Assessing the ecological risks of salinity increases within the Goulburn-Broken catchment, Victoria

J.Angus Webb, Barry T. Hart and Michael R. Grace
Water Studies Centre, Department of Chemistry and CRC for Freshwater Ecology,
Monash University, Clayton, Vic. 3800
E-mail: angus.webb@sci.monash.edu.au barry.hart@sci.monash.edu.au mike.grace@sci.monash.edu.au

Abstract

Before efforts can be made to reduce the effects of secondary salinisation, management agencies need to be able to identify those areas most at risk. Such an assessment allows priority areas to be identified, and limited resources to be allocated accordingly. This talk will describe an ecological risk assessment method that is being applied to river and stream environments in the Goulburn-Broken Catchment, and that will be used to identify those areas at greatest risk from salinity increases over time scales ranging from present day to ~100 years. The method uses output from a water quality model to describe the likelihood of various salinity thresholds being exceeded; and uses existing data on the occurrence of animal and plant taxa (including 'Flagship' species) in saline environments to quantify the expected ecological consequences for biodiversity when thresholds are exceeded. Unlike many existing techniques for ecological risk assessment, the system will provide estimates of uncertainty by describing both the likelihood and consequences data as statistical distributions. The risk to the ecosystem is then determined by the overlap of the likelihood and effects distributions. Data for some of the sites being investigated will be presented.

As risk is defined as the product of both the likelihood of an event and consequences should that event occur, the risk estimates produced by this method will be dictated not only by the expected profile of salinity readings, but also by the taxa found in the system being assessed, their perceived importance, and their sensitivities to saline environments

River & Catchment Health:

Presenting current research in the Goulburn Broken Catchment

Status of SedNet sediment and nutrient modelling work in the GB catchment

DeRose RC, and Wilkinson S

CSIRO Land and Water, GPOBOX 1666, Canberra ACT 2601.

Ronald.derose@csiro.au

Abstract

The Goulburn-Broken catchment was selected to test regional application of the SedNet sediment and nutrient modelling framework. SedNet provides a spatially distributed assessment of river sediment and nutrient loads. It predicts sources of sediment and nutrients as well as sites of bedload accumulation, levels of floodplain accretion and reservoir deposition. SedNet can be used to identify source areas and erosion processes affecting downstream water quality and can model future scenarios of how catchment rehabilitation would reduce river loads. Predicted water quality has been validated against measurements, showing good model performance in the Goulburn-Broken catchment.

Ongoing research is improving representations of bank erosion and sediment transport processes in the SedNet model to quantify and reduce uncertainties in model results. Broader impacts of common management actions on water quality and biological aspects of stream health are also being investigated to help prioritise river and catchment management. This work is being undertaken as part of CRC for Catchment Hydrology and National Rivers Consortium projects.

Adverse changes to the abundance and diversity of native fish in the Goulburn catchment

Carmel A. Pollino [1], Pat Feehan [2], Mike Grace [1], Barry Hart [1]*
[1] Water Studies Centre, PO Box 23, Monash University 3800, Australia
[2] Goulburn-Murray Water, PO Box 165, Tatura 3630, Australia

Abstract

The National Program for Sustainable Irrigation is funding an ecological risk assessment (ERA) project to develop and test a generic framework for assessing the ecological risks associated with Australian irrigation systems. An issue of importance identified in the Goulburn River was changes in native fish abundance and diversity. Using a modelling approach, hazards to native fish communities in the Goulburn catchment are being quantified. The predictive model will be used to assist management decisions.

The modelling technique being used is Bayesian networks. Bayesian networks are graphical models that maintain clarity by making causal relationships between factors explicit, and facilitating probability calculations. They are able to incorporate data with high uncertainty, and can integrate empirical data and expert opinion. Relationships between environmental condition (average, maximum, minimum flows; water quality; barriers; structural habitat) and native fish abundance are being quantified using available data. The spatial scale of interest is flexible and can extend from site, to reach, to catchment.

Key Findings

The Bayesian network structure represents the current knowledge of factors affecting native fish abundance and diversity in the Goulburn catchment. The model integrates multiple sources of information (both empirical and expert opinion) from multiple scales.

- Fisheries data and preliminary model results suggest:

1. Lake Eildon has generally alienated the section of the Goulburn River between Eildon and Seymour from habitation of native fish species. The effect of the barrier is compounded by the loss of natural flow regime and altered thermal characteristics;
2. Generally, tributaries between Eildon and Lake Nagambie are good habitats for native fish, but communities are composed largely of non-migratory species;
3. The Lake Nagambie fishery has potential to be a good habitat for native fish, but rehabilitation of the hydrological regime is required and Goulburn Weir alienates the Lake from the lower section of the Goulburn River;
4. Below Goulburn Weir, rehabilitation of the hydrological regime, and to a lesser extent, improvements in structural habitat in the river main stem and tributaries are required to improve the fishery.

- The impact of recreational fishing on native fish communities in the catchment is largely unknown.

What are the implications of your findings?

The Bayesian network models are intended to provide a scientific prediction of fish community responses to environmental condition. It is intended that the end product will be used to inform the decision making process and inform policy, in conjunction with other tools available.

- The model produced will inform stakeholders of key knowledge gaps in the model, and our understanding of the system, and will indicate how these gaps might be filled.
- The protocols used in this ERA project will be used in conjunction with parallel studies to develop and test a generic framework for assessing the ecological risks associated with Australian irrigation systems.

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Summary

Examination of fisheries data shows the make-up of fish communities in different parts of the Goulburn catchment differ. The upper reaches of the main channel are composed largely of alien fish species. In contrast, the tributaries between Eildon and Seymour have large communities of native fish, but populations are typically non-migratory. The lower reaches of the Goulburn are composed of migratory and non-migratory native fish species, and alien species.

- The preliminary model findings demonstrate that environmental stressors cannot be managed independently.
- The model highlights the need for a more rigorous and consistent sampling regime. Physical data, and more predominantly, biological data is sparse throughout the catchment.
- A comprehensive survey of fish communities throughout the catchments of interest is required to lower the uncertainty of model predictions. A thorough study would also circumvent the need for expert opinion to be a major component in the model.

River & Catchment Health:

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Restoration Ecology in Sand-Slugged Creeks

P.S.Lake. N.Bond, A.Glaister and K.Cousins

Phone 03-99055653 e-mail sam.lake@sci.monash.edu.au

Abstract

Restoration ecology involves the use and development of ecological principles to the practice of restoration. Many streams in Australia have been badly degraded by excessive sedimentation. This study is centred on the "Granite Creeks" just south of Euroa. Initially, the origins and causes of the sedimentation to the chain-of ponds creeks on the Goulburn flood plain were determined. Then followed a faunal survey of the intact and the sandslugged creek sections, that revealed major differences in both macroinvertebrates and fish. For restoration at a local scale, it was decided to use red gum sleeper-structures, designed by CRC for Catchment Hydrology, built and installed by Goulburn-Broken CMA in mid 2001 as two treatments (1 and 4 structures per section). The structures produced scour pools.. In late 2001, no significant response was found for the macroinvertebrates, and a small but positive response was shown by native fish (3 species). The severe drought prevented sampling in 2002.

Key Findings

- Sedimentation producing sand slugs greatly reduces habitat heterogeneity and complexity.
- Both the invertebrate and fish fauna are depleted by the sand slugs.
- Red gum sleeper structures were successful in producing scour pools, which in the short term produced a small positive response by native fish.

What are the implications of your findings?

- Sand slugs badly degrade both habitat structure and faunal community structure. They may also exacerbate the damaging effects of droughts.
- Sand slug removal is not a management option in most cases, and thus the restoration of habitat in the sand slugs is the alternative strategy. Experimentally, it appears that the sleeper structure do generate habitat favourable to some stream biota and thus, they may be an important component of overall stream restoration.
- Thus, for future restoration at the scale of entire sand slugs, the placement of structures, such as the sleeper structures, will need to scaled-up. Furthermore, adequate flow will need to be reliably provided.

Summary

- Human-generated sedimentation of streams creating sand slugs is a major cause of stream degradation in Australia, especially in areas with granitic catchments..
- Sand slugs, which may be static, reduce habitat structure and variety, which in turn depletes the instream fauna.
- It is possible at the local scale to restore habitat in sand slugs—the challenge now lies in scaling-up local habitat restoration to the scale of entire sand slugs.
- While streams may be degraded rapidly, successful restoration is a long-term undertaking.
- The success of restoration of streams at the local scale can be governed by the operation of large-scale factors, such as the existence of upstream dams that prevent the provision of natural stream flows.
- For successful stream restoration, a variety of measures will usually be required. For example in the Granite creeks" in addition to restoration of in-channel habitat, other measures are also required for the riparian zone and for provision of natural flows.

Further Reading

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Setting environmental flows recommendations for the Goulburn River

Peter Cottingham and Mike Stewardson
David Crook, Terry Hillman, Jane Roberts and Ian Rutherfurd
Contact: Peter Cottingham (peter.c@enterprise.canberra.edu.au)

Abstract

Environmental flow recommendations for the Goulburn River were set using the FLOWS method developed for Victoria, supplemented by the Flow Events Method developed by the CRC Catchment Hydrology.

