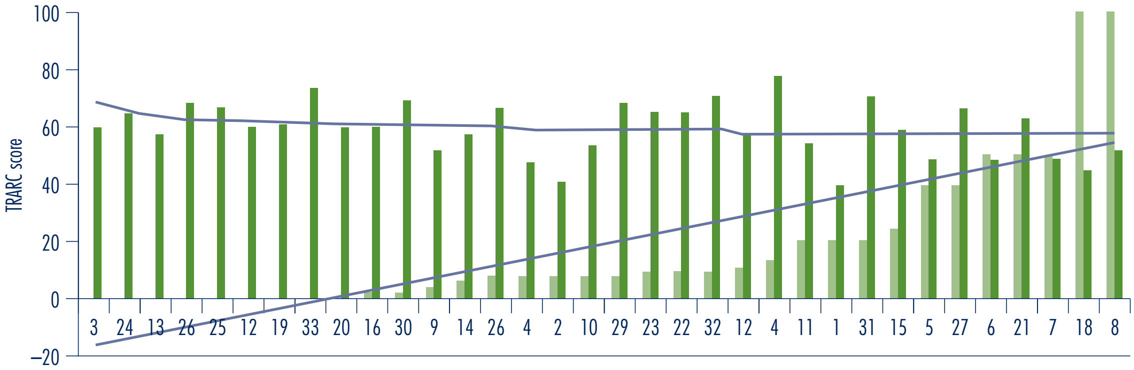

***Figure 3**: Graph with trend lines indicating the relationship between the TRARC scores for all 34 sites and the number of cowpats at each site in the Burdekin River catchment preliminary study. TRARC scores are represented by the dark green blocks (each site); numbers of cow pats are represented by the light green blocks.*

health of the surveyed sites is not as poor as indicated by the quantitative indicators. If single indicators such as: the presence of weeds; the regeneration and population structure of dominant trees; and degree of geomorphologic degradation as indicated by slumping and gullying, were incorporated into the scoring system, the average site score may increase considerably. It may be that the TRARC scoring system needs to be refined to incorporate these other measures.

The site data gathered by the TRARC method may also be used for other purposes. For example, site 'characterisation' as determined by a small number of 'spot' indicators is possible. Sites can be characterised by the dominant tree species, the dominant deleterious weed species, and stocking rates, among other characters. Site characterisation may assist with determining degrees of vulnerability within discreet areas such as single rivers or catchments. The results of the 34 sites indicate that the presence of certain dominant tree species may predispose the site to weed infestation or the damage caused by cattle. Conversely, it may be that certain weed species tend to infest certain ecological settings. For example, the rubber vine, *Cryptostegia grandiflora*, has a propensity in the surveyed sites to become established in sites where the population structure of the dominant tree species is deemed 'healthy'. The TRARC data may be useful for identifying other such correlations and associations.

Improvements to the TRARC method

Further development of the TRARC will consider the potential variation between different seasons, users and sites. Ideally, sites should be surveyed a number of times per year to determine an 'average' condition based on a variety of seasonal influences — for example, some of the deleterious weeds species can be transitory across the landscape, reflecting seasonal changes and long-term climate perturbations. Inter-operator variability will be extensively tested and the TRARC methods refined accordingly to ensure consistency of data collection. The TRARC, like other rapid appraisals, aims to provide a balance between scientific accuracy, time, cost and ease of use. On completion of these trials, a collaborative Land & Water Australia and Tropical Savannas CRC – River and Riparian Management Technical Guideline (like the *Rapid Appraisal of Riparian Condition Technical Update 4*) will be produced to communicate the method.

Concluding comments

As Jansen et al. (2004) concluded that their RARC method, as used in river systems of south-east Australia, was "a good indicator of the biodiversity and functioning of riparian zones", the same can be said of the TRARC method in the seasonally dry/monsoonal areas of tropical Australia. This trial of the method in the Burdekin River catchment provides a basis on which to improve the TRARC method, and expand its use to other systems in tropical Australia. Savanna land managers in northern Australia will soon have a standard method for rapidly appraising the condition of their riparian vegetation.

For further information

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CATCHMENT assessment techniques to help determine priorities in river

by Scott Wilkinson

Introduction

There is growing interest in rehabilitating streams to improve their physical and ecological condition. Common stream problems include poor water quality, sedimentation of aquatic habitat and degraded riparian zones. Unfortunately, the magnitude of work required to repair past degradation far exceeds the resources available. Stream rehabilitation must therefore be targetted to those high-priority areas that will produce greatest environmental benefit from the resources available. It is also wise to tackle high-priority sites as early as possible, since physical and ecological response times to rehabilitation actions can be long. Environmental degradation of stressed systems can occur in response to cumulative flood or drought events, and the longer a system is degraded prior to rehabilitation, the greater the risk that the natural resilience of the system will be exceeded.

Planning and funding decisions for river management are increasingly being made at the regional scale. There is also a growing requirement for a technical basis to underpin decisions about river management. There are well established frameworks for setting rehabilitation priorities (for example, the *Rehabilitating Australian Streams*, CD ROM and Manual, Rutherfurd et al.) and these are being implemented by many catchment managers using databases that also consider the social and economic goals for the catchment. However, there is often a lack of quantitative information on catchment condition to enter into these databases. This project aims to provide regional scale techniques for assessing suspended sediment, sedimentation of habitat and riparian condition, which can be used to identify priorities for the location and type of rehabilitation activities to achieve maximum environmental benefit.

Approach

The approach we have taken to developing catchment assessment techniques is to represent environmental processes in a GIS framework. We are using spatial datasets as inputs to assess condition across large-scale river networks. The process basis to the assessments allows condition to be assessed, as well as identifying the *causes* of poor condition (and the necessary requirements for good condition). This enables priorities for action to not only be identified, but to be simulated so that the impact of different rehabilitation actions can be compared.

The two assessment techniques being developed are:

- SedNet sediment budgets for river networks (Prosser et al. 2001a, 2001b)
- Rapid Appraisal of Riparian Condition (RARC) — an assessment of the biodiversity and function of riparian zones (Jansen & Robertson 2001, Jansen et al. 2004, see page 4).

Both of these techniques existed prior to this project, however, neither technique was suited, nor tested, as a technical basis for regional catchment assessment and prioritisation. SedNet was developed as a continental scale technique for the National Land and Water Resources Assessment, and the RARC was designed as a site based assessment technique.

The project has three focus catchments where we are adapting, further developing, and testing the techniques for setting priorities at a regional scale. The catchments are the Murrumbidgee upstream of Wagga Wagga in New South Wales, the Goulburn-Broken in Victoria and the Mt Lofty Ranges in South Australia. These catchments were chosen because they are of suitable regional scale (6000–30,000 km^2); erosion and riparian condition are important issues; and they have management agencies actively planning stream rehabilitation at the regional scale. Importantly, all three catchments have a sufficient amount of data to enable the assessment techniques to be applied. The project is testing the assessment techniques in collaboration with the catchment management agencies, to determine in practice how useful they are in informing the process of setting rehabilitation priorities to achieve a specified catchment vision.

restoration

SedNet

SedNet constructs sediment budgets (mass balances) for each reach or link in a river network (see Figure 1). Conceptual representations of erosion, transport and deposition processes are parameterised using regional datasets of canopy cover, landuse, a digital elevation model and stream flow.

Tailoring SedNet for catchment-scale assessment has involved developing methods for using high-resolution datasets, improving the process representations to reduce uncertainty in the predictions, and testing against observations. These changes have meant that SedNet can now predict the location of bedload accumulation (e.g. 'sand slugs'), and the consequent impact on river habitat (see Figure 2), with an accuracy of up to 80%. This information can be used to identify where habitat enhancement structures may be used to provide passage through reaches affected by bedload accumulation. The technique also allows us to predict the future trajectories of these sand slugs given planned reductions in sediment supply.

In the stream rehabilitation strategies for all three focus catchments, reducing the supply of suspended sediment is an important element in achieving the desired catchment vision. Since we predict the sediment supply from each erosion process, SedNet can be used to identify the dominant erosion process as the greatest priority for control measures. For example, channel erosion (river bank and gully) can be reduced by riparian revegetation, while hillslope erosion can be reduced by landuse and practise management.

SedNet can also be used to target erosion control measures in the areas that supply the highest rates of sediment (t/ha/y) to the stream network. Sometimes the goal is to reduce suspended sediment export to the coast or downstream river systems, and in this case the efficiency of transport to the catchment outlet is also considered to determine the rate of 'contribution' to export. Figure 3 shows the rate of contribution to suspended sediment export from the Murrumbidgee focus catchment in t/ha/y.

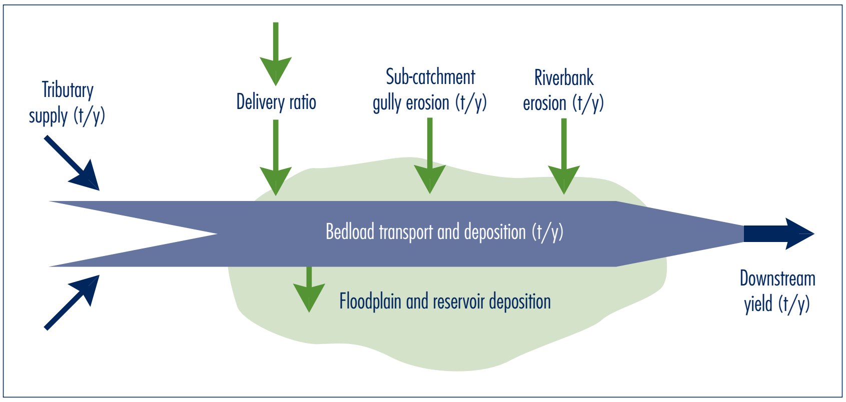


Figure 1: *Erosion, transport and deposition terms included in the SedNet mass balance of sediment for a river link*

Figure 2: *A sand slug caused by bedload accumulation in the Murrumbidgee catchment.*

The data shows that erosion downstream of the reservoirs contributes the most to export, while erosion above the reservoirs settles out in the reservoirs. Targeting erosion control to the areas with the highest rates of erosion can produce a much greater reduction in suspended sediment loads than the spatially random erosion control measures that are commonly used. In the Murrumbidgee catchment, channel erosion is the dominant sediment source. We found that targetting 600 kilometres of riparian revegetation to the purple 'hotspot' areas in Figure 3, could give twice the reduction in suspended sediment export than would be provided by 600 kilometres of revegetation done at random. Figure 4 shows this response.

