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.

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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.

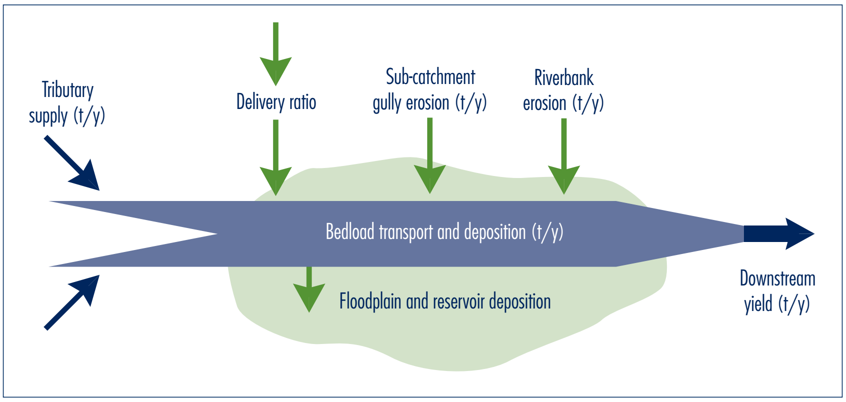


***Figure 1**: Erosion, transport and deposition terms included in the SedNet mass balance of sediment for a river link*

***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

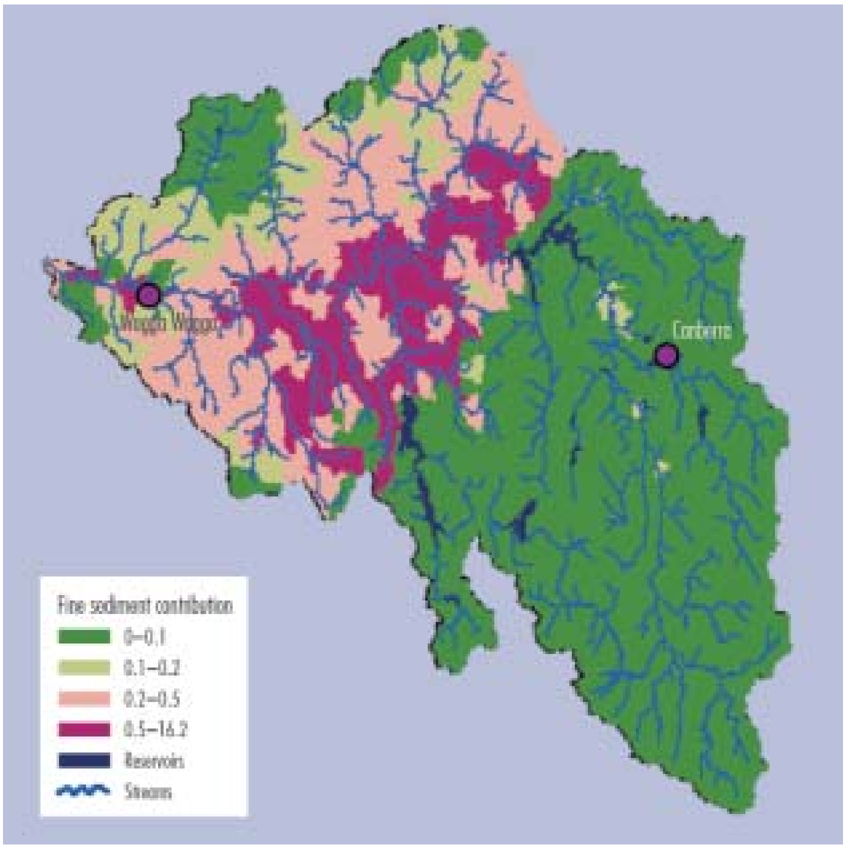
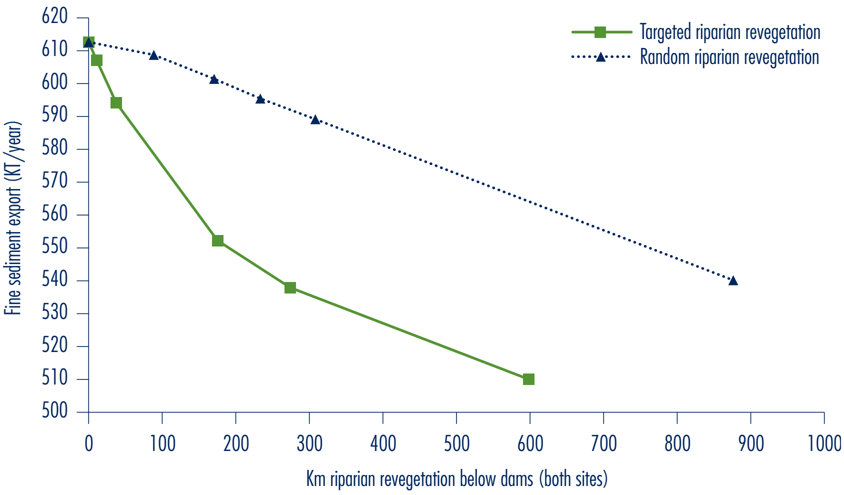