The project considers changes to the current flow regime that will maintain or improve the ecological condition of the river. This information will provide the basis for evaluating the potential benefits that might be derived from the Goulburn Rivers' contribution to the three reference point flows being considered by the Living Murray project.

Changes to the flow regime as a result of current management and potential ecological implications were considered along 5 representative reaches between Lake Eildon and the Murray River

Environmental flow recommendations are being developed to address issues related to the seasonal flow inversion between Lake Eildon and Goulburn Weir, reduced frequency of wetland and floodplain inundation along the entire study area, and low flows in the river channel below Goulburn Weir. Additional complimentary (non-flow) management actions will also be identified so that ecological benefits associated with the implementation of flow recommendations can be maximised.

Key Findings

- The methods adopted by the Scientific Panel in developing its recommendations will be presented, including its approach to:
    1. Floodplain/wetland inundation events (all Reaches);
    2. Increased low flows to provide additional of deep-water habitat for fish (Goulburn Weir to the Murray River);
    3. Addressing issues related to season flow reversal, such as increased stream velocity and the loss of riffle habitat in summer-autumn (Lake Eildon to Goulburn Weir);
    4. An experimental increase to the duration of bench inundation, particularly in spring (Goulburn Weir to Shepparton);
    5. Ensuring that rates of rise and fall in river levels are within the natural range (releases from Lake Eildon and Goulburn Weir).
- The current condition of the Goulburn River is the result of many factors operating at a range of temporal and spatial scales. Changes to the flow regime offer many potential benefits to the ecology of the river. However, maximising ecological benefits will also require complementary management actions, such as addressing issues related to water quality, instream and floodplain habitat condition and availability, land management, and the control of invasive species.

Implications

- This project was designed to inform the debate on achieving a balance between ecological, social and economic considerations currently being undertaken as part of the Living Murray project.
- The project focussed on ecological issues related to the flow regime of the Goulburn River and did not include social and economic considerations, which will be evaluated separately through the Living Murray project.
- Significant ecological benefits can be gained by delivering additional water within the range of 70 – 300 GL, which is indicative of the Goulburn River's potential contribution to the Living Murray reference volumes. It is acknowledged that some recommendations will have significant social and economic implications that must be considered during the Living Murray process.

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Summary

- Current management has resulted in many changes to the flow regime and ultimately the ecological condition of the Goulburn River.
- There are a number of opportunities for changing the current flow regime to maintain or improve the ecology of the river and its floodplain and wetlands.
- Social and economic considerations have not been addressed in this study; this is an essential part of the wider Living Murray project.

Further Reading

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Rehabilitation of Sand Bed Streams

D. Borg, I. Rutherfurd & M. Stewardson
Dr. Michael Stewardson
River Restoration Program Leader
CRC for Catchment Hydrology
The University of Melbourne
mjstew@unimelb.edu.au Ph: (03) 8344 7733

Abstract

An investigation into the rehabilitation of sand bed streams was undertaken in the Granite Creeks system of the Goulburn-Broken Catchment in a joint project of the CRC for Catchment Hydrology and the CRC for Freshwater Ecology. A significant proportion of stream length in multiple creeks of the system are effected by sediment slugs, defined as discrete bodies of sediment deposited in the stream channel (Davis and Finlayson, 2000). This has lead to a largely altered channel form, with buried large woody debris and infilled deep pools, resulting in a flat, shallow bed of low hydraulic and geomorphic diversity.

This study investigated the use of large woody debris (LWD) to restore the geomorphic and hydraulic diversity in two streams of the system, Castle and Creightons Creeks (the ecological component of the investigation was undertaken by the CRC for Freshwater Ecology). The LWD treatment consisted of a number of River Red Gum (*Eucalyptus camaldulensis*) railway sleepers bolted together, placed perpendicularly to the flow at an elevation just above the streambed and spanning the width of the creek. Nine sites in each of the two streams were subject to an individual LWD treatment, a series of four LWD treatments (spaced approximately 8m apart) or no treatment at all. Bed elevation, and flow depth were monitored once before the LWD treatment, and at multiple occasions following the treatment. Some preliminary results, observations and implications for sand bed stream restoration will be presented.

Key Findings

- Observations of LWD-induced scour over time at each of the 18 sites revealed that the depth of a given scour pool depends not only on the magnitude and duration of scouring flow events, but also on the time between events, where scour pools can be subject to infilling.
- Flow events following the infilling of LWD-induced scour pools can lead to the return of scour pools. However local aggradation at a number of treatment sites was observed, resulting in LWD burial, confirming researchers concerns about initiation of scour once LWD is buried (Marsh *et al.*, 2001).
- Specific changes observed:
  - There were no significant differences in flow depths between control and treatment sites before LWD treatment. Following the treatments, flow depth at treatment sites increased significantly.
  - Following LWD treatment, bed elevation decreased at all LWD sites (indicating LWD-induced scour of 0.2 – 0.5m), whereas bed elevation data at control sites generally indicated localised aggradation (up to 0.3m).
  - LWD-induced scour depth was variable within and between treatment sites and also varied with time.
  - Progressive infilling of LWD-induced scour pools was observed during low flows, in some cases to the point of total pool infilling.
  - Following low-flow pool infilling (to the point of total infilling) and subsequent flow events, the return of LWD-induced scour pools was observed, however a small proportion of LWD treatments were buried by local aggradation.

What are the implications of your findings?

Results from this investigation indicate that LWD can be used to restore hydraulic and geomorphic diversity in sand bed streams. A number of research and management implications have arisen from this investigation:

- Considerable scientific uncertainty remains regarding the persistence of LWD-induced scour, the ecological implications of scour pool persistence and the long term failure rate of LWD treatments by aggradation. These scientific knowledge gaps are currently being addressed by the CRC for Catchment Hydrology.
- Results of this investigation have revealed that the restoration of geomorphic and hydraulic diversity in sand bed streams with LWD is entirely dependent on flow regime, with subsequent implications for environmental flows and prioritisation of treatment sites. Design of LWD treatments may need to be modified for different environmental flow regimes or local hydraulic conditions to best maximise hydraulic and geomorphic diversity.
- The investigation explored the restoration of sand bed streams at a reach scale. The reach scale outcomes of this investigation need to be considered at a catchment scale and in the context of recent geomorphic recovery research (Bartley and Rutherfurd, 2001).
- Many experimental and applied river restoration projects have been undertaken throughout the Goulburn River catchment. These projects deal with specific aspects of the river and river reaches. There would be some benefit in using the results of these projects to construct an evolving knowledge base or conceptual geomorphic and ecological model for the Goulburn River Catchment to underpin integrated planning of restoration work at the catchment-scale.

Summary

- The use of LWD to restore geomorphic and hydraulic diversity was investigated in the Granite Creeks system of the Goulburn Broken Catchment.
- Treatment with LWD did result in greater flow depths and significant LWD-induced scour, even when control sites were aggrading.
- The investigation highlighted the dependence of LWD-induced scour on flow regime. Scour pool infilling was observed during low flows. The return of previously infilled LWD-induced scour pools was subsequently observed following flow events of sufficient magnitude.
- There remains some uncertainty regarding the failure rate of LWD treatments. A small proportion of structure experienced total burial due to local aggradation during the investigation period. The long term failure rate of LWD treatments is unknown.
- The outcomes of this investigation have implications both for research and management. Any LWD restoration in sand bed streams should consider the dynamic nature of scour pool persistence and the potential risks of LWD treatment failure.

Further Reading

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Monitoring the impact of kangaroo grazing on the vegetation of the Barmah State Park.

Cheryl O'Dwyer and Steve Hamilton
University of Melbourne, Dookie College, Victoria, 3647.
email: cherylo@unimelb.edu.au and steveh@unimelb.edu.au

Abstract

The purpose of the project is to establish a monitoring system for the evaluation of the impact of kangaroo grazing on the vegetation of the Barmah State Park, part of the largest River Red Gum forest in the world. High numbers of kangaroos in the eastern areas of the forest, and a commensurate perception of grazing impact within the Park, has been an issue of some prominence, however, there have been no studies that have monitored the longer-term impact of this grazing on the vegetation of the forest.

Kangaroo exclusion plots erected at Ulupna Island will be utilised as the basis for the monitoring. A series of permanent quadrats will be established within and immediately outside exclosures, and floristic and structural parameters measured several times annually for a number of years to evaluate the influence of grazing on plant species attributes and vegetation structure.

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Likely effects on growth and mortality of brown trout (*Salmo trutta* L.) in the Goulburn River after mitigation of coldwater discharge from Lake Eildon.

Paul Brown
Marine and Freshwater Resources Institute, Department of Primary Industry.
Private Bag 20, Alexandra, VIC 3714, Australia.
Email: paul.brown@dpi.vic.gov.au

Abstract

Published empirical models for growth and natural mortality were examined to investigate some of the potential effects on brown trout populations of flows managed to increase river temperatures downstream of a large reservoir. Models were fitted to length-at-age and size-at-maturity observations for brown trout (*Salmo trutta* L.) and to three years of river temperature data, to predict growth and mortality.

The Goulburn River downstream of Eildon currently supports a valuable and popular recreational fishery for brown and rainbow trout; and a thriving aquaculture industry based on rainbow trout farming. The objectives of this study were to predict the likely effects of river temperature elevation on the quality and quantity of brown trout potentially available to support the recreational fishery.