t/y = tonnes/year
t/ha/y = tonnes/hectare/year

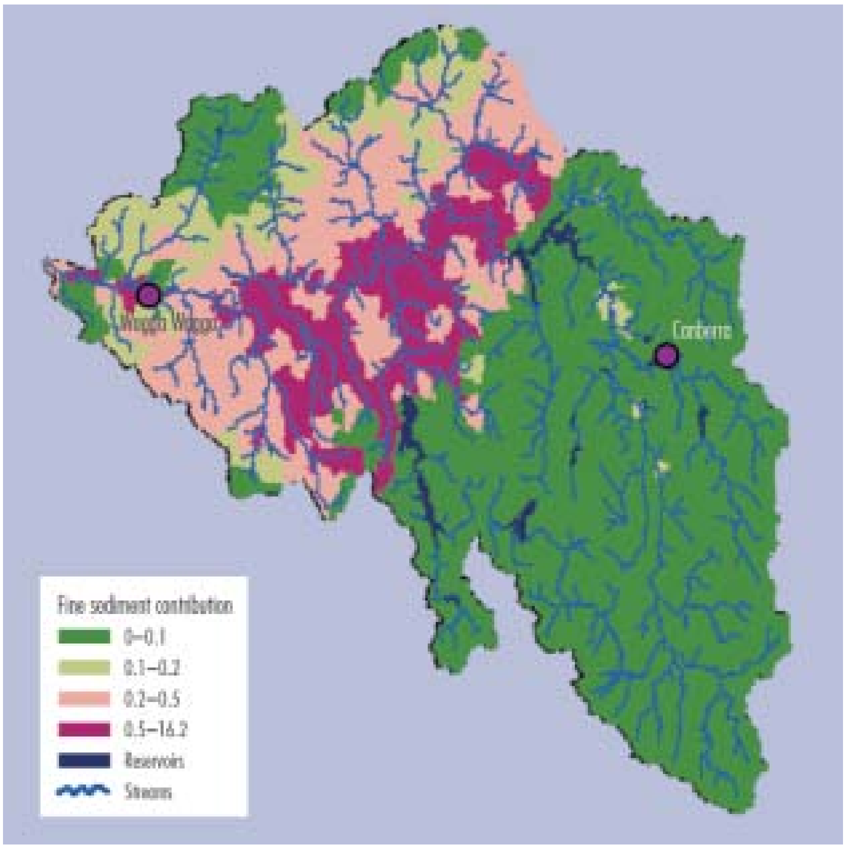
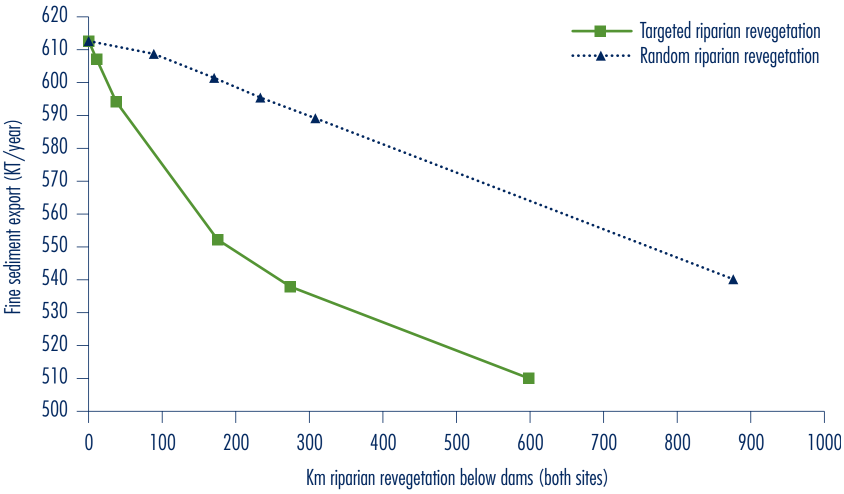


***Figure 3**: Rates of specific suspended sediment contribution (t/ha/y) to Wagga Wagga in the Murrumbigee catchment.*

***Figure 4**: Comparing the effect of targetted vs random channel erosion control on suspended sediment levels at Wagga Wagga.*



The benefits of targeting rehabilitation efforts to high priority areas will take a number of years to be realised, as vegetation takes time to establish and stabilise gullies and river banks. The value of using SedNet is that it focuses activity and resources in areas that will return the greatest benefit, preventing scarce resources from being diluted by randomly choosing sites for rehabilitation.

Extending the Rapid Appraisal of Riparian Condition

For catchment-scale assessment, we needed a method of assessing riparian condition that does not require on-ground visits, since many catchments are large and field time is expensive. The aim of this part of the project was to determine whether existing vegetation cover mapping, derived from satellite imagery, could be used to assess riparian condition. Firstly, we investigated the relationship between the total RARC score for a site and those scores that potentially could be measured from remotely sensed data. These scores included canopy cover, riparian vegetation width and longitudinal continuity of riparian vegetation. Canopy cover explained 67% of the variance in the total RARC score for 46 sites in the Goulburn-Broken catchment in Victoria, while adding riparian vegetation width and longitudinal continuity of riparian vegetation increased this to about 75%. These three variables can be readily measured from remotely sensed vegetation cover layers.

To compare the results from on-ground surveys with those from satellite imagery, we then derived canopy cover, riparian vegetation width and longitudinal continuity of riparian vegetation from satellite imagery, at the 46 sites where on-ground measurements were made. The imagery we used was derived from SPOT pan-chromatic imagery, using 10m pixels, called TREEDEN25, which is available for all of Victoria. Figure 5 shows the relationship between the on-ground total RARC score, and the score for the 3 components derived from the satellite imagery at the same sites. Measurement of these 3 components explained 66% of the variance in the on-ground RARC scores. In fact, measurement of the canopy cover score alone from the satellite imagery explained a similar amount of variance in the on-ground RARC scores.

Given the good relationship between canopy cover measured from the satellite imagery, and on-ground RARC scores, there is now potential to assess riparian condition from existing vegetation cover data. We did this for the Goulburn-Broken catchment by assessing canopy cover in riparian zones four times the width of stream channels, using the TREEDEN 25 vegetation layer as an indicator of riparian

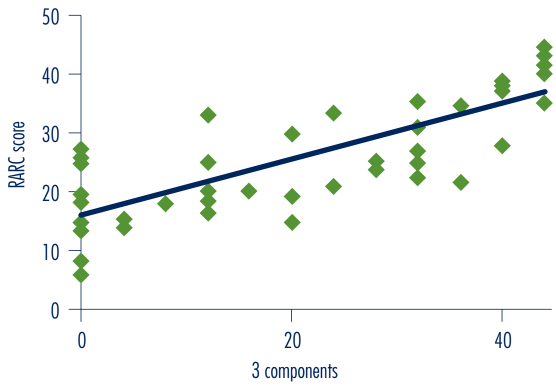


Figure 5*: Measurement of the three components (canopy cover, riparian vegetation width and longitudinal continuity of riparian vegetation) derived from satellite imagery in relation to total on-ground RARC scores at 46 sites in the Goulburn-Broken catchment, Victoria.*

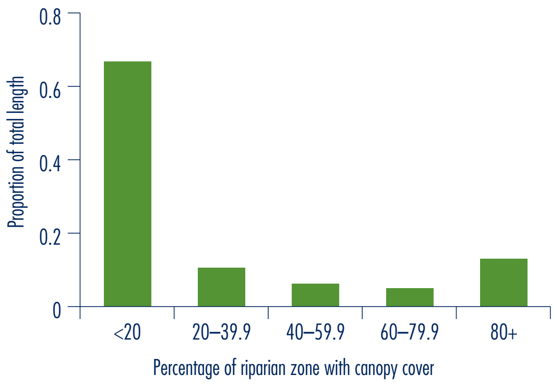


Figure 6*: Proportion of total stream length with riparian zone canopy cover as indicated, for streams in the Goulburn-Broken catchment, Victoria.*

condition. Figure 6 shows that of a total length of 4620 kilometres of streams assessed, a very high percentage (67%) has <20% tree cover in the riparian zone, indicating very poor riparian zone condition. Less than 15% of the total length had >80% canopy cover in the riparian zone, indicating good condition.

These results suggest that riparian condition can be assessed using satellite imagery, albeit with some loss of detailed information. The information lost is clearly related to the condition of understorey and ground cover layers, which although often highly correlated with tree cover, may vary depending on the land management practices of individual property owners. Whilst this detailed information is important, combining the RARC assessment approach with satellite imagery allows broader catchment wide assessments to be made about riparian condition, with this approach useful for setting priorities for rehabilitation. For example, this technique will enable groups to target and protect small remnants of vegetation in upstream reaches that are in good condition, or to target revegetation efforts so that they build outwards from areas already in good condition.

Application

An important final stage of the project will be to develop protocols for how SedNet and the RARC could be used more widely by catchment groups and others, to simulate scenarios and make informed choices in planning rehabilitation activities. SedNet software is being developed in the Catchment Modelling Toolkit, and this will provide one avenue for adoption. We will also evaluate the benefits of using the techniques in achieving river rehabilitation goals. This information, along with the focus catchment demonstrations, will hopefully result in the techniques being broadly adopted as the basis for planning activities designed to improve the condition of our streams. The project is due for completion in June 2006, and we will have full details of where you can access the final product in *RipRap* and on the www.rivers.gov.au website.

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RIPARIAN RESTORATION reduces in-stream thermal stress

by Peter Davies, Terry Walshe and Barbara Cook

Riparian vegetation has considerable benefits for many different aspects of river structure, biotic composition and ecological function. Despite these multiple benefits, it has remained difficult to be prescriptive about the actual amount of vegetation required to achieve various ecological goals. This is unfortunate, as riparian zones are highly productive areas of agricultural landscapes and farmers are often understandably reticent to set-aside significant riparian regions for vaguely-defined benefits.

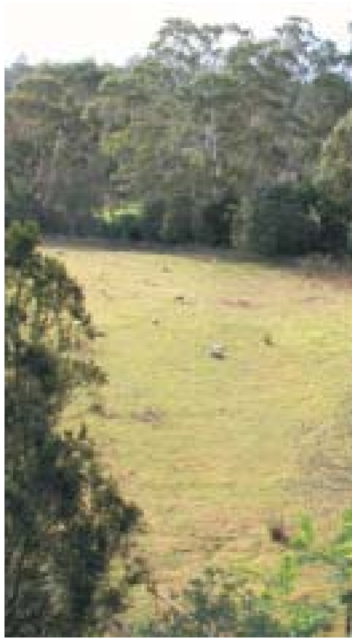
Riparian vegetation shades channels and consequently reduces in-stream water temperatures. Temperature controls many ecological processes and can directly affect biodiversity by exceeding upper lethal limits of resident aquatic fauna, or indirectly by both increasing oxygen demand and decreasing oxygen saturation; the combined effects of both can lead to anoxia (Bunn & Davies 2002).

While river managers need to consider the broad range of benefits of riparian vegetation, one advantage of focussing restoration effort on achieving temperature targets is that the results of on-ground action may be more easily predicted, measured and demonstrated, compared to other stressors such as nutrients or sedimentation. Consequently, a recently completed project funded by Land & Water Australia characterised bioregional temperature regimes throughout Australia and provided prescriptions for riparian restoration needed to satisfy predetermined temperature thresholds.

Elevated in-stream temperature is a highly variable environmental stressor in both 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 relatively 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.

Prior to European settlement and associated broad-scale land clearing, it was likely that in warmer times of the year and during times of low flow, most bioregions and catchments in Australia experienced patches of temperature stress that probably exceeded lethal or sub-lethal levels for resident biota. At larger spatial scales, in times of elevated thermal stress, higher-order streams would effectively act as seasonal refugia for sensitive components of the biota. At a more local scale, deeper pools in smaller streams would also provide some refugia function.

__Left__: Sampling in the upper reaches of the Coal River, south-east Tasmania on a mid-winter's morning.
__Centre__: WhiteKanga – intact and fences riparian vegetation, south-east Tasmania.
__Right__: Kauri-up – a tributary of the Johnstone River, Far North Queensland.



Upcoming guidelines for managers

Under natural conditions, the interplay of climate and flow would sometimes result in the transient loss of habitat and the imposition of thermal barriers to effective dispersal and migration. With the widespread removal or degradation of riparian vegetation, the problem today is that what was once a localised and transient loss of habitat, has become a common and possibly dominant feature throughout many Australian streams and rivers.