Figure 3*: Rates of specific suspended sediment contribution (t/ha/y) to Wagga Wagga in the Murrumbigee catchment.*

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

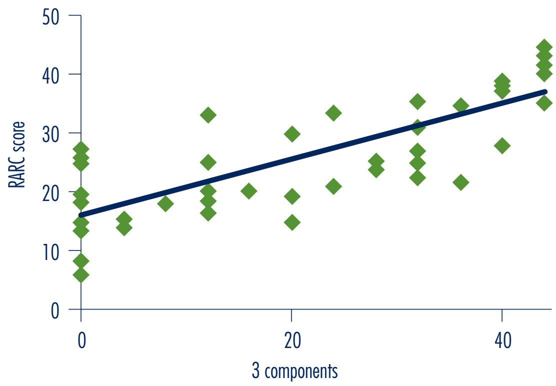


Figure 5: Measurement of the three components (canopy cover, riparian vegetation width and longitudinal continuity of riparian vegetation) derived from satellite imagery in relation to total on-ground RARC scores at 46 sites in the Goulburn-Broken catchment, Victoria.

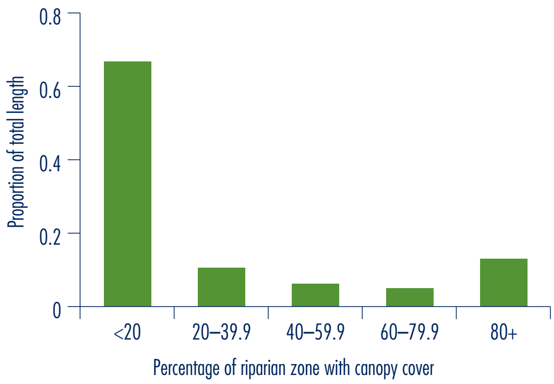


Figure 6: Proportion of total stream length with riparian zone canopy cover as indicated, for streams in the Goulburn-Broken catchment, Victoria.

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.

References

Jansen, A. & Robertson, A. 2001, Relationships between livestock management and the ecological condition of riparian habitats along an Australian floodplain river, *Journal of Applied Ecology*, vol. 38, pp. 63–75.

Jansen, A., Robertson, A., Thompson, L. & Wilson, A. 2004, Development and application of a method for the rapid appraisal of riparian condition, *River Management Technical Guideline no. 4*. Land & Water Australia, Canberra. (available from website www.rivers.gov.au).

Prosser, I.P., Rustomji, P., Young, B., Moran, C. & Hughes, A. 2001a, *Constructing river basin sediment budgets for the National Land and Water Resources Audit*, Technical Report 15/01, CSIRO Land and Water, Canberra.

Prosser, I.P., Hughes, A., Rustomji, P., Young, W.J., Moran, C.J. 2001b, 'Predictions of the sediment regime of Australian rivers', in I.D. Rutherfurd, F. Sheldon, G. Brierley & C. Kenyon (eds), *Third Australian Stream Management Conference*, Brisbane, 27–29 August, Cooperative Research Centre for Catchment Hydrology, pp. 529–533.

Rutherfurd I.D., Jerie K. & Marsh N. 2000, *A rehabilitation manual for Australian streams*, CD ROM and Manual, Land & Water Australia, Canberra (available from website www.rivers.gov.au).

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