Scenarios of growth and mortality of brown trout were simulated for river temperature regimes elevated by 2°C and 4°C above recent ambient average daily temperatures

The present study shows that the quality and quantity of brown trout that would be available under strategies proposed to mitigate coldwater flows are unlikely to continue to sustain a viable, high quality trout fishery.

Key Findings

- For an average daily 2°C increase: The potential maximum size of brown trout was reduced by 4–38% and the time taken to reach 300g increased by up to 31%. The increase in average instantaneous natural mortality rate was between 9% and 73%
- For an average daily 4°C increase: The potential maximum size of brown trout was reduced by 30–43% and the time taken to reach 300 g was increased by 66–144%. The increase in average instantaneous natural mortality rate was between 28% and 80%

What are the implications of your findings?

- Relatively small increases (2–4°C) in average daily temperature in Victorian 'tailrace" trout fisheries may have substantial effects on the quality and quantity of trout available to the recreational fishery. This may have negative flow-on effects to the community if such changes to the trout population result in reduced participation rates in the fishery.
- Rainbow trout growth and mortality is likely to be similarly effected. If so, small elevations in river temperature may be expected to substantially increase costs and reduce viability for the $9 Million aquaculture industry that is based along the Goulburn River.
- Future Research:
  - Predicted changes in trout growth and mortality should be incorporated into a full population model to better understand complex interactions and the potential effects of density dependence.
  - Predictions of growth rates under elevated river temperature regimes should be translated into production costs for the trout aquaculture industry
  - Social and economic consequences of reduced catch quality and quantity can now be explored through appropriately designed angler-surveys

River & Catchment Health:

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Summary

- Mitigation of the "thermal pollution" caused by hypolimnionic discharge from large reservoirs is currently being discussed as a strategy to rehabilitate the native-ecology of many rivers and streams in Australia.
- Such mitigation clearly has a down-side where valuable and popular coldwater recreational fisheries or coldwater aquaculture industries exist
- Any ecological benefits of such thermal-mitigation strategies should be weighed against the economic and social costs incurred by degrading currently existing, cold-water based, recreational fisheries.
- Whichever management strategy is chosen for each 'tail-race' should be based on sound science and transparent reasoning to achieve a decision through balanced argument.

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Healthy Rivers require healthy food supplies

Rod Oliver/ Chester Merrick
Contact detail/ email address: PO Box 921, Albury NSW 2640.
Ph: (02) 60582300/ email: rod.oliver@csiro.au

Abstract

Biological systems, either agricultural or natural, are sustained by supplies of energy. The primary source of energy is sunlight captured by plants and converted into organic compounds, which provide food that animals ingest. The energy is passed along food-chains from herbivores to carnivores with the quantity of animals supported dependent on the initial supply of organic compounds. The food supply for riverine animals comes from aquatic plants or organic material washed from the landscape. Metabolic activity was measured in the Murray, Ovens and Broken Rivers to assess the food supply and to identify its sources. Differences between rivers were attributed to altered flow regimes and water quality characteristics. Artificial plants were installed in the Broken River to provide fish habitat and to stimulate food supplies by increasing surfaces for growth of attached algae. These studies suggest augmented, heterogenous food supplies will enhance animal populations in regulated rivers and are obtained by improving river connection with the floodplain and modifying flow regimes to increase attached algal production.

Key Findings

- The food supply in the flow-regulated Murray River consists almost exclusively of micro-algae growing in the water column (phytoplankton), with only small contributions from external sources.
  In contrast, attached algae and external supplies of organic compounds make the largest contributions to food resources in the less regulated Ovens River and in the smaller Broken River, with water column algae playing a minor role.
- In the Murray River, daily production of phytoplankton was directly related to light availability with net production close to zero, suggesting that the light-limited phytoplankton production was completely metabolised in food chains and that the system was food limited.
  In the Broken and Ovens Rivers food limitation was less likely due to external supplies of organic material.
- Artificial macrophytes were installed in the Broken River to examine whether they influenced fish populations by increasing food supplies and providing habitat.
  The artificial macrophytes enhanced the development of algal, zooplankton and macro-invertebrate communities and it is likely that these increased the food supplies available to support fish populations, but larval and juvenile fish did not use the artificial macrophytes for habitat in this system, possibly due to high siltation rates.

What are the implications of your findings?

- Food limitation in regulated rivers has important implications for management strategies as it suggests that improvements in the physical and chemical habitat alone, through strategies including regulation of discharge, replacement of large woody debri and alteration of river morphology, will not necessarily lead to enhanced populations of aquatic animals unless food resources are also improved.
- Rivers with more natural flow regimes had larger food supplies due mainly to increased production by attached algae and increased delivery of organic material from the catchment.
  To improve the food resources in regulated rivers, environmental flow protocols and physical works will need to enhance the area for production by attached algae and provide appropriate connection with the floodplain and catchment. Further quantification is required so that these conditions can be included in management strategies and policies.
- Food resources were enhanced by the deployment of artificial macrophytes, suggesting that re-establishment of natural macrophytes would be advantageous to regulated rivers.
  A major problem with their deployment in the Broken River was the high rate of siltation, and in some cases burial, that occurred. Flow conditions, silt load and bed-movement appear to be major problems to the re-establishment of macrophytes in regulated rivers.
  Further research is required so that appropriate policies can be developed.

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Summary

- The sizes of riverine animal populations (crustaceans, fish etc.) are affected by the availability of suitable food resources, with both the quantity and types of food being important.
- The food supply utilized in the regulated Murray River consists of planktonic micro-algae (phytoplankton) supplemented with small amounts of external organic material. Phytoplankton production is limited by light availability and is completely used within the system. Here the growth of animal populations may be restricted by the limited quantity and reduced variety of the food supply.
- Food resources in the shallower and/or less regulated Broken and Ovens Rivers are larger and more variable than in the Murray River. The largest contributions come from external supplies of organic material and the production of attached algae, with a smaller contribution from phytoplankton.
- These results suggest that riverine food supplies can be enhanced in regulated rivers by appropriate management strategies. These requirements should be incorporated into policies aimed at improving the health of riverine animal populations.

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Creating a disturbance manipulating flows in slackwaters of the Broken River

Paul Humphries, Rob Cook, Adam Richardson and Luciano Serafini
Cooperative Research Centre for Freshwater Ecology, Monash University, Department of Biological Sciences, c/- Murray-Darling Freshwater Research Centre, PO Box 921, Albury, NSW, Australia 2640. Paul.Humphries@csiro.au

Abstract:

Slackwater habitats appear to be important as nursery habitats for the young stages of fish and shrimp in Australian lowland rivers. River regulation alters the nature and extent of the availability of this type of habitat for riverine biota in general. We conducted a flow manipulation experiment over the spring and summer of 2002/2003, the aims of which were: (a) to divert flow into slackwater habitats, thus increasing the current velocity passing through them ('destroyed slackwaters') and (b) to divert flow away from edge habitats, thus creating slackwater habitats ('created slackwaters'). Control habitats were unmanipulated natural slackwater and flowing edge habitats. We also collected material washed out of slackwaters during the initial diversion of flow. We also sampled the zooplankton and microbenthic faunas, presumed to be important as prey for the young stages of fish and some shrimp, to determine if changes in their abundance could explain changes in abundance of fish.

Key Findings

- Diversion of flow through slackwaters displaced fish larvae from these habitats
- There were significantly more larval and juvenile fish and shrimp in created slackwaters than in the corresponding controls and that there were significantly fewer larval and juvenile fish and shrimp in destroyed slackwaters than in the corresponding controls.
- The species of fish (common carp, crimson-spotted rainbowfish,, carp gudgeons and gambusia) and shrimp (*Caridina mccullochi, Paratya australiensis* and *Macrobrachium australiensei*) collected in created slackwaters were also those most commonly found in natural slackwaters.
- There were no significant differences in zooplankton or microbenthos as a result of our flow manipulations.

What are the implications of your findings?

- The way that rivers are currently managed, especially with seasonal flow reversal is likely to be detrimental to fish populations
- Managing lowland rivers so that low flows occur during the time when they would naturally occur, should figure prominently in any future implementation plans
- Slackwater habitats must be recognised as significant nursery habitats in lowland rivers

Summary

- Slackwaters in lowland rivers are important nursery habitats for the young stages of fish and shrimp
- There is the potential for irrigation flows to reduce the area of slackwaters
- Reduction in area or availability of slackwaters may limit recruitment of fish and shrimp in lowland rivers
- Managing rivers must take into account these important habitats

Further Reading

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River & Catchment Health:
Presenting current research in the Goulburn Broken Catchment

Understanding landholder management of riparian zones in the Goulburn Broken Catchment

Andrea Wilson / Amy Jansen / Allan Curtis / Alistar Robertson
School of Science & Technology,
Charles Sturt University,
Locked Bag 588, Wagga Wagga , NSW
E-mail: awilson@csu.edu.au

Abstract
Riparian habitats support high levels of biodiversity and management practices adopted by private landholders, such as the grazing of domestic livestock, can influence the condition of riparian habitats. In this project, we interviewed thirty-three landholders and undertook ecological condition assessments at forty-five sites to investigate the relationship between landholder management practices and riparian condition in the Goulburn Broken Catchment. To improve our understanding of landholder knowledge of riparian zones, we compared landholder and scientist assessments of ecological condition in riparian zones on private properties. We also collected information about potential impediments to the adoption of best management practices for riparian habitats.