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 (Rutherford et al. 1997, Rutherford et al. 1999). 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.

What might be a tolerable level of heat stress for Australian systems? In this project, 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 macro-invertebrates occurring in "cool" and "hot" climates, respectively. Of the 14 locations around Australia modelled in the project, we defined 'hot climates' as any region having a latitude less than 18°S of the equator. 'Cool climate' locations assigned temperature thresholds (based on LT_{50} testing) of 21°C were those with latitudes greater than –35°. 'Intermediate' locations were assigned a temperature threshold calculated conservatively as a linear interpolation between 21°C and 29°C based on latitude. For example, thresholds for Melbourne and Broome were calculated as 21°C and 29°C, respectively. Townsville's assigned threshold was 28.4°C.

In reporting lethal effects, LT_{50} tests comprise two components — absolute temperature and the time duration of exposure to that specific temperature. The 21°C and 29°C thresholds for cool and hot climates 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 in the project was to define eight hours as the daily "window" of time beyond which temperatures, in excess of the threshold, were regarded as intolerable.

This approach acknowledges that, even where riparian vegetation is intact, the physiology of temperature sensitive biota will be occasionally compromised under summer or low flow conditions. In defining a time window of eight hours, it is implicitly assumed that this level of exposure represents a low level of risk for the longer term integrity of a stream's structure, function and composition. By necessity, this is a working assumption and more detailed ecological and physiological studies are needed to substantiate its validity.

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 fauna.

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 the 14 Australian locations were run under conditions of zero shade, with each of the 12 simulations representing average monthly flow and weather conditions. The maximum temperatures for each month reported by these simulations for Broome, Townsville and Melbourne are shown in Figure 1.

Maximum temperatures are a coarse descriptor of thermal stress. Greater insight is offered by considering the amount of time (both monthly and daily) a site experiences in-stream temperatures in excess of specified thresholds. Figure 2 illustrates the average effects of seasonality on diurnal in-stream temperatures for three locations as a three-dimensional surface chart. For example, thermal stress in first-order streams is likely to occur throughout the year at Broome and Townsville, while in Melbourne it is restricted to the warmer months.

The simulated data used to produce the three-dimensional surface charts in Figure 2 are summarised in Table 1, where the average daily time window in which temperature thresholds are exceeded are provided for each location and month. Although Broome and Townsville all experience in-stream temperatures beyond their associated threshold throughout the 12 months of the year, the exposure time during cooler months is ecological tolerable, being less than eight hours.

The simulation output shown in the figures and table are for lower order streams having no shade. For each location, simulations were re-run with varying shade levels to ascertain the shade required to reduce the average daily exposure time to eight hours or less within each month. For Broome, Townsville and Melbourne shade targets of 60, 50 and 55% were identified respectively. Of the 14 locations modelled, the most extreme shade targets were for Sydney (75%) and Hobart (5%).

Simulation results suggested no simple pattern in the shade requirements for different

Stream shade created by downcutting (topographical shading), Western Australian wheatbelt.

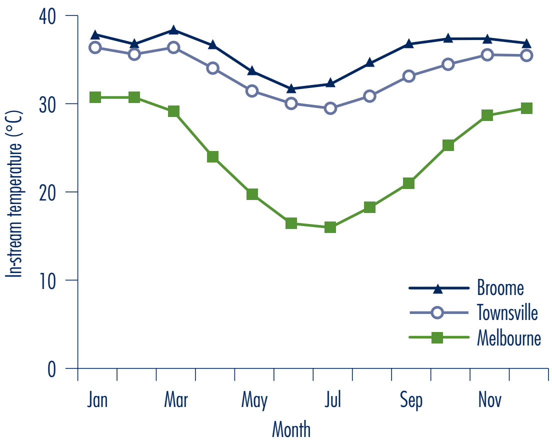


***Figure 1**: Average maximum daily in-stream temperatures at three locations for a hypothetical first-order stream having zero shade.*

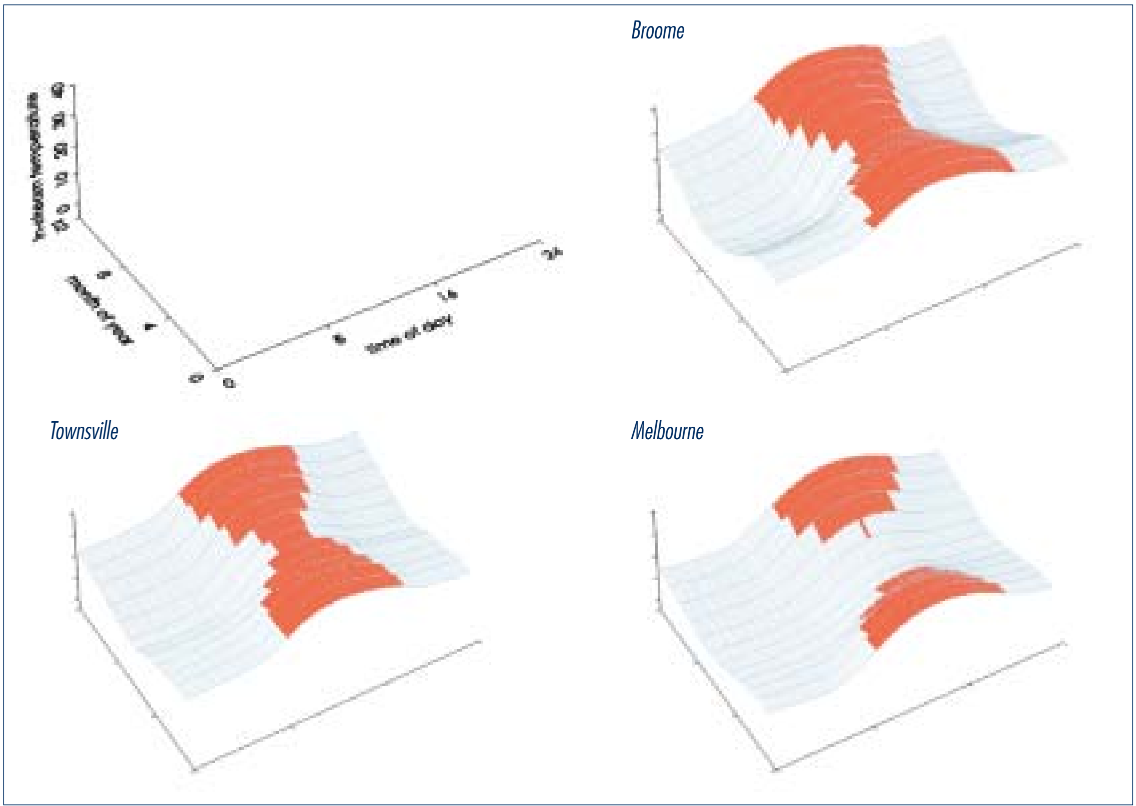


***Figure 2**: Three-dimensional surface charts showing monthly and diurnal trends in average in-stream temperature for a hypothetical first order stream, with zero shade, at three of the 14 locations modelled. The three axes represent time of day, (x-axis) with 0 and 24 hours = midnight, 8 hours = 8 am and 16 hours = 4 pm; month of year (y-axis) with 4 = April, 8 = August and 12 = December; and in-stream temperature (z-axis) ranging from –5°C to 40°C. Shaded areas are times where in-stream temperature exceeds the threshold associated with the location.*

	Broome (threshold = 29°C)	Townsville (threshold = 28.4°C)	Melbourne (threshold = 21°C)
January	10.5	10.0	11.0
February	9.75	9.5	10.25
March	10.25	9.0	8.5
April	9.25	7.25	4.75
May	7.5	5.5	0
June	5.75	3.25	0
July	6.0	2.5	0
August	7.0	4.0	0
September	8.75	6.5	0.5
October	9.75	8.0	6.5
November	10.25	9.0	9.0
December	10.5	9.75	10.25

***Table 1**: Average daily hours of threshold exceedence by month and location, under conditions of zero shade. Shaded cells represent months and locations where average conditions under zero shade result in intolerable exposure to high in-stream temperatures.*

biogeographic regions of Australia. The location-specific interactive effects of seasonal variation in meteorological variables and flow mean that the targets need to be used with caution when applied to locations other than those modelled in the project.

Shade can be provided in three ways — bank shade, vegetative shade from riparian vegetation, and macro-topographic shade from surrounding hills and landforms. Although the shade targets derived from simulation do not discriminate between these three components, the project also reports a method to estimate the relative shade provided by macro-topography and field observations needed to estimate the individual and cumulative effect of bank and vegetative shade. The project also included photographs showing the % shade of different types of vegetation.

Land & Water Australia will make the project's findings more readily available to river managers through an upcoming River and Riparian Management Technical Update. See next *RipRap* for details, or www.rivers.gov.au.

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UNDERSTANDING our River Landscapes
A new way of learning about our rivers

by Siwan Lovett

A new interactive educational tool 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 communities that live along them. 'Understanding our River Lanscapes' 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.

Forested headwater streams

Ephemeral streans

Getting started…

To get started — jump on to the website www.rivers.gov.au 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.

We hope you enjoy this new way of exploring of rivers. We intend to link as much of our research into Understanding River Landscapes so that it is continuously updated with the most recent findings from our programs.

AN AUSTRALIAN Handbook of Stream Roughness Coefficients

By Tony Ladson

Over the last three years, a group of researchers at Monash University and The University of Melbourne has been funded by Land & Water Australia to develop an *Australian Handbook of Stream Roughness Coefficients*. Although still being expanded, this handbook is now ready to be shared with technically minded readers of *RipRap* and others working to protect and manage rivers.

Stream roughness

If you have ever tried to work out discharge, flow depth or channel dimensions to carry a particular flow, you have probably needed to estimate a roughness coefficient, the most common being Manning's *n*. Using Manning's *n* is a simple and widely adopted approach to characterising energy losses as water flows down a stream. Manning's *n* is used in the Manning equation.

$$Q = \frac{AR^{\frac{2}{3}}S^{\frac{1}{2}}}{n}$$

Where, Q is discharge, A cross-sectional area, S is slope, R is hydraulic radius (area divided by wetted perimeter) and *n* is Manning's *n*.

Although there has been criticism of this formula and other methods have been suggested, the use of Manning's *n* for simple hydraulic calculations remains the preferred approach of Australian engineers and other practitioners working in the field of 'open channel' flow. Manning's *n* is a key parameter in a range of activities associated with hydrology and water resources including floodplain management, stream restoration, and the design of hydraulic structures.

Manning's *n* typically ranges from 0.01 in smooth concrete channels with no obstructions to 0.10 in streams with large amounts of large woody debris and vegetation that impedes flow. Rarely, values as high as 0.2 have been used.

Existing guides to estimating stream roughness

Generally it is necessary to estimate Manning's *n* value for a particular situation and this is usually based on handbooks or experience. In other countries such as New Zealand, Switzerland, Canada and the United States, roughness coefficients have been collected for some streams and pictorial guides or empirical equations, provide a firm basis for estimating values in new situations. Unfortunately, there has been little specific guidance for Australian streams. That is where the *Australian Handbook for Stream Roughness Coefficients* comes in. We have gathered information on roughness characteristics of Australian streams and converted this work into a web-based system that is easy to interrogate and update.

We recognise that international guides will often be useful to assist roughness estimation in Australia and the handbook web site provides links to the key stream roughness databases that have been developed by others such as the United States Geological Survey and the US Army Corps of Engineers. We have also referenced all the guides we could find, even if they are not available on the Internet. We hope that this collection of sources for roughness estimation will be valuable for people working to rehabilitate streams.

A guide for Australian streams

There will also be many Australian streams that are quite different from their international counterparts. To provide specific information on Australian stream roughness, we approached key individuals, consultants, government departments and reviewed the literature including reports, conference papers and journal articles. From these sources, data on roughness coefficients was collected on 25 Australian streams with sites in Victoria, New South Wales, Queensland and the ACT. We are now seeking copyright approval to include as much information as possible about each of these streams. Web pages associated with each stream will be released as soon as we have clearance. Check the site regularly for updates.

www.rivers.gov.au

Information provided in the database

For each stream a standard report is provided that includes:

~ location;
~ nearest stream gauge;
~ catchment area; and
~ mean daily flow

We also aim to include links to a reach map, photographs, cross section plots and, if possible, a scanned copy of the document that provides the source of the information. If, for copyright reasons, we can't reproduce the document, a reference will be provided. Any other information such as bed material size, and details on measurements are also included.

An example: Acheron River at Taggerty

As an example, consider the Acheron River at Taggerty, in North East Victoria (Figure 1). Basic information about this river and the measurement site is provided on the web site as in Table 1. For this site, roughness has been estimated for 12 discharges and all the measurements are included. An extract is shown in Table 2. The relationship between discharge and Manning's n value is also graphed (e.g. Figure 2). Where cross sections are available, these are provided along with the water surface elevations for the highest and lowest discharge.

Searching the database

The key problem in applying Manning's equation is to estimate n values for a particular site where there are probably no existing measurements. When using the *Handbook*, the challenge will be to find one or more sites where measurements are available, that are reasonably similar to the site were estimates are required.

The *Handbook* website provides search options to help with this task. The database on Australian stream roughness coefficients can be searched by: location of site, type of stream, and method used to estimation roughness. Some roughness estimation methods are more accurate than others and we provide a rating of our confidence in the resulting values.

If you need to check estimates for similar streams at sites outside Australia, there is also information on international websites and guides.

Figure 1: *Acheron River at Taggerty — reach where roughness measurements were made.*

Range of Manning's n values	0.034–0.047
Estimated by	Direct measurement of hydraulic properties
Nearest stream gauge	405209
Catchment area	619 km^2
Latitude	7.317°
Longitude	145.717°
Elevation	198.177 metres
Average daily flow	800 ML/d
Channel type	Gravel bed stream

Table 1: *Extract of information that is provided for each site in the roughness handbook. This example is for the Acheron River at Taggerty in Victoria.*

Discharge (m^3/s)	**ARI** (yr)	**Flow** Percentile	**Manning** n
3.17	0.1	26.8%	0.047
21.64	0.2	87.8%	0.043
72.94	1.7	99.7%	0.043
ARI = Average Recurrence Interval			

Table 2: *Extract of roughness information provided in the Handbook, for the Acheron River at Taggerty.*

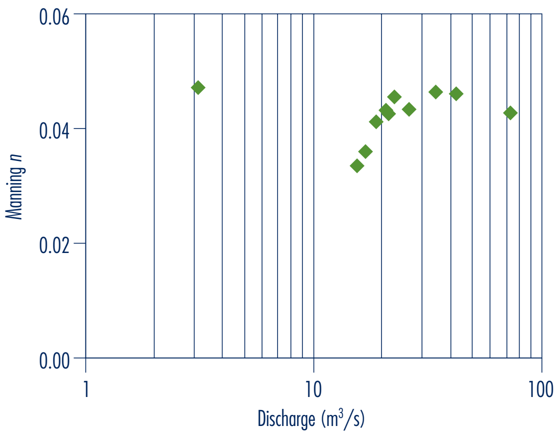

***Figure 2**: Variation of Manning's n with discharge for the Acheron River at Taggerty.*

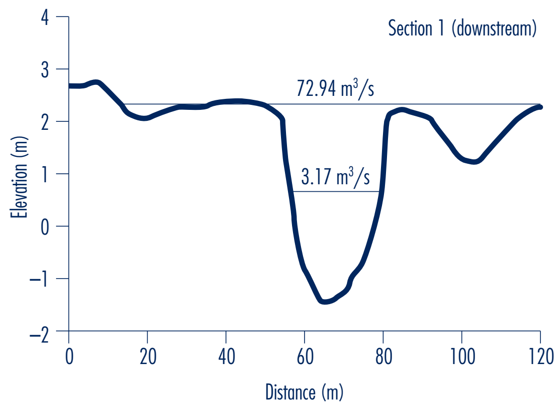

***Figure 3**: Cross-section for the Acheron River at Taggerty and location of the highest and lowest discharges where roughness measurements were made.*

Expanding the database

Although these case studies and the links to other guides are a good start in developing the *Handbook*, the project could be improved if there were further contributions. If you know of data that should be included in the *Handbook*, or have data to contribute, please contact me, Tony Ladson <tony.ladson@eng.monash.edu.au>.

A particularly important source of data could be from stream gauges where there are regular measurements of discharge. If additional water level measurements could be made at cross sections upstream and downstream of the main gauging site then roughness could be calculated routinely. This would be a major advance in the understanding of stream roughness in Australia. A similar approach was undertaken in New Zealand to produce probably the best data on stream roughness available from anywhere in the world (see Hicks & Mason 1998).

Conclusion

An *Australian Handbook of Stream Roughness Coefficients* is now available at www.rivers.gov.au under the 'tools and techniques' side menu heading on the front page of the site. Information on roughness in Australian streams and links to other roughness guides and references is provided. Please visit the site, use the examples, and check back regularly as we will provide more information as it becomes available.

Your contributions are also welcome. If you know of information that should be included, or have your own measurements to contribute, please get in touch. We are also happy to receive feedback on how the site can be improved. Two papers have been submitted to the Journal of Water Resources on this research — they will be available from the www.rivers.gov.au website once reviewed and accepted.

Acknowledgements

I would like to acknowledge the assistance of my colleagues: Brett Anderson, Ian Rutherfurd and Simon Lang and members of the steering committee Bob Keller, Erwin Weinmann, John Fenton and Rex Candy. Siwan Lovett and Phil Price from Land & Water Australia have had the vision and perseverance to see this task through. Brenda Moon and Kim Lynch of The Reef Multimedia are responsible for the website development.

Information on the Acheron River at Taggerty was obtained from Thiess Services Pty Ltd and we gratefully acknowledge their assistance. In particular, the help of Michael Briggs and Barbara Dworakowski is greatly appreciated.

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Ladson, A., Lang, S., Anderson, B. & Rutherfurd, I. 2003, *An Australian Handbook of Stream Roughness Coefficients*, 28th Hydrology and Water Resources Symposium, Wollongong, NSW, The Institution of Engineers, Australia.

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NATIONAL RIVERS CONSORTIUM PROJECT HIGHLIGHTS

Post-Graduate Certificate Course in River Management

The first Post-Graduate Certificate Course in River Restoration and Management being delivered by Charles Sturt University, Wagga Wagga, has commenced and will run over two semesters in 2004. Course material for River Hydrology and Geomorphology, and Floodplain Ecology, have been printed and materials for River Protection and Restoration, and Water Policy and Management, are currently being developed. Enquiries were received from a wide range of prospective students in 2003 and it is anticipated that an increase in enrolments will occur in 2004.

For further information

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Coastal Floodplain Guidelines

In January 2004, Senator The Hon. Judith Troeth, Parliamentary Secretary to the Minister for Agriculture, Fisheries and Forestry launched floodgate and drainage guidelines for coastal agricultural floodplains of the Clarence River in northern NSW. Poorly designed drainage of these areas in the past has led to fish kills in important commercial and recreational fisheries, and significant issues with acid-sulphate soils. The guidelines outline principles and strategies that can be used to improve the environmental performance of floodplain drainage systems, while retaining their benefits for agriculture. See page 27 for further details.

For further information

A website with a printable version of the guidelines is available at www.agric.nsw.gov.au/reader/floodgate-guidelines

Tropical Rivers Data Audit

In response to the need to better understand Australia's tropical river systems, the Tropical Rivers Data Audit Project was commissioned with funding provided by the Natural Heritage Trust's Rivercare program. The project was undertaken between July and December 2003, by NGIS Australia in conjunction with Gutteridge Haskins Davey and Ecobyte Systems.

The data audit covered the major themes of Typology and Classification, Water Resources, River Condition, Biodiversity, and Estuary condition. The project collected over 250 data and metadata sets covering the targeted themes within the project area. It was found that many of these themes were adequately covered by existing data sets. However, there were important gaps in information about some of the key themes, leading to a number of recommendations for future research. Copies of the report are available from the website www.rivers.gov.au.

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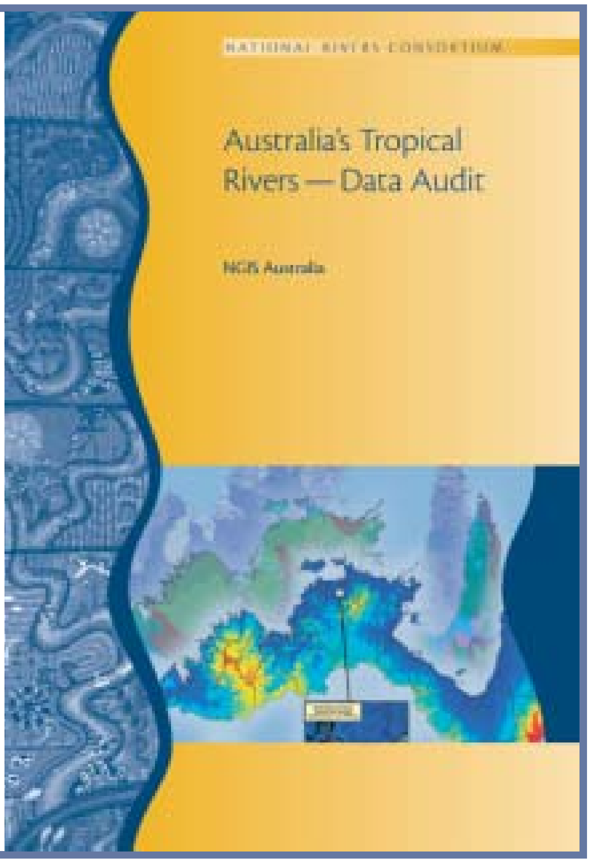

National Program for Sustainable Irrigation

Working at the interface between biophysical and social science, a research project being conducted under the National Program for Sustainable Irrigation aims to change the way risk-based approaches are incorporated into natural resource management decision processes. This new decision support tool will assist Australian irrigation industries to quantify, prioritise, address and manage ecological risks.

Principal researcher Professor Barry Hart says risk management is not new for the agricultural community, but that this project will provide a structured and rigorous methodology. The project will involve extensive stakeholder consultation to identify all the relevant issues and enable those issues to be assessed and prioritised. Case study projects that will inform the development of the decision-support tool are underway or already complete in the Goulburn-Broken (Victoria), Ord (Western Australia) and Fitzroy (Queensland) catchments.