Key Findings
- The riparian zones sampled during this study were generally in poor condition. All sites had exotic plant species in the ground cover layer.
- Broad relationships between ecological condition and domestic stock grazing were indicated. In general, riparian condition scores declined significantly with increased stocking rates.
- Landholder and scientist assessments of ecological condition showed a significant positive correlation. Although this indicated good agreement between landholder and scientist assessments, a substantial proportion of landholders overestimated riparian condition within their riparian zones.

What are the implications of your findings?
- Discussions with landholders revealed that the time and cost associated with riparian rehabilitation were often an impediment to the adoption of recommended practices. A number of other impediments to adoption were also identified, such as the loss of fences during flooding, the continued maintenance required in rehabilitated areas and the perceived lack of necessity for change.
- There is no evidence to support the hypothesised relationship between landholders riparian assessment scores and the adoption of recommended riparian management practices. It seems that understanding of riparian function is a more important factor contributing to adoption than the ability to accurately complete a descriptive assessment score.
- We suggest that increased awareness of the functional importance of riparian habitat attributes may play an important role in encouraging the adoption of best practice riparian management.

Summary
- Riparian zones in the GBC were generally in poor ecological condition, particularly in relation to the invasion of exotic plant species.
- Broad relationships between ecological condition and grazing of domestic stock were indicated, with riparian condition scores declining with both cowpat density and stocking rate. This suggests a significant contribution of domestic livestock grazing to the degradation of riparian zones in the GBC.
- Although some landholders will be encouraged by funding to take up recommended management practices for riparian zone improvement, a large proportion remain unconvinced. Increased confidence in the effectiveness of these practices and awareness of the need for their implementation is required.

- Scientist and landholder assessments of riparian condition were significantly correlated. However, some landholders substantially overestimated the ecological condition of riparian zones on their properties.
- Increased understanding of the importance of riparian zone attributes to ecological function may be necessary to improve adoption of current recommended practices.

Further Reading

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Assessing Community Capacity for Riparian Restoration

Don Thomson & Sharon Pepperdine
Landscape_social@mac.com, phone 03 5466 2320

Abstract:

This project involved a review of five of LWA's National Riparian Lands Program 'Demonstration and Evaluation Projects', of which the Goulburn Broken CMA was a participant between 1998 and 2000. The review occurred between May 2002 and June 2003.

The aim of the national review was to identify the extent to which the 'Demonstration and Evaluation' projects had built the capacity of regional communities for riparian restoration. The project aimed to identify the critical success and failure points and issues that affected community capacity, and to develop a way of assessing the capacity of regional communities.

Qualitative research was undertaken with a range of people involved in various aspects of the 'demonstration and evaluation' projects in each of five regions (Johnstone and Mary River Catchments in QLD; Far South Coast catchments, NSW; the Blackwood River Catchment in WA; and, the Goulburn-Broken Catchments in Victoria).

Focus groups, site-inspections and interviews with landholders, agency and catchment authority staff were the principal research tools.

Key Findings

- Community 'capacity' for riparian restoration encompasses many social, economic and physical components or elements.
- These elements can have both positive and negative impacts at different places and times. We therefore termed these the 'enabling and constraining *dimensions* of capacity'.
- We identified around 35 dimensions that are particularly relevant for communities engaged in riparian rehabilitation.
- While each of the five regions studied had unique biophysical, social and economic characteristics, the same dimensions of capacity were identified in each region.
- Communities have developed different methods of overcoming limitations in 'capacity' by investing in particular dimensions of capacity. These have not always been deliberate investments designed to overcome 'capacity' limitations. However, there is much that can be learnt from these experiences for future 'capacity building' initiatives.
- What was needed, it was identified, was a 'tool' to help communities understand their strengths and weaknesses in relation to 'capacity' so that 'capacity building (we prefer 'capacity development') could be better targeted.

What are the implications of your findings?

- Limitations in 'capacity' in one 'dimension' can be overcome through investment in other 'dimensions'. A key challenge for 'capacity development' is therefore to identify which dimensions need to be addressed.
- Because of the social, economic and physical diversity within and between catchments there can be no single 'one-size-fits-all' approach to 'capacity building'. However, by understanding the many dimensions of capacity, how they interact to produce different outcomes, and how these dimensions can be influenced, communities can more successfully steer the process of change towards more desirable outcomes.
- A 'capacity assessment tool' was developed as part of this project. The tool is designed for groups, policy developers and program managers to help them identify the range of issues that impact on community capacity for riparian restoration, and to identify strengths and weaknesses of their groups/communities/agencies.
- Another key outcome of this project was a new way of considering 'capacity'. This was based on a 'dialectical' approach to capacity, where 'things' are considered as being outcomes of underlying processes.

- A new definition of capacity emerged from this perspective: "Capacity is the capability of individuals, groups and institutions to understand and deal with the enabling and constraining elements, dimensions and issues that drive the process of capital accumulation and decline (in all its forms) to produce desirable outcomes".
- This approach to 'capacity' has implications for capacity development initiatives beyond riparian restoration, and was well received at a national workshop in Canberra in April 2003.

Summary

- The processes that drive riparian management outcomes have many dimensions, which wax and wane in space and time.
- Limitations in particular dimensions of capacity can be compensated for by investing in other dimensions of capacity.
- To understand how to achieve better outcomes for riparian lands, we need a better understanding of how the underlying processes interact, and how they can be influenced.
- Each region will have a unique set of circumstances that will require any 'capacity development' initiative to be tailored to that region.
- A 'capacity assessment tool' is available to help groups, program managers and policy developers identify strengths and weaknesses of their communities for riparian rehabilitation.

Further Reading

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Two Case Studies to Assess Ecosystem Services: Lower Goulburn Floodplain and Sheep Pen Creek Sub-catchment

Jenny Langridge, Russell Gorddard(f), Art Langston, Paul Ryan, Nick Abel, Roel Plant(s), Mark Howden(f) and John Ives*
(f=floodplain only, s=Sheepen only)
**CSIRO Sustainable Ecosystems, GPO Box 284, Canberra 2601. Jenny.langridge@csiro.au 02 62421579*

Abstract

Project Design: Scenario development is a feature of our work with two approaches used. Scenario development for the floodplain case study is a participatory process, leading to the development of a spatially explicit dynamic model of vegetation regeneration and growth. The model documents current knowledge of key floodplain processes and can explore tradeoffs in ecosystem services and production between scenarios. The project is awaiting the completion of a hydrological model of flood events. A biodiversity enhancement scenario for the Sheepen Creek sub-catchment case study in contrast, was drawn from existing catchment management documents with vegetation maps of increasing (but static) revegetation targets (10 to 100%) generated using rules relating to catchment objectives, ecological theory and design principles, multi-criteria evaluation and an expert panel. Seven ecosystem services were evaluated against the resulting revegetation patterns using a range of analysis tools appropriate to the service.
Questions:
What is the value of agricultural production and ecosystem services currently and with implementation of the proposed floodplain rehabilitation scheme, different land uses and management scenarios?
What are the plausible vegetation patterns associated with incremental revegetation targets?
What is the value of ecosystem services for progressive incremental vegetation targets in the Sheepen Creek sub catchment?

Key Findings

FLOODPLAIN

- significant information deficiencies exist, particularly about the floodplain scale behaviour of the system and available data is of variable quality;
- key ecosystem services have values that are significantly affected by management and are underpinned by the same biophysical processes;
- the key determinant of woody vegetation on the floodplain are frequency and extent of flood controlled germination events, the flood regime, competition from herbaceous species, survival and growth of germination cohorts. Increases in vegetation biomass is most sensitive to changes in the management regime in the medium term (20-30 years) settling down in the longer term as the woody vegetation matures.

SHEEPEN CREEK several services are dependent on vegetation pattern with agricultural vegetation providing less ecosystem services than native vegetation;

- the 'habitat' value of patches of native vegetation increase over time when more patches are added;
- reductions in bank erosion increase more rapidly in the lower reaches of the sub-catchment under increasing vegetation targets, however this only represents 3 percent of the total length of creeks; and
- in relation to the service "regulation of river flows and ground water" yield to channel reduces more rapidly than loss to deep drainage as native vegetation target increases. Water yield to channel is sensitive to the spatial configuration of vegetation although this sensitivity is not expressed in a strong way in end of catchment yields. Water loss to deep drainage is sensitive to the extent of deep rooted perennials.
- expert ecological opinion gave a high weight to the set of biodiversity decision rules that affect the adequacy of a pattern of native vegetation in providing habitat for native species in the presence of threatening processes. Weights were also high with regard to locating vegetation close to drainage lines to enhance the aquatic environment. Less weight was given to rules affecting pre-settlement distributions, the representation of variation within Ecological Vegetation Classes, and social imperatives such as the conservation of rare and threatened species.

What are the implications of your findings?