The overarching project is also working with Murray Irrigation Ltd and the New South Wales Environmental Protection Agency as a pilot study for the consultation process and the decision framework. The project has been conducted in three phases. The final phase of developing ecological risk assessment protocols will be completed later this year.

A detailed factsheet on this project can be found on the National Program for Sustainable Irrigation website at www.npsi.gov.au.

For further information

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NATIONAL PROGRAM FOR
Sustainable Irrigation

LWA Board Director Tim Fisher on protecting rivers

In my ten years or more of involvement in water, I've seen an explosion of public interest in both river health and water resource policy.

When I think about the reasons for this growing interest it's hard to pin down to a single factor. A range of drivers are at work, including microeconomic reform; growing public environmental concerns; the Murray Darling 'Cap'; long-term drought; and increasing conflict over access to water resources.

Sustainability concerns around water and rivers has gained far more prominence now than ever before.

In the process, the profile of science in rivers and water resources has risen dramatically. The Wentworth Group of concerned scientists, for example, achieved unparalleled prominence for science in the water policy debate. Meanwhile we've seen a backlash in some quarters against the legitimacy of science — and scientists — on water policy in particular.

Whether it is new irrigated agriculture, growing cities, or new urban and coastal development, demand for water resources continues to grow. In contrast, climate change is likely to reduce water resource availability and increase climate variability. Water in Australia is getting scarcer and scarcer.

If we're going to manage these tensions and tradeoffs successfully, the role of science will be crucial.

In conservation terms, we know far more about protecting terrestrial ecosystems than we do about protecting aquatic ecosystems. In collaboration with the Department of Environment and Heritage, Land & Water Australia has commissioned research on designing a broad national framework for protecting aquatic ecosystems with high conservation values.

Obviously science has a role in informing how we strike a sustainable balance in the more developed parts of Australia where issues such as environmental flows, water quality, and in-stream and riparian habitat are at stake. In the Murray Darling Basin, for instance, this is a huge long-term challenge.

We also need to ensure that we don't make the same mistakes elsewhere. It is far easier to protect the environmental values in rivers now than it is to restore them later. And with pressure mounting to develop the water resources of northern Australia, earning about these northern tropical rivers, wetlands, estuaries and aquifers is a major challenge for Land & Water Australia over coming years.

Tim Fisher
Co-ordinator, Land & Water Ecosystems Program
Australian Conservation Foundation

New South Wales

by Scott Johnston and Peter Slavich

Managing floodgates and drainage systems on coastal floodplains for improved water quality

Extensive networks of drains and modified watercourses have been constructed on eastern Australia's coastal floodplains. These drains usually have floodgates located at their confluence with the river. Floodgates allow outflow, but prevent tidal ingress, thus promoting a stagnant, poorly flushed aquatic environment. While drainage was intended to mitigate the effects of floods and aid the establishment of rural settlements and industries, it has also caused large changes to floodplain watertables, vegetation and acid sulfate soils (ASS). This has led to adverse impacts on fish habitat and estuarine water quality, particularly from acid sulfate soils.

Concern about these impacts from communities on the NSW north coast led to the establishment of the Clarence Floodplain Project (CFP). The CFP was coordinated through a steering committee of the Clarence River County Council, the local organisation responsible for the operation of the drainage system. The CFP aimed to reduce the adverse environmental effects of coastal floodplain drainage by promoting management changes. Management changes include a) opening floodgates to allow both tidal exchange with estuarine water and fish passage b) retaining more water within the drain or backswamp and c) shallowing, in-filling and re-design of drainage systems. Works conducted through the CFP provided opportunities to research the effectiveness and risks associated with the above management changes.

Research approach

The research conducted by NSW Agriculture quantified changes in drainage water quality and the amount of acidity carried by the drainage waters before and after management changes. It also evaluated risks from introducing tidal flows of saline water into drainage systems and assessed vegetation changes in backswamps. The study focussed on former wetlands with shallow ASS. The project was coordinated with a Fisheries Research & Development Corporation/ NSW Fisheries project that focussed on fish movement and habitat characteristics. The research projects shared field sites, data, conducted joint presentations and published joint extension material.

Key findings and management implications

Field studies demonstrated that floodgate opening and exchange with river water can improve drain water quality, raising pH and increasing / stabilising dissolved oxygen levels. However, once floodgates are closed again there is often a rapid reversion in water quality (Figure 1). Small, frequent openings are better at maintaining stable improvements than large, infrequent openings. Automatic floodgate opening devices are preferred as they allow some exchange on each tidal cycle and also provide good water level control, thus preventing overtopping of low agricultural land.

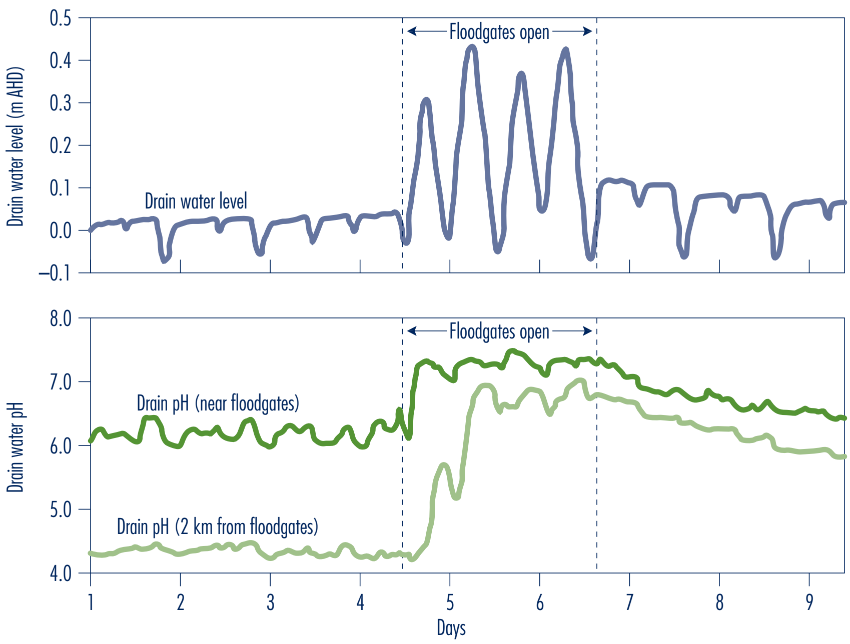


Figure 1: This chart shows a short term improvement in drain water pH in response to several days of floodgate opening. pH values begin decreasing again as soon as floodgates are closed.

K = hydraulic conductivity. The permeability of soil.

Macropores = large, water conducting pores in the soil.

An important discovery was that some backswamps contain ASS with very high (>100 m/day) hydraulic conductivity (K). Such high values had not been previously reported in Australian ASS and were associated with macropores (Figure 2). Drains which intercept such highly permeable soil horizons can receive substantial acid groundwater seepage. This seepage is driven by groundwater gradients which are modulated by tidal draw down of adjacent drain water levels. Reducing hydraulic gradients by retaining drain water was shown to be a highly effective means of reducing acid export at sites where main acid export pathway is groundwater seepage (Figure 3).

Agricultural industries were concerned that opening floodgates could contaminate adjacent groundwater with marine salts. Most coastal floodplain soils have relatively low K and the long term balance between rainfall and evapotranspiration favours net discharge. Thus, the risk of saline drain water seeping very far into shallow groundwater is limited at most sites; a point confirmed by field studies. However, at sites with very high K soils, saline drain water can rapidly seep into adjacent shallow groundwater. Given the risk this poses to agriculture, assessment of soil K is important prior to opening floodgates, particularly in ASS backswamp environments.

Large floods in northern NSW during 2001 were followed by extreme deoxygenation in several estuaries (Figure 4). Data captured during this event demonstrated that drainage of ASS backswamps increased the severity and duration of estuarine deoxygenation in the Clarence River (Johnston et al. 2003a). Anaerobic surface waters occurring in the backswamps after flooding were strongly influenced by iron and sulfur biogeochemistry. Changing drainage to mimic natural surface water residence times and re-establishing flood tolerant native vegetation species in backswamps could help reduce the magnitude and duration of such events.

Figure 2: *Acid groundwater flowing through soil macropores rapidly filling an excavated pit. Even though this acid sulfate soil has a clay texture, it has high hydraulic conductivity and rapid lateral movement of groundwater due to the network of interconnected pores and cracks. Photo Thor Aaso.*

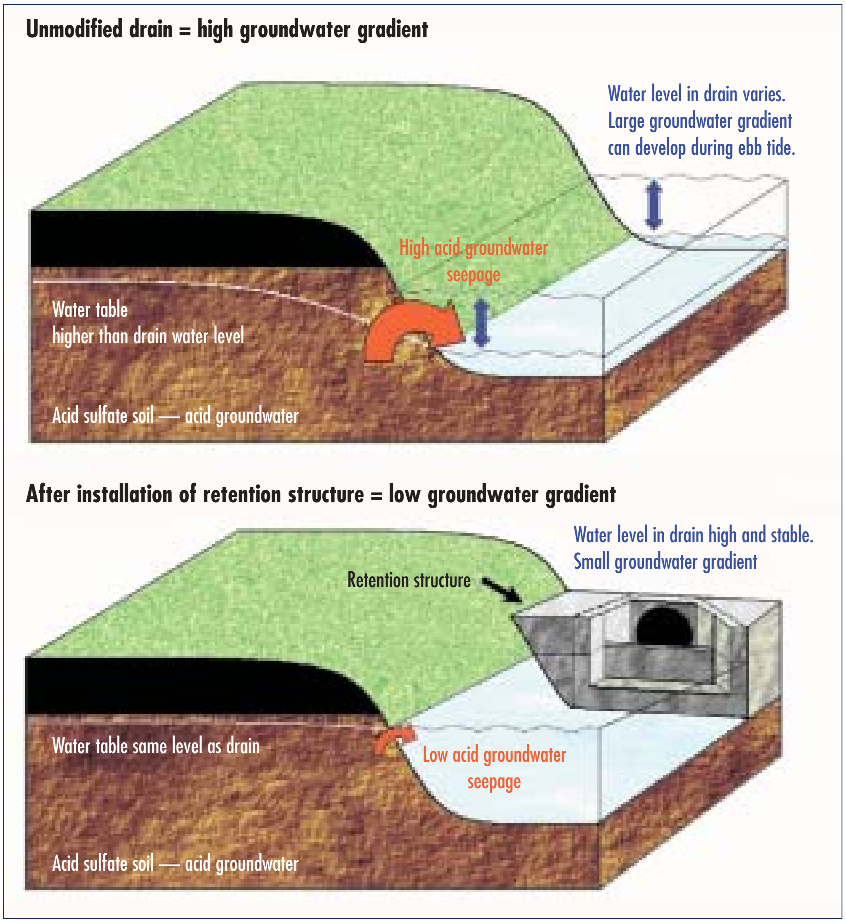


Figure 3: *These diagrams demonstrate the principle of reducing groundwater gradients by keeping drain water levels high and stable using a retention structure. This helps contain acid groundwater in the landscape and reduce acid export to rivers. Diagrams Scott Johnston*

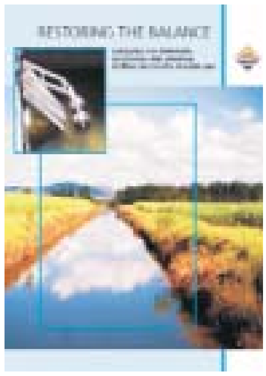
Figure 4: 'Black' deoxygenated water draining from areas of acid sulfate soils into brown river water after flooding. Large 'black' water events can deoxygenate entire estuaries. Photos Mitch Tulau.

This project also found that encroachment of *Melaleuca quinquenervia* (broad leaf paperbark) in an ASS backswamp had substantially altered sediment and groundwater geochemistry (Johnston et al. 2003b). Large increases in the acidity of groundwater and soil were occurring and this had not been documented before. This has potential to enhance acid flux loads from drains which bisect such areas. This research raises many interesting questions about geochemical processes occuring in the root zone in ASS backswamps and the long term effects of changing vegetation communities and hydrology.

The project demonstrated that the chemical characteristics of surface water, groundwater and drainage water in ASS backswamps are influenced by many complex interactions between the soils, hydrology, vegetation and altered drainage. An important overall conclusion of the research was that there is no 'one size fits all' management approach for floodplain drainage systems. The dynamic and diverse nature of coastal floodplain environments means that each drainage system has unique characteristics. Effective management needs to be adaptive and based on an understanding of these site specific characteristics. This means that thorough site assessment is a very important precursor to making management changes.

For further information

A major extension output from the project was a set of guidelines for management floodgate and drainage systems on coastal floodplains. It provides guidance on assessing drainage systems and outlines the benefits and risks associated with various management options. A copy of these guidelines can be downloaded from www.agric.nsw.gov.au/reader/floodgate-guidelines.



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Victoria by Paul Wilson

Streamside zone indicators for the index of stream condition 2004 — Using the Habitat Hectares approach to riparian corridors in Victoria

The second benchmark of stream condition at 3000 sites in Victoria is under way using the Index of Stream Condition (ISC). Since its first application in 1999, the ISC has undergone a major review to incorporate recent advances in scientific knowledge. The ISC is an integrated measure of stream health incorporating five major areas (sub-indices) namely: hydrology, aquatic life, physical form, streamside zone and water quality. Developments since 1999 in any of these areas were planned to be incorporated into future analysis. In this second benchmarking exercise, the streamside zone (or riparian zone) component has been significantly altered.

There has been a strong push within Victoria's Department of Sustainability and Environment (DSE) to ensure that all vegetation across the state is assessed in a consistent way. The standard method for assessing vegetation health in Victoria is the Habitat Hectares approach. This standard approach has been modified by DSE's River Health Program to make it applicable to narrow riparian corridors and increase its practicality to allow Catchment Management Authority staff to undertake the data collection. These modifications include reducing the number of life forms to be assessed from 21 to 16, and modifying identification needs so that native and exotic are separated (but not between native and endemic), but not down to the level of individual identification of species.

The Habitat Hectares methodology divides the State into 27 bio-regions. Within each bioregion Ecological Vegetation Classes (EVCs) have been identified along with their 'benchmark'. An EVC is defined by a combination of floristics, life forms and position in the landscape; whilst the make up of a mature and long-undisturbed EVC is known as its benchmark. There are around 1000 such benchmarks for Victoria. These bio-regional benchmarks have been generated from information about existing native vegetation. The information is a combination of quadrat analyses held within DSE flora information systems, bio-regional mapping

Murray River, upstream of the Hume Dam, Victoria. Photo Frances Marston

units, expert input from botanists, as well as limited field testing within sites that are known to be undisturbed for particular habitat components. Where this has not been possible, due to the poor condition of all remaining examples of a vegetation type, the benchmark values are devised to represent the *presumed* long-undisturbed condition. This is done with reference to historical information and to knowledge of how similar vegetation types have been affected by disturbance.

At each of the 3000 ISC sites it is necessary to confirm the EVC on site and this is done by trained field operators. The vegetation data that is collected covers:

~ Width of streamside zone and width of the neighbouring EVC.

~ Large trees — number and health. The benchmark gives the number of large trees (specified by a particular diameter at breast height). Large trees are a difficult habitat feature to replace once lost. For this reason, and because of their critical importance as habitat for fauna and their impact on the local environment, it is important to know how many large trees remain. The assessment notes that while large trees in declining


Red gum, Barmah Forest, Victoria. Photo Frances Marston

health (including dead trees) still have value as fauna habitat (notably hollows), they provide reduced function in terms of a nectar source and their impact on the root zone. A measure of the future viability of these trees in the landscape is also undertaken as part of the assessment, and this can highlight the presence of existing threats that may need attention.

~ Canopy — cover and health. Includes all native trees that range from 5 metres tall to 80% of the benchmark height.
~ Weeds of high impact (as defined in the benchmark) and Catchment Management Authority top 10 riparian weeds. In some cases the high impact weed list is extensive and requires detailed botanical knowledge. To overcome this, each Catchment Management Authority developed a top 10 list of their riparian weeds.
~ Organic litter — cover and quality (native or exotic). Too much litter is penalised as it can impede regeneration.
~ Logs — total length and number of large logs (which is defined in the Benchmark — large tree diameter at breast height).
~ Understorey life forms — presence and whether they are substantially modified. The life form is defined as the three-dimensional structure of the plant (height and shape). The ISC uses 16 life forms ranging from immature trees, tall shrubs, small shrubs, large herbs, large tufted graminoids, small non-tufted graminoids, ferns etc. This component assess if the life form is present (requires a benchmark cover of <10% and at least one reproductively mature individual present) or if it is substantially modified (defined as the current cover being less than 50% of the benchmark cover).
~ Recent recruitment — immature numbers compared with mature numbers. For recruitment to be present the immature numbers must be at least 10% of the mature numbers present. Numbers are for the different life forms present and not the individual species.
~ Longitudinal continuity (percentage of stream bank vegetated).

For many field assessors the above changes are a new way of looking at the streamside zone, and a two-day training session has been provided to assist them with the transition to using the new method. Once assessors got over the shock of all the new 'rules', the Habitat Hectares method is surprisingly straightforward and shows very little variation in measurements between different field assessors.

The ISC Reference Committee (which is a panel of well respected experts covering all five ISC sub-indices) is still to decide on how to combine these vegetation metrics into the streamside zone sub-index (a score from 0–10). The results from the current round of ISC data collection will be available by the end of 2004.

Graminoids are grasses or grass like plants — usually distinguished by long strap like leaves e.g. reeds and rushes

For further information

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Northern Territory

by Peter Gehrke and Michael Douglas

Forum on Sustainable Futures for Australia's Tropical Rivers Charles Darwin University, Darwin, 1–3 February 2004

Tropical rivers are a hot topic! There is a growing appreciation of the social, cultural and economic values of tropical rivers and estuaries, but at the same time there is increasing interest from southern Australia in what appear to be vast and untapped water resources to the north. In response to the increasing social, political and business interest in the water resources of northern Australia, a forum was convened in recognition of the need to be proactive in providing the scientific knowledge that is critical to guide current and future policy and decision-making on the use of these rivers. The forum was supported by Land & Water Australia, CSIRO Land and Water, the Department of Agriculture, Fisheries and Forestry, Charles Darwin University and by residual funds from the National Conference on *Sustaining Our Environments* held in Townsville in 2001.

The objectives of the forum were to assemble and synthesise existing scientific knowledge of Australia's tropical river systems, and to identify critical knowledge gaps to provide a launch pad for future research needs. The approach adopted for the forum was to build a whole-of-river system analysis, examining the functioning of tropical rivers, their floodplains, wetlands and riparian zones, estuaries and near-shore environments, as well as the impacts of land-use, water use and other activities. The geographic scope of the forum spanned tropical Australia from Broome to Rockhampton.

The forum received outstanding support from a broad spectrum of scientific, government, industry, community, indigenous and conservation interests, with 117 registered participants from 42 organisations, reflecting the high level of interest in tropical river issues. Associate Professor Stephen Hamilton, from the Kellogg Biological Station of Michigan State University attended as keynote speaker and provided a global context by drawing on his research and management experiences of tropical river systems in South America.

Baines River

The following is a brief summary of the main points that emerged from the forum.

National context and relative significance

Australia's tropical rivers include some of the country's most pristine river systems, as well as some that have been significantly modified by water resource development. Tropical river systems, their wetlands and estuaries, are important for their biodiversity and cultural significance, especially among indigenous people. Tropical rivers also have high economic value to industries associated with the Great Barrier Reef and fisheries such as the Northern Prawn Fishery. The interactions between catchment changes, river flow cycles and water quality, estuarine and coastal productivity need to be better understood to allow responsible management of the environmental, social and economic assets of tropical Australia.

Outlook for development and community needs

Projections for economic expansion in the near term are low across most of the region, constrained in part by remoteness, a lack of supporting infrastructure, and the large proportion of land held by Aboriginal Title. Estimates of sustainable water yields are unreliable in most catchments making it difficult to develop responsible water plans. Local communities want more input into management decisions concerning these systems to protect their interests, and this requires effective engagement with science planning, environmental management and decision-making processes over large distances.

The combination of the desire for local community involvement in decision making, and new legislation empowering aboriginal land management, means that successful conservation and natural resource management programs will require the support and involvement of local communities in the future. This will require a long-term commitment by those wishing to work on tropical rivers, as building relationships takes time and cultural differences need to be respected.

Identification of knowledge needs

Improving the gauge network is a necessary investment to develop the long-term hydrological data sets essential to underpin resource management decisions and policy under the National Water Initiative. Basic information needs include flow in tidal estuarine reaches, estimation of floodplain flows, stage — discharge relationships at lowest and highest flows linked with flood forecasting and rainfall patterns. Greater integration is needed to manage surface waters and ground water from freshwater to marine environments, and to develop balanced water accounting systems.

Baseline data exists for many ecological system components, but spatial and temporal coverage is patchy and ecosystems have been changing, presenting difficulties when interpolating available data. Greater use of innovative data sources, such as remote sensing and automated monitoring systems, is required to improve data coverage. Beyond descriptive inventory data sets, little information is available on ecosystem processes and services. Methods for assessing ecological condition in tropical rivers require more development to deliver robust and sensitive indicators that can be applied across regions.

There is a need to understand ecological linkages among hydrologic subsystems, through interactions between ground water and surface water; river and floodplain habitats; freshwater, estuarine and marine coastal systems. The food resources for economically important food webs, supporting species such as prawns, barramundi and crocodiles, and their links to river flow are poorly understood, so that there is insufficient knowledge about the resources that need to be protected to sustain these key resources.

National goals and how science can contribute

Science has played a key role to date in decision-making and policy development with regard to tropical rivers, but mostly in reaction to perceived problems (e.g. mining, ocean pollution) as opposed to a proactive role in supporting conservation and management, or in devising sustainable options for economic and social development. There is an acknowledged need to build local capacity to conduct, interpret, and use research. This need must be balanced against the reality that much of the national research capacity is located elsewhere, dictating that research will need to be done by external research providers in close consultation with local community representatives.

Landscape analysis and systematic conservation planning are underway at scales from catchment to nationwide. Coordination of these activities for maximum efficiency relies on sharing of data among organisations. Whilst some organisations have intentionally open access policies on data availability, others have issues with confidentiality and cost recovery that prohibit open, free exchange of data.

Any preferred vision for the future may need to balance ecosystem services against biodiversity values to develop conservation priorities and policies. As Commonwealth initiatives progress toward National Framework approaches to achieve consistent policy implementation, activities within tropical catchments will be required to demonstrate consistency with national policy to achieve local-scale priority objectives.