- scenarios are an effective way of setting the scope for analysing ecosystem services

FLOODPLAIN

- the ecosystem services framework has provided some insights into the complexity of a highly interconnected system, identified the key drivers of the system and is a good basis for exploring trade-offs; and
- as extremely long time scales are involved in the vegetation change process the benefit from managing for ecosystem services varies over time with some benefits not being fully realised in a conventional management time frame.

SHEEPEN

- because gains in the spatial habitat value of native vegetation per unit area increase above a 30-40% native vegetation cover targets, it is better to concentrate funds for revegetation in several small areas rather than disperse it across the landscape;
- some ecosystem services show thresholds and non-linear responses as native vegetation cover increases; taking account of these thresholds will affect the returns to investment in revegetation;
- there is a tradeoff between maintaining channel yield and increasing habitat values, reducing risks to soil health and reducing erosion and water loss to deep drainage as the extent of native woody vegetation increases. Although water yield in the channel under pre 1750 conditions is estimated to be about an eighth of the current flow, it is an increasingly valuable commodity today. Implications of possible future reductions in water yield as vegetation is put back into the landscape need to be considered in management/policy; and
- from ecological principles revegetation should focus on connecting and enhancing existing patches with some emphasis given to linkages along watercourses. The ecosystem service of 'maintaining healthy waterways' in particular is enhanced by such a strategy.

Summary

- the 'value' of ecosystem services can change over time so measurement at one time may result in inappropriate action. It may be that maximum enhancement of an ecosystem service/s may not be realised in the current management time frame;
- many service indicators cannot or should not be expressed as dollar values because this is dependent upon peoples perceptions and market forces;
- significant interconnections between different goods and services mean that issue by issue policy making is inappropriate. A policy solution to one issue may have surprising and unwanted consequences in other areas;
- link incentives for re-vegetation to sub-catchment plans so that efficient trade-offs are made among ecosystem services;
- increase native re-vegetation targets to take advantage of thresholds in ecosystem service responses;
- efficient replanting of native vegetation can be achieved by following rules we derived from state policy and conservation biology theory.

Further Reading

www.ecosystemservicesproject.org for links to the ecosystem service project and related research. Documentation of the two case studies is in progress and will be accessible from this web site when complete.

Evaluating the water requirements of isolated floodplain wetlands: The rehabilitation of Kanyapella Basin

Hugh Robertson & Kimberley James
School of Ecology & Environment, Deakin University, Burwood. Email: harobert@deakin.edu.au

Abstract

Environmental water allocations (EWAs) are frequently utilised in the Goulburn-Broken catchment in the management and rehabilitation of wetland ecosystems. However, decisions regarding the provision of EWAs are often not based on a sound understanding of vegetation-hydrology relationships.

Our research aims to evaluate the vegetation water requirements of Kanyapella Basin (a 2581 ha wetland on the Lower Goulburn River floodplain), by examining vegetation-hydrology relationships using different plant classification systems (i.e. species level - vegetation community).

Vegetation was surveyed over two years (2000-2002), and in combination with aerial photographs (from 1945-1992) and an assessment of the soil seed bank (2002-2003), provided a pool of spatially referenced data to predict the impact of future water regimes on vegetation. In addition, an oral history was conducted to collate local knowledge of the flooding, ecology and management of Kanyapella Basin.

To date, results indicate that by targeting particular management objectives, such as 'the maintenance and regeneration of overstorey species' and 'the elimination of terrestrial weeds' within a GIS framework, the water requirements of different landscape units can be defined. It is argued that such wetland-scale assessments of vegetation-hydrology relationships are critical in determining the volume, timing, duration and frequency of EWAs.

Key Findings

- Ten distinct vegetation communities were identified at Kanyapella Basin based on dominant plant species and differences in understorey plant composition. Differences between the vegetation communities reflected short and long-tern flooding history, and land use history (e.g. tree clearing).

- Application of different plant classification systems influenced the assessment of wetland water requirements. That is, use of selected plant species (e.g. structural dominants), water tolerance categories (aquatic/amphibious/terrestrial) or provenance (native/exotic) to analyse the ecological 'character' of the wetland and subsequently define wetland water requirements resulted in different outcomes. However, by targeting particular management objectives, such as 'maintenance and regeneration of overstorey species' and 'elimination of terrestrial weeds' within a GIS framework the water requirements of different landscape units were able to be defined.

- The soil seed bank contained a significant propagule store, including a number of native wetland plant species not observed in the extant vegetation. Inundation of the soil cores in the seed bank experiment favoured the establishment of native wetland plants over introduced taxa. Spatial analysis of the plants that emerged from the seed bank indicated that most of the wetland species were widely dispersed, in contrast to the localised distribution of many of the plants in the extant vegetation.

- The oral history enabled the values and concerns of local community to be recorded, and provided a historical perspective of the wetland ecosystem, which have contributed to planning for the wetland's rehabilitation.

- Utilisation of a GIS based spatial model, incorporating data from the extant vegetation surveys, seed bank experiment, aerial photographs and digital elevation model, provided a valuable tool to evaluate different water management options.

What are the implications of your findings?

- Use of GIS to collate spatially referenced data of wetland vegetation, hydrology, water quality, soils and fauna provides a tool to evaluate the impacts of future wetting and drying regimes at the scale at which management will occur. This may include modelling the impact of a specific volume EWA on extant vegetation in floodplain wetlands.

- Due to the limited availability of environmental water in the Goulburn-Broken catchment, assessments of vegetation-hydrology relationships using GIS based spatial models provide an important resource to determine the volume, frequency, timing and duration of EWAs required to conserve isolated floodplain wetlands such as Kanyapella Basin.

- Seed bank experiments, especially of dry and degraded wetlands, can be used to investigate the abundance and distribution of wetland plants that may establish following the reestablishment of a wetting and drying regime. These assessments are enhanced by spatial analysis of seed bank data with environmental factors (e.g. hydrology).

- In addition to the historical information gained, community support for wetland projects is enhanced by their participation in oral history. This enables early conflict resolution between managers and the community, which is beneficial when planning wetland management.

Summary

- Little data on the ecology and condition of wetlands is available for managers to prioritise conservation actions and make informed decisions regarding the provision of EWAs.

- Analysis of vegetation-hydrology relationships at spatial scales appropriate for management is central in determining the environmental water requirements for the rehabilitation of floodplain wetlands.

- GIS based spatial models provide a tool to integrate ecological and hydrological data and evaluate policy options regarding environmental water, but remain underutilised in wetland management.

- This method of assessment has the potential to determine whether management objectives are realistically achievable given the limited environmental water and other management constraints.

Further Reading

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River & Catchment Health:
Presenting current research in the Goulburn Broken Catchment

Grazing Impacts on Riparian Vegetation

Kylie Lewin, Michael Shirley, Wayne Tennant
Sinclair Knight Merz, 590 Orrong Road, Armadale Vic. 3143
Goulburn Broken Catchment Management Authority, PO Box 1752, Shepparton Vic. 3632
klewin@skm.com.au,, mshirley@skm.com.au, waynet@gbcma.vic.gov.au

Abstract

A healthy riparian community is a key requirement for a healthy stream ecosystem and much effort is being put into management and rehabilitation of these communities. This study compared characteristics of riparian vegetation between grazed, partially grazed and un-grazed sites at a number of streams in the Goulburn-Broken Catchment in Northern Victoria.

The overall aim of the project was to identify the best management practice for grazing in riparian zones within the Goulburn-Broken Catchment by assessing the vegetation community responses to grazing. Specifically, the impact of grazing on vegetation composition and abundance and the cover of litter and bare ground.

Methods

The field survey was conducted at sites along six waterways within the Goulburn Broken Catchment; Goulburn River, Broken River, Seven Mile Creek, Blind Creek, Sams Creek and Ryans Creek. On each waterway there were at least two sites. The grazing regime of each site was categorised as either non-grazing, partial grazing or unrestricted grazing and each site was fenced accordingly.

Vegetation surveys were undertaken in October 1999, March, July and October 2000 and March 2001. Transects (three per site) ran from the permanently dry zone to the wet zone and data was collected using 1x1m quadrats. Modified Braun-Blanquet cover-abundance values were used to measure vegetation cover. Open water, bare ground and litter cover were also recorded.

The effect of grazing on vegetation composition and abundance and the cover of litter and bare ground was analysed using Analysis of Variance (ANOVA). Post-hoc procedures (Tukey) were used to test which grazing regime produced different results when the grazing regime was found to significantly effect the level of a particular variable.

Results and discussion

Grazing regime significantly affected the mean biodiversity, number of native species, mean number of introduced species, and proportion of litter and bare ground.

- Biodiversity was greatest at non grazed sites
- Native species diversity were greatest at non grazed and partially grazed sites
- Introduced species were greatest at partially grazed sites
- Litter was greatest at partially grazed sites and lowest at grazed sites
- Bare ground was greatest at grazed sites and lowest at partially and ungrazed sites

River & Catchment Health:

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Key Findings

This study suggests that partial grazing does not have a detrimental effect on the vegetation communities of the riparian zone. However, it is likely that the effect of grazing on riparian zones is dependent on local environmental factors and the types and numbers of stock grazing. While it can be concluded that it is not necessary to restrict all grazing in the riparian zone, an upper limit on the level of grazing cannot be determined from this study.