For further information

A more detailed document containing the proceedings and recommendations for future research in Tropical Rivers is available from Land & Water Australia. This document will form the basis upon which a Tropical Rivers Program Plan will be developed and released for comment and involvement of agencies interested in funding a new initiative in Australia's north. If you would like more information:

Contact

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FROM NATIONAL TO INTERNATIONAL

INTERNATIONAL River Restoration Survey

Results and further information related to the International River Restoration Survey originally launched in November 2003 are now available in a variety of formats on the survey website:
www.geog.soton.ac.uk/users/WheatonJ/RestorationSurvey_Cover.asp
The survey will continue to run indefinitely and the results are automatically updated to the website. Thank you to the over 480 respondents from 36 countries who have already responded! If you have not already taken the survey why not share your views and experience with the international river restoration community?

More information

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Water assessment and planning activities underway as part of the National Action Plan

The Tasmanian Water Assessment and Planning Branch in Department of Planning Infrastructure, Water and Environment's (DPIWE) Water Resources Division is currently running three major projects funded under the National Action Plan for Salinity and Water Quality (NAP).

Collectively, these projects are aimed at increasing knowledge of water quality, hydrology and river health in catchments across the NAP region (Figure 1). Two projects have strong community capacity building components aimed at developing skills within the regional communities to carry out ongoing water quality monitoring and biological river health assessments. Community groups will be provided with tools to access Tasmania's baseline water quality monitoring network. This accessibility will enable regional groups to provide input into natural resource management planning into the future.

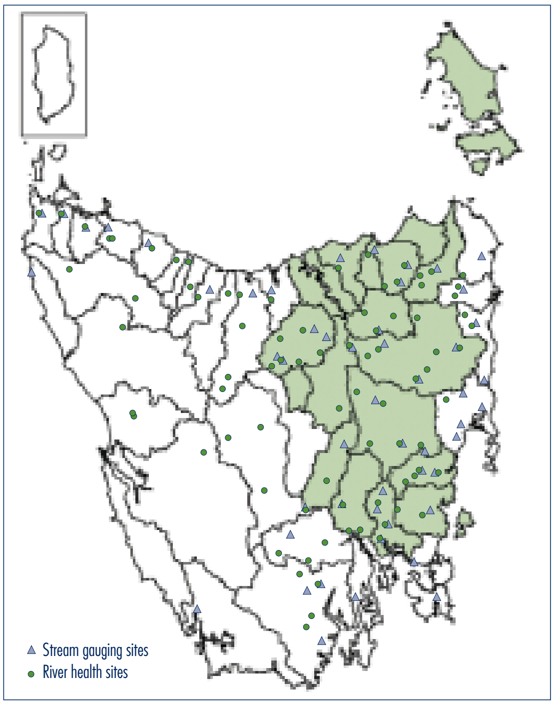

***Figure 1**: DPIWE's streamflow, water quality and river health monitoring network (NAP region shaded pale green)*

1. Water Quality Linkages and Baseline Data Project

This project will expand the current baseline monitoring network in the NAP Region and allow a collaborative approach to water quality monitoring between state, local and regional stakeholders via partnerships. It will act as a pilot project for the remainder of the State to illustrate how water quality monitoring can effectively combine scientific credibility and value, with community input and ownership.

Expansion of the State's network has been ongoing since 2001 as part of the State Government's Water Infrastructure Program. During 2004, water quality probes will be installed throughout the NAP region at several existing flow monitoring sites to continuously monitor various water quality parameters such as temperature, salinity, turbidity, dissolved oxygen and pH. Monthly nutrient sampling will also be undertaken at each site. Collectively, these data form the basis of long term baseline water quality monitoring in the NAP region. The water quality information collected is also relevant for core indicators under the Natural Resources Management Monitoring and Evaluation Framework; against which natural resource management actions will be assessed and regional water quality targets set.

The second component of this project is to develop a trial system for the improved coordination of data collection, monitoring, storage and reporting in the NAP region. This will be achieved by providing internet access to the states baseline water quality monitoring network and water information. The project will promote the baseline system to local councils, community groups and industries. By centralising the State's water information at a single site, DPIWE will facilitate the coordinated collection and collation of water information onto the Tasmanian water quality database. Community capacity will be developed through training in water quality monitoring and the promotion of access and input of community water information into a centralised database. This approach will streamline data collection, reduce duplication and promote a consolidated approach to the management and planning of Tasmania's water resources.

2. Implementation of a NAP Region River Health Monitoring System

A river health monitoring and reporting program is currently being developed for waterways in the

NAP Region. This program will undertake river health (AusRivAS) bio-assessment to compliment the physico-chemical and stream flow monitoring in the NAP region. Community capacity will be developed by training and accrediting existing community groups in using AusRivAS rapid assessment methods.

Three training courses have already been conducted in 2004, and many community group members are currently gaining AusRivAS accreditation to carry out biological assessments of river health. The courses cover four AusRivAS training modules addressing study design and site selection, habitat assessment, sampling and sample processing, and taxonomy and output interpretation. As a sub-project, these results will be used to assess and compare the quality assurance of non-specialist and specialist personnel using the AusRivAS protocols. This will contribute to the development of community capacity in river health monitoring by local stakeholders.

3. Development of a Holistic Environmental Flow Methodology for the NAP Region

A third project will develop a methodology for recommending holistic environmental flow regimes for catchments in the NAP region. This project will conduct a pilot study in the Little Swanport catchment to investigate Environmental Water Requirements (EWRs) by employing a holistic whole of catchment approach. This will involve the investigation of the importance of 'high' flows and floods to ecosystems and physical processes not only within the river channel, but also for the geomorphology of the catchment, riparian vegetation and the downstream estuarine environments.

The Little Swanport Catchment on the east coast of Tasmania drains approximately 600 km^2 over 61 km from its source in the midlands of Tasmania. The upper reaches of this system comprise upland plateaus and marshes that are predominantly developed for agriculture. The lower system is steeper in gradient and comprised of gorges with nearly pristine riparian vegetation and surrounding open native woodlands. The lower estuary supports native aquatic species and a productive shellfish aquaculture industry.

The environmental flows project will investigate the impacts of droughts, peak flow events as well as the effects of land use practices such as the cumulative impacts of in-stream storages on water quality, in-stream and estuarine processes. Several methods have been used to develop EWRs for river systems in Tasmania. Most of these methodologies have used minimal EWRs as a critical component of the flow regime in determining availability of aquatic habitat. More recent approaches nationally and overseas have incorporated other ecosystem components such as geomorphological and estuarine water requirements, as well as considering flow components such as flush and flood events. The NAP project will investigate the importance of these components in maintaining ecosystem processes in order to develop a methodology that will be applicable to other Tasmanian riverine ecosystems.

In summary

These projects aim to increase knowledge and information of water quality and river health issues within the Tasmanian NAP region. The investigations of environmental water requirements in the Little Swanport River will provide important knowledge that will be applicable to river systems throughout the NAP region and the rest of Tasmania. The river health monitoring and baseline data projects will develop a consolidated approach that will develop community capacity in water quality monitoring and biological assessment of river health. The collation of water information from community, council and industry groups will assist the Tasmanian Government to carry out important baseline monitoring and evaluation of strategies that will address water quality and salinity problems in the NAP Region.

Water quality sampling. Photo K. Wilson.

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Tools and techniques for riparian areas — Foreshore Condition Assessment

A simple tool to assess the condition of riparian zones has been used widely throughout south-west Western Australia for many years. Developed by the late Dr Luke Pen and Margaret Scott (Pen & Scott 1995) for assessment of waterways in farming areas of south west Western Australia, the foreshore condition assessment technique is now widely available as a chapter in the Water and Rivers Commission's *River Restoration Manual* (WRC 1999). The methodology has also been adapted for use in urban and semi-rural areas (WRC 1999a) and is being adapted for use in the Pilbara. While the focus of each tool is on different waterways and land uses, the key elements remain consistent.

The southwest methodology

The Foreshore Condition Assessment Form (as provided in WRC 1999 & 1999a) collects the following information:

- ~ general condition of the foreshore area — A, B, C or D grading;
- ~ fencing status and stock access;
- ~ bank steepness and general soil cohesion;
- ~ major erosion of siltation features; and
- ~ overall stream environmental rating.

The foreshore condition survey provides a broad picture of the condition of a waterway, and enables areas of degradation to be identified and rehabilitation works to be targeted where they will be most effective. Used properly, the survey methodology ensures that future surveys will collect and record data in a consistent manner, so that any number of people can conduct surveys over a period of time. It therefore allows baseline information to be recorded so the impact of project activities can be monitored and evaluated over time. One key aim was to enable community groups and individuals to conduct foreshore surveys to increase their understanding of riparian management issues and to provide a framework for assessing the success of river restoration activities.

The method consists of grading a section of river into one of four broad contiguous categories — A, B, C and D. This grading reflects the typical process of foreshore degradation. 'A grade' is essentially a foreshore that is relatively unchanged from natural; 'B grade' retains bush but with significant displacement of native understorey species by weeds and erosion development; 'C grade' is trees over pasture species with higher levels of erosion; and 'D grade' is an eroding or completely weed infested foreshore that looks more like a ditch or drain than a healthy waterway. The categories are illustrated in Figure 1. Surveys can be done at this basic level or refined to incorporate three sub-categories for each grade, e.g. B1, B2, B3.

The use of 'A, B, C and D' is to create a language synonymous with quality or health, as in getting an A for a test or being of A1 health. At the other end of the spectrum is C grade in referring to a basic pass, and at the extreme end, D grade meaning a fail. These are concepts used in every day speech and do not require non-experts to learn new jargon.

The simplicity of this methodology enables its use and comprehension by a broad range of people and makes the collection and interpretation of data a simple and cheap exercise, lending itself to ground truthing of remote sensing data which may assist in covering broader areas. To date, at least 32 foreshore surveys have been conducted by landowners, community groups and department staff in the south west of Western Australia.

The Pilbara methodology

The basics of the methodology used in the southwest of WA are now being adapted for use in the north-west of WA, in particular the Pilbara. The assessment of the state of waterways anywhere in Australia, with the recurring cycles of flood and drought, is difficult. However, the north-west of Australia experiences climatic extremes, accentuated by cyclones, making assessment particularly complicated. Rivers that are dry for most of the year can become raging torrents in a matter of days, and be dry again in almost as many days.