Key conclusions:

Unrestricted grazing in the riparian zone reduces biodiversity, abundance of native species and litter cover.
Unrestricted grazing in the riparian zone increases the number of introduced species and cover of bare ground.

Recommendations:

- The riparian zone should be fenced to prevent unrestricted grazing.
- Only controlled grazing should be permitted and levels should be based on local environmental conditions, the precautionary principal and adaptive management.
- Stock should not be allowed to graze in stretches of riparian zone that are still relatively intact.
- Weed and pest control should take place in sites once stock have been removed from the riparian zone.

Further Reading

Goulburn Broken Catchment Management Authority and Land and Water Australia (2002), Demonstration and Evaluation of Riparian Management, Volume 2 – Demonstration and Evaluation - (Riparian Management Trials in the Goulburn Broken Catchment), Land and Water Australia, Canberra

Acknowledgements: Lisa Voorwinde and Lien Sim

Landmark Project – the sustainability of current land use and management in the upper Goulburn Broken pilot region (Victoria)

David Clarke
Landmark Communication Leader
149 Main Road Hepburn Springs VIC 3461
ph: 03 5348 4900, email: david@efect.com.au

Abstract

The Landmark project is a four year research project funded by the Murray-Darling Basin Commission. Its objective is:

"to identify the need for land use and land management change and explore policy responses which may facilitate change in broadacre dryland regions in the Murray-Darling Basin."

Landmark worked in three pilot regions of the Murray-Darling Basin with contrasting land uses and in different environments:

- high rainfall (>600mm) grazing landscapes in the upper Goulburn Broken catchment in Victoria;
- cropping and grazing landscapes of the Billabong Creek catchment in southern NSW; and
- cropping landscapes in part of the Condamine/Central Downs region of south-eastern Queensland.

Results of Landmark's work in the upper Goulburn Broken pilot region will be presented. These results will be of interest to governments at all levels, regional planners, policy makers and advisors, rural industry bodies, community organisations and research organisations.

David Clarke is the Landmark communication leader.

Key Findings

- Landmark assessed the sustainability of current land use and management in the high rainfall grazing industries in the upper Goulburn Broken region against five environmental indicators – soil erosion, soil acidity, nutrient management, conservation of biodiversity and water balance. Social and economic indicators were also assessed.
- Current land use and management trends were assessed to be economically and socially sustainable at a regional scale.
- For almost all environmental indicators, Landmark concluded the current land use and management is not meeting environmental sustainability requirements.
- A range of Current Recommended Practices (CRPs) covering all aspects of land use and management in the upper Goulburn Broken pilot region were defined. However, adoption rates of these CRPs were found to be low, with widespread adoption in many cases not considered feasible.
- In some cases even with the widespread adoption of CRPs, current land use and management still fails to meet environmental sustainability requirements. This is particularly so for biodiversity and water balance indicators, where land use change offers the only pathway to environmental sustainability.

What are the implications of your findings?

- Landmark's results indicate that new and challenging directions are required should the community wish to make substantial progress towards environmental sustainability in the upper Goulburn Broken pilot region.
- For high rainfall grazing enterprises, widespread adoption of CRPs relating to soil erosion, soil acidity and nutrient management must be pursued across the region.
- In steeper areas, where the risk of erosion, nutrient and water loss and ongoing soil acidification are high, significant changes in land use are required to less intensive, perennial dominated land uses, including revegetation with native species.
- Increasing effort is required to ensure small (hobby and lifestyle) farms, which represent an increasing proportion of the region, also adopt CRPs.
- New CRPs developed by Landmark relating to biodiversity should be widely adopted. Application of these biodiversity CRPs will involve some land use change from high rainfall grazing to native vegetation over about 30,500 ha, or approximately 5% of the cleared land in the pilot region.
- The identification of salt stores is a high priority to allow remediation works, included revegetation and protection of important assets, to be implemented to address significant water imbalances.

Summary

- Current land use and management trends were assessed to be economically and socially sustainable at a regional scale.
- For almost all environmental indicators tested, Landmark concluded the current land use and management is not meeting environmental sustainability requirements.
- Landmark's results shed new light on the challenge of achieving sustainable land use and management in the upper Goulburn Broken pilot region, and provide a basis to propose new policies.
- Landmark is currently developing a suite of new policies to address this challenge, and an action plan, including costings.
- These policies, including those from the other Landmark pilot regions, will be presented to the Murray-Darling Basin Commission Ministerial Council for consideration in late 2003.
- Landmark's results and policies will be widely available in late 2003 for consideration by governments, industry and communities.

Further Reading

- More information about the Landmark project is available on our website – www.landmark.mdbc.gov.au
- A number of reports will be published in late 2003, including a Goulburn Broken pilot region report, overall (integrated) report, and methods report. These will also be available on a CD-ROM, which will also include further reading and information.

Better Managing Farm Business and Biodiversity

Jim Moll, Jim Crosthwaite and Josh Dorrough
Department of Sustainability and Environment, Victoria
Contact: Jim Moll, DPI Benalla 0357 611 619 jim.moll@dse.vic.gov.au

Abstract

Better ways of managing native biodiversity and farm business are being examined on 8 case study properties in the Broadford and Violet Town regions in the Goulburn Broken Catchment. Future management options are being developed in close collaboration with each landholder in order to enhance native biodiversity while maintaining or improving farm profitability. Detailed vegetation surveys are being carried out on each property, and a set of management options being developed that are consistent with regional conservation priorities. The options will involve various levels of capital expenditure and outlay of time and resources. The challenge of the project is to come up with solutions that help offset this outlay of resources and minimise the costs involved. Preliminary findings from the biodiversity surveys and the evaluation of the financial position of the farms are reported.

Key Findings

As the project is still in its early stages, the project team can only comment on the findings to date. We are expecting more detailed results towards the end of this year.

Case Study farmers: The case study farmers chosen are diverse but represent typical landholders and farmers in both study regions. Initial farm visits and data collection has generally revealed a strong production focus with varying environmental interests. Both small (under 300ha) and large properties have been selected to participate in the project and will provide the project with a variation in agricultural issues, management styles and attitudes to biodiversity.

The case study landholders all hope to gain knowledge that will help them solve some of their current environmental problems, as well as make them some money down the track.

Farm Business Situation: Off farm income is generally a large contributor to farm disposable income. It is therefore an important factor in considering landholder capacity to invest in biodiversity conservation, and in business production. Gross farm income, equity and operating profit vary significantly over the participating farms, which is reflected in the differences in return on capital amongst the farms. These performance indicators will be used to assess the impact of future changes in farm management, in relation to improved biodiversity management.

Agricultural Productivity: The profitability of agricultural enterprises have been analysed, and gross margins are shown to be extremely variable. Dry seasonal conditions, stock purchases and other farm enterprises competing for the same land, all have a hand in explaining some of the variations observed in enterprise performance.

What are the implications of your findings?

Clarifying the effect of various management options on the bottom line of the farm business will allow landholders to decide themselves if they have the capacity to invest in biodiversity conservation, or if they need external help. As shown from the initial financial data collection, this capacity will vary.

The changes in farm management to accommodate biodiversity, has the potential to be low cost with the major cost being labour and time. If this is the case, landholders will be more likely to adopt the results, especially if there is a chance of improved production and business performance. The challenge will be to prove to landholders that some low cost changes to their farm management will produce benefits to native biodiversity, and have minimal impact on (and perhaps improved) productivity and profitability in the future.

Moving down this path may lead landholders to consider other more costly options that have significant biodiversity benefits. Issues still to be explored in the study include whether there are investment possibilities for generating the cash flow to fund biodiversity works, and other personal goals. The role for government is still to be investigated. Will capacity building initiatives, such as training in business management and pasture management be enough? Is there scope to adopt a new farm plan that pays for biodiversity management through more intensive management elsewhere on the farm? Or should government simply invest directly in biodiversity conservation? The research findings will help address these questions.

The project team is seeking to enhance ways of achieving the biodiversity goals set out in the Regional Catchment Strategy and Biodiversity Action Plans. Collaboration with regional officers from the Goulburn Broken CMA and DSE will ensure that the project results are utilised in local area planning, education and natural resource management programs and projects being undertaken across the catchment.

Summary

- Local researchers and landholders are seeking practical ways of balancing conserving local native plants, animals and ecosystems while improving on-farm cash flow, productivity and other management goals.
- Landholders involved in the project will demonstrate that biodiversity has a range of values and can be managed as part of a productive, profitable enterprise, and also part of a smaller less profitable enterprise.
- The financial costs and whole-of-business benefits borne by farmers of undertaking conservation work will be highlighted by the project.
- Landholders involved in the project will learn more about biodiversity on their farms, and how to better manage it to help develop more profitable and sustainable farms.
- Financial, knowledge and physical barriers faced by landholders when conserving native biodiversity will also be clarified, with recommendations developed for farmers and policy makers on how these barriers may be overcome.

Further Reading

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Towards achieving environmental flows in unregulated catchments: research by the Department of Primary Industries' Targeted Water project in the Goulburn Broken Catchment

Lucy Finger and Sze Flett
Department of Primary Industries, Tatura
Private Bag 1, Ferguson Road, Tatura, VIC, 3616
Ph. (03) 5833 5324, Email: Lucy.Finger@dpi.vic.gov.au

Abstract:

In Victorian *unregulated* catchments, Streamflow Management Plans (SFMP) specify an environmental flow regime designed to maintain and improve environmental values within that stream system. To maintain that regime, agricultural water users may face periods of rostering, restrictions, and bans on water abstraction during critical seasonal periods. To help water users in unregulated catchments meet their environmental flow obligations whilst maintaining or increasing agricultural production, targeted water management strategies are required. This project, funded through DPI's Ecologically Sustainable Agriculture Initiative, seeks to provide that support to assist the delivery of environmental flows in unregulated catchments.

The four main elements of the "Targeted Water Management Strategies for Ecologically Sustainable Agricultural Industries" project are:

- Development of a prioritisation tool (SPPLASH) for the selection of sub-catchments for SFMP development
- Development of generic guidelines on how to monitor the ecological impacts of implemented environmental flow regimes in unregulated catchments
- Development of a toolbox of water management strategies to assist agricultural water users
- Case studies to investigate the effectiveness of options and interactions between agricultural water management and aquatic biodiversity.

The project team consists of staff from the Department of Primary Industries and the Department of Sustainability and Environment. The project commenced in December 2001 and concludes in June 2005.

Key Findings

- A prototype prioritisation tool (SPPLASH) has been developed for use by CMA staff. Currently populated for 5 sub-catchments of the Goulburn-Broken, it seeks to identify those catchments that have high ecological value and high levels of water use, which should have a SFMP developed as a priority. There is very little data on actual water use available in unregulated catchments.
- A literature review revealed that very little research has been undertaken to measure the success of implemented environmental flows in Australia, and that work on implemented environmental flows in unregulated catchments was almost non-existent.
- Social research, conducted as part of the development of the toolbox of water management options, has uncovered many unexpected findings about the attitudes and current irrigation practices of agricultural water users in the King Parrot Creek, Yea River and Hoddles Creek SFMP catchments.

What are the implications of your findings?

- SPPLASH was developed for CMA use in selecting which catchments should have SFMP developed and which can be managed according to Statewide Rules, in accordance with their new responsibilities under the Victorian River Health Strategy 2002. It is designed to provide a consistent statewide approach to the process, to allow greater transparency to the wider catchment community.
- Further work looking at demonstrating the ecological impact of implemented environmental flows, particularly in unregulated catchments, may be required for continued regional community support of environmental flow processes.
- Social research may provide a valuable insight into water use in a catchment prior to the development of a SFMP, and contribute significantly to the future success of SFMP implementation.
- The success of environmental flows in unregulated catchments relies on the cooperation, support and commitment of agricultural water users. Therefore, it is critical they are considered and consulted during all stages of environmental flow planning.

Summary

- This project is conducted in consultation with several agencies to develop practical outputs that will assist a variety of audiences with the implementation of environmental flows in Victorian unregulated catchments. Much of the work has been conducted in the Goulburn-Broken catchment.
- A prioritisation tool (SPPLASH) has been developed to assist Catchment Management Authorities in deciding which sub-catchments should have a SFMP developed as a priority, based on environmental values and levels of water use.
- A review of the literature has shown there is potential for further scientific research into the effectiveness of implemented environmental flows in Australia, particularly in unregulated catchments.
- A greater initial understanding of the attitudes and practices of irrigators in unregulated catchments will assist in the development of environmental flow regimes that are achievable and endorsed by the community of that catchment.

Further Reading

Please contact Lucy Finger for further information about the overall project or its components.

Increasing fishing opportunity through Access and Habitat Enhancement

Wayne Tennant, Tom O'Dwyer and Paul Brown
Goulburn Broken Catchment Management Authority, PO Box 1752, Shepparton Vic. 3632
Marine and Freshwater Resources Institute, Department of Primary Industry. Private Bag 20, Alexandra, VIC 3714
Email: waynet@gbcma.vic.gov.au, tomo@gbcma.vic.gov.au, paul.brown@dpi.vic.gov.au

Abstract

Stream rehabilitation, where native recreational fishing species exist, appears to well accepted, by governments and communities, when considered in the context of stream health. However, trout-habitat programs are less accepted as they are often seen to conflict with this concept.

As a result the management of recreational fisheries and rivers are often planned, implemented and monitored in isolation of one another.

Currently the catchment management authorities have a key role to play, in association with fisheries managers, in creating improved habitat for aquatic systems, including recreational fisheries (both native and exotic). This is particularly the case where stream are important for their social and economic values.

The Goulburn Broken Catchment Management Authority, in partnership with Fisheries Managers at the Marine and Freshwater Resources Institute has undertaken rehabilitation programs in target areas where exotic (trout) species are present. These actions include improvement of access points, management of vegetation, revegetation and habitat enhancement. But has this improved recreational experience?

Follow up monitoring was conducted which provided some preliminary results.

Key Finding to date

- Informal discussions with local anglers and professional fishing guide services and personal observations, indicate that many trout have been angled within the areas where willow removal has facilitated access. Feedback from all anglers has been positive over the twot fishing seasosn since the project started

- After willow removal and instream rehabilitation a side-channel offers good habitat for catchable trout. It contains pools over 60 cm in depth, runs, riffles and velocity refuges (boulders and logs) along with overhead cover, from introduced half-logs and other natural features. Observation suggests that there has been a shift in the dominant substrate type towards more gravel and less silt.

- During the first fishing season (1 September – 10 June, 2002) after work was completed, at the four locations where pedestrian access to the river was monitored, we estimated that over 4,635 persons accessed the riparian and instream zones via the enhanced access points

What are the implications of your findings?

The intention of this project was not primarily to increase fish production by providing more habitats. The project objectives were mainly about providing more access to the stream for the anglers. However, the effects of large-scale willow management required some mitigation for the trout-habitat. Consequently the project successfully achieved its objectives:

- Anglers were better able to access the trout in the rehabilitated sites
- Trout did use the rehabilitated sites.

We can conclude from the monitoring that the project achieved its objectives and that these methods (improvement to instream habitat and access) can be applied again with confidence to other locations on the Goulburn or similar catchments. Another consequence is that we may be able to manipulate flow or other habitat characteristics in other parts of the river in order to optimise trout habitat and angler access.

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Summary

- Access figures are available at a number of sites, subsequent to completing works. Use pattens will be monitored for long-term trends and site-comparisons.
- Secondary impacts of willow-management on quality of trout-habitat can be successfully mitigated by in-stream and riparian habitat rehabilitation

Further Reading

Tennant W and O'Dwyer T (2003), Enhancing Recreational Fisheries through Stream Rehabilitation Programs, in Brown P (ed) Proceedings of the Workshop on: Stream Habitat Rehabilitation for Recreational Fisheries, Marine and Freshwater Resources Institute

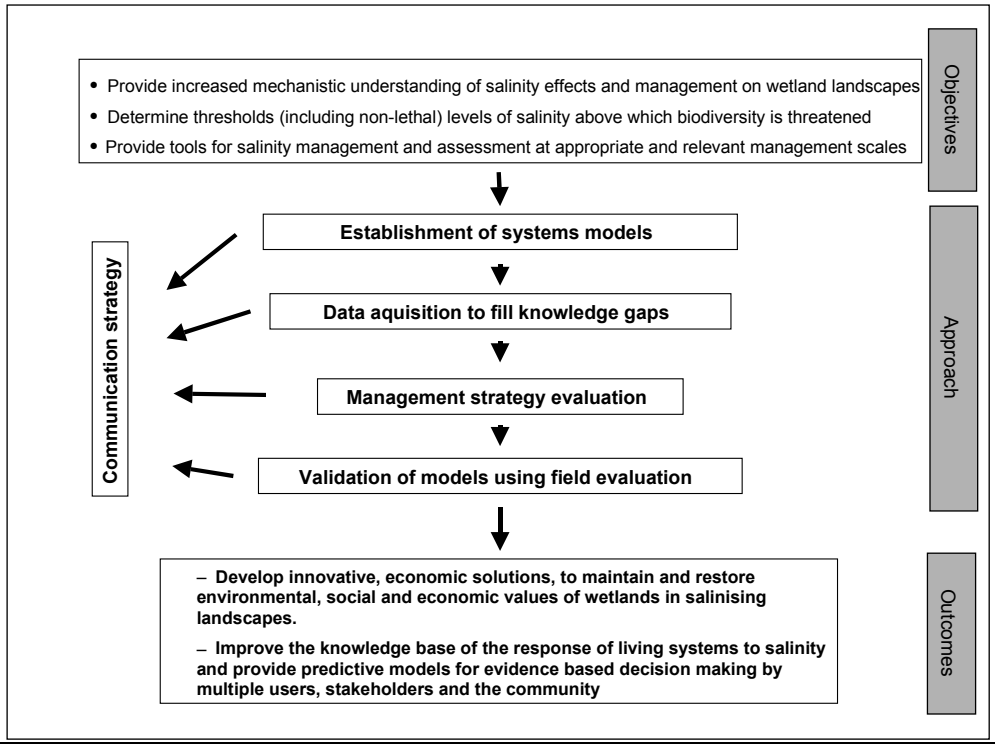
Brown P (2002), Improving Recreational Fishing Opportunities in Side-Channels of the mid-Goulburn River: Provision of Research and Development Services, Marine and Freshwater Resources Institute.