Other factors which complicate land assessment in the north-west include the vast size of properties. Consequently, a waterway on one pastoral lease may meander through many land systems, habitats, and different types of river banks associated with these landforms. Management of the degradation of waterways is

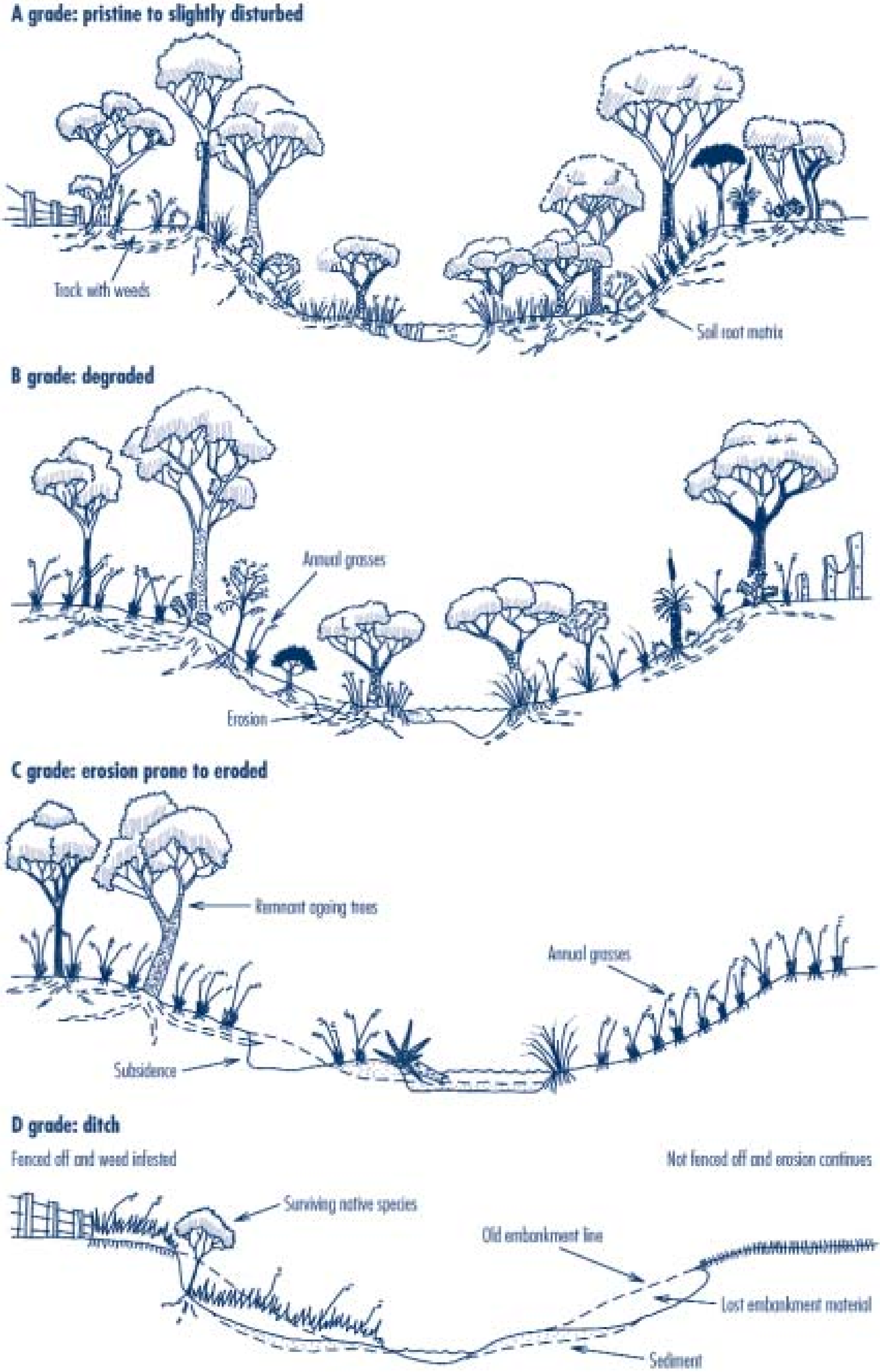

Figure 1*: The four grades of river foreshore condition following the general process of river degradation from pristine (A) to ditch (D). Source: Water and Rivers Commission 1999.*

For further information

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complicated by the prohibitive costs of fencing off waterways and the necessity to use rivers for stock watering holes. These are just some of the factors that complicate any sort of broad-scale assessment and management of waterways in the north-west.

The aim of this project is to develop a foreshore assessment framework that is suitable for use in Pilbara waterways and can be applied for a range of purposes. It is intended that the framework will enable assessment at three levels, depending of the purpose of the assessment and will consist of a:

~ self management/education tool for lease holders;
~ lease management assessment (where leases on foreshores of rivers, or impoundments and corresponds to management action targets of NRM framework); and
~ resource condition assessment (for Natural Resources Management (NRM), State of Environment reporting, and corresponding to resource condition targets level of NRM framework).

Summary

These riparian assessment tools enable the community and government to engage in meaningful discussion of foreshore health and provide a framework to gain a longer term understanding of the effectiveness of river restoration activities. Their strength is that they are designed with the community in mind, and enable people without a scientific background to gain an understanding of the condition of their river and riparian areas.

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LUKE PEN Scholarship Fund

by Marion Burchell

The Department of Environment's Luke Pen Scholarship Fund was established to honour the life and work of the late Dr Luke Pen, and was developed in accordance with his wishes. The purpose of the Scholarship is to support Honours projects in the areas identified by Luke as in critical need of research to support, understand and assist in waterways management.

The Scholarship encourages young people to be involved in gaining scientific experience in the characteristics of rivers, build skills and networks, and ensure Western Australia has a bright future in waterways management. The Scholarship is currently open to honours students, but may be expanded to include masters and PhD students. Eligible projects include:

~ research into wheatbelt valleys and their river systems,
~ the hydrology of south west WA,
~ plants that use more water to help manage changes in hydrology,
~ salt tolerant plants for use in saline landscapes.

The Department has allocated a total of $50,000 over a 5-year period for the Luke Pen Scholarship.

The recipient of this year's Scholarship award was Fiona Gibson from the University of Western Australia, who will be researching the implications of waterborne pathogens on the management of an oyster farm in Oyster Harbour, Albany.

Minister Edwards and Fiona Gibson (Scholarship recipient) in centre, surrounded by the Pen family.

South Australia by Tom Carrangis and Steve Gatti

Riparian zone condition assessment for works planning in the Mount Lofty Ranges

Over the last few decades, developments in the availability, management and presentation of natural resource data have enabled more refined assessments to be undertaken to assist catchment rehabilitation. The application of catchment and riparian health assessments in the Mount Lofty Ranges provides an example of the evolution of the survey and prioritisation processes that we can now use, as well as the challenges facing managers to keep up with additional available information whilst maintaining community enthusiasm to care for their catchments.

Coordinated riparian zone condition assessment and prioritisation for works programming were undertaken in the Mount Lofty Ranges in the mid 1990s. With the assistance of the Natural Heritage Trust, the then Department of Environment and Natural Resources with the Environment Protection Authority commenced a series of riparian zone assessments across the ranges that were linked to awareness raising campaigns for landholders. Due to the cost of surveying and processing, only third order and greater watercourses were surveyed in that program.

The process involved agency staff walking the length of the watercourses and surveying the physical and biological condition of the riparian zone. Records were taken of issues such as vegetation type, cover and condition (recorded as level of weed invasion into native vegetation), bed and bank stability. The data was then presented to landholders from the regions surveyed at a series of open workshops. At these workshop sessions, landholders were given brief introductions to riparian management and then through a process of voting, established prioritised works programs for their subcatchments. This process was significant in raising the awareness of communities in the region about the value and importance of riparian zones, and the actions that are needed to rehabilitate these largely degraded areas. One drawback, however, was that priorities focussed on in-ground works in the most visibly degraded areas, largely overlooking the importance of protecting remnant environmental values.

Subsequent prioritisation processes have tried to address this problem, by drawing on more data about riparian condition and using it to highlight the importance of the relationship between the riparian zone, terrestrial landscapes and other activities occurring in the broader catchment. In addition, all watercourses (including first and second order streams) are now included in the process.

The South Australian catchment water management boards took on the responsibility of leading prioritisation processes since their establishment in the late 1990s. One of the partnership projects funded by four of the boards was the Watercourse Survey and Prioritisation Project, which was completed in 2003. This project aimed to apply the 12 steps to watercourse rehabilitation outlined in the *Rehabilitation Manual for Australian Streams* (Rutherfurd et al.). The project reviewed available data, developed methods for on ground data capture and prioritised activities on the basis of a risk assessment process. Riparian condition was assessed using information from stream geomorphology, vegetation condition, water quality and hydrology data sources. The Boards are now using the outputs of the prioritisation project in the implementation of an auction based approach to funding fair and cost effective biodiversity and water quality conservation services provided by landholders. The auction based approach is being designed by the Boards in conjunction with CSIRO as part of the Market Based Instruments Pilot Program.

Other watercourse assessment and prioritisation processes are currently underway including the Land & Water Australia Catchment Assessment Techniques Project (see page 12). This project, focusing on catchment processes, such as erosion and sedimentation, as well as vegetation condition, will add to the existing information available to managing agencies to assist with focussing their investment in watercourse and riparian protection and rehabilitation.

Land & Water Australia has also provided funding for the development of a rapid assessment method for ephemeral river health which when completed will further add to the riparian manager's toolkit. This project is being lead by the CRCs for Freshwater Ecology and Catchment Hydrology and has its field research areas in the Mount Lofty Ranges.

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Australian Capital Territory by Rachelle McConville

Community monitoring through Frogwatch

ACT Frogwatch is a community frog monitoring program that collects information about frog species, their distribution and abundance. Frogwatch volunteers get out to their local waterways and discover these fascinating amphibians living in rivers, streams, lakes, dams and wetlands. The program was initiated in 2000 by the Ginninderra Catchment Group, and has since expanded to the ACT and surrounding region. The first ACT and Region National Water Week Community Frogwatch Census was held in October 2002, and now includes over 150 participants, monitoring frogs at almost 120 sites.

Why monitor frogs?

Frogs are well known for their sensitivity to pollution and habitat degradation, which makes them ideal indicators of the health of our environment. Monitoring frog populations can allow us to assess the health of our waterways by assuming that healthy habitats provide suitable conditions for diverse and abundant frog populations. Unhealthy or degraded habitats, on the other hand, have few or no frogs present. Monitoring frogs is easy because each species has a distinctive mating call, so they we can be easily identified using tape recordings.

The most important part of the Frogwatch program are volunteers. Each year hundreds of volunteers attend training sessions, where they learn about the frog species of the ACT, threats to their survival, and how to recognise their particular mating call. Frogwatch participants also learnt about basic safety and site selection guidelines, procedures for preventing the spread of potential frog pathogens, frog identification techniques and procedures for undertaking and recording detailed observations about their site, weather, vegetation and other relevant parameters.

The data collected by volunteers contributes significant information about the types and abundance of frogs found in our region. It contributes to an overall wildlife monitoring network that is investigating the impacts of bushfires and drought on our waterways. In October 2003, a total of eight frog species were found in the region, and sites were identified with the greatest and least diversity of frog species. Those with the greatest diversity were highlighted as priorities for protection in broader catchment management initiatives. It is envisaged that as monitoring continues in the long term, we will be able to identify any changes in the distribution and abundance of frog species in the region. This information will also help to identify future community monitoring and action programs that will create a more frog friendly Upper Murrumbidgee Catchment.

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South Australia continued

These projects will add to the data available for prioritising works, with improved access and relevance of data enabling managing agencies to prioritise the provision of funding assistance for catchment rehabilitation. The challenges for catchment management agencies is to ensure that the land owners and managers, who are key partners in the rehabilitation works, are kept up to date with developments in thinking. This is especially relevant in many parts of the region that are involving landholder management committees or catchment groups directly, to make investment decisions for the agencies. A key focus of many of the programs in the region is to inspire all landholders across the catchment to actively manage the condition of their riparian areas as part of good property management, no matter where they fall in the landscape.

Program managers and extension staff in the region are mindful to enure that their messages to these communities do not lead to a feeling that careful management is only required for reaches that are considered "priorities". Rather, they seek to promote a catchment care ethic that considers all activities in the catchment contribute to the condition of the riparian areas. Applying the increasing level of knowledge in a way that preserves this ethic, remains the greatest challenge for the management agencies.

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