Critical Functional Relationships between Salinity Solutions and Biodiversity

Sabine G. Schreiber
Freshwater Ecology
Arthur Rylah Institute for Environmental Research
Department of Sustainability & Environment
123 Brown Street, Heidelberg 3084
Sabine.Schreiber@dse.vic.gov.au

Abstract:
Wetlands, often regarded as highly threatened ecosystems, can be disproportionately affected by changing salinities due to their location in the landscape. Yet we still lack a functional understanding of the relationship between changes in salinity and wetland ecology, particularly at large scales that are likely to be important for their management. Management needs to understand whether key thresholds exist in ecological systems and whether changes between states are associated with biodiversity loss, or breakdown in critical ecosystem functions (eg. nutrient cycling) if exceeded. Identifying these thresholds requires a functional understanding of how biodiversity is maintained at the large scale and not simply an inventory. We are now starting a project that aims to identify these thresholds and apply this knowledge to practical management solutions. We aim to work closely with all stakeholders from the inception of the project and call on any interested parties to contact us.

Approach –



Implications of this approach:
Establishment of system models requires collaboration amongst a wide range of stakeholders. Currently available management options need to be translated into scientific hypotheses that can be experimentally tested here. As such the project relies on input from a wide range of stakeholders at its very beginning.

Aquatic Fauna and Habitat Structure of Seven Creeks: Status of Pre and Post-Rehabilitation Works Condition

S.R. Saddlier, Di Crowther and Phil Papas
Freshwater Ecology
Arthur Rylah Institute for Environmental Research
Department of Sustainability & Environment
123 Brown Street, Heidelberg 3084
Stephen.Saddlier@dse.vic.gov.au

Abstract

- Project design

This project follows the BACI (Before and After Control Impact) design for testing the effects of rehabilitation works on a range of biological and physical parameters within Seven Creeks near Euroa. An assessment of fish fauna included the number and size of each fish captured from the stretch of water extending from Galls Gap Road Bridge, upstream to Gooram Falls (a distance of 2,820 metres). Aquatic macroinvertebrate assemblages were also recorded at selected sites throughout the rehabilitation section as well as at sites further upstream. The physical form of stream bank and bed was also recorded at sites where rehabilitation works were to proceed including the measurement of three cross section transects. This information will be used to assess the effects of works on instream fauna, stream form, substrate and depth.

- Aims/Objectives

The aim of this project is to monitor the result of instream works (conducted between April – May 2002) which were designed to improve the quality of instream and riparian habitat for Trout Cod in Seven Creeks.

- Treatments

Rehabilitation works were conducted at 11 sites within the study area. At each site, a combination of works were conducted including the mechanical removal of stream-bed material, and the addition of habitat elements which included lunkers (submerged timber structures used to mimic undercut banks), sleepers (instream cover and bed scouring structures), rocks (instream habitat and flow refuges) and timber piles (flow diversion and sediment traps)

Key Findings

- Eight native fish species (totalling 469 fish) were captured from the 2.82 km treatment section, including 80 Trout Cod, 135 Macquarie Perch, 112 Mountain Galaxias, 2 Golden Perch, 80 Western Carp-gudgeon, one Southern Pygmy-perch, 34 Australian Smelt and 25 River blackfish. Of the 47 introduced freshwater fish captured during this survey, 39 Carp were collected, as well as 8 Redfin Perch.

- Preliminary macroinvertebrate results suggest good water quality throughout the Seven Creeks study area. Further work combining results from two seasons of sampling and analysis using SIGNAL and AusRivAS will provide a more comprehensive assessment of biotic and environmental health of the study area.

- Comparison of graphs of pre and post works stream profiles vary significantly from transect to transect. Reasons for these large variations are a result of a number of factors including the precise transect position in relation to the actual works location as well as to the early developmental stage of the restoration works.

What are the implications of your findings

- Pre-works habitat assessment will provide base-line data upon which, the success of the short-term aims of this project can be assessed. This includes the success of the project in providing greater instream physical habitat diversity suitable for Trout Cod and other species of native freshwater fish within Sevens Creek.

- The collation of fish and aquatic macroinvertebrate data will greatly assist in assessing the success of the ultimate aim of this project (provision of instream habitat suitable for Trout Cod and other aquatic fauna). This research will ensure that future works can be modified (if necessary) in a systematic and coordinated manner to better provide for the biological and habitat requirements of native aquatic fauna

Summary

- A systematic approach to assessing the outcomes of restoration works is an essential part of the restoration process
- Ensure the collection of data to allow for the assessment of short-term aims (in this case habitat creation)
- Ensure the collection of data to allow for the assessment of long-term aims (in this case fish fauna)

Freshwater ecology education and awareness program for Victorian stream-side land-holders

Phil Papas and Steve Saddlier
Freshwater Ecology
Arthur Rylah Institute for Environmental Research
Department of Sustainability & Environment
123 Brown Street, Heidelberg 3084
Phil.Papas@dse.vic.gov.au / Stephen.Saddlier@dse.vic.gov.au

Abstract

- Project design

Eight field days that were held between October and December in 2002 in four Victorian Catchment Management Authority (CMA) regions including two in the Goulburn-Broken CMA, two in the North East CMA, three in the North Central CMA, and one in the Corangamite CMA. The field day locations were selected by the CMAs at sites that (a) were in areas where the CMAs judged land-holders would benefit from a stream education program and (b) had enough water as to adequately perform the sampling demonstrations. All field days were held adjacent to the stream

- Aims/Objectives

This project aimed to conduct ecological education and awareness field days in strategic areas (which have been prioritised by CMAs) in order to increase land-holders willingness to consider rehabilitation activities.

- Analysis

Two questionnaires completed by landholders and CMA staff were reviewed and the results were tabulated and graphed.

Key Findings

- Over 100 people attended the field days and the majority of participants found the field day enjoyable and easy to understand. Most participants felt the talks and demonstrations were of high value and that they had gained knowledge on aquatic biodiversity and associated issues from the information presented in the field day.
- Of the stream health issues, water quality ranked highest with the participants. The majority of participants felt they would consider changing the way they manage their stream frontage following the field day.
- CMA staff felt the information was pitched at the right level and gave the participants a better appreciation of aquatic biodiversity values, however were not confident that participants were likely to change their stream management practices following the field day. The CMA staff perceptions appear to conflict slightly with land holders perceptions.
- CMA staff perceptions of what land-holder's considered most important of the five key stream issues were quite different to the participants opinions. Land-holders rated the importance of the five key stream issues more highly than expected by the CMAs.
- Overwhelmingly, CMA staff responses indicated that the field days would make it easier to persuade land-holders to conduct rehabilitation works – this was the principal aim of the field day.

What are the implications of your findings?

- The attitude of land-holders to environmental rehabilitation a vital factor in the process of waterway health improvement. For many land-holders, waterways are seen solely as a resource which sustains agricultural practices, often ignoring inherent biological values within the aquatic system.
- A great deal of ignorance is perpetuated through lack of knowledge and misinformation handed down from pervious generations.
- The field days addressed these key problem areas and results indicated we were able to positively influence attitudes and perceptions of stream ecological values, thus assisting with CMA rehabilitation efforts.

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Summary

- The education field days provided an effective means of disseminating aquatic ecological information to landholders and CMA staff.
- Following the field day, landholders that attended the day indicated they were generally willing to consider changing their stream frontage management practices.
- CMA and landholders perceptions and attitudes on stream issues/management appeared to differ.
- Through the field days we were able to positively influence attitudes and perceptions of stream ecological values, thus assisting with CMA rehabilitation efforts.
- Most CMAs were willing to expand the aquatic ecology field day concept.

Further Reading

Papas, P. and Saddlier, S. (2003) Freshwater ecology education and awareness program for stream-side land-holders. Final report to the Natural Heritage Trust. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria. March 2003.

River & Catchment Health:

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Community Water Quality Monitoring

David Hodgkins
Waterwatch Catchment Coordinator
Phone: 5832 0460
Email: davidh@gvwater.vic.gov.au

Abstract:

The Goulburn Broken Waterwatch Program encourages long term changes in attitudes to water resource management by increasing community understanding of water quality issues. Our program combines awareness activities with a strong emphasis on data collection and interpretation.

A strategically structured community monitoring program has the potential to gather good information on the state of our waterways and to monitor changes or trends in water quality over time. However, the program must be carefully planned, in terms of parameters monitored, testing frequency and site selection, if data is to be useful in waterway management.

Monitoring for the long term is desirable if the program is to achieve more than simply an increase in community awareness of water quality issues. A long term program is essential to properly monitor the effectiveness of on-ground actions by the community.

A method of representing and reporting data collected by groups was needed to attract and retain participants in our monitoring program. A data confidence program was also prepared to ensure the validity of the data collected by volunteers.

Key Findings

- A community water quality monitoring program can operate at a number of levels depending on the objectives and resources of the program.
- At the most basic level, community participants carry out water tests with simple and inexpensive equipment and collect factual information about the water quality at their monitoring site. They monitor to learn about water quality issues in general. This level of monitoring commitment is often insufficient to maintain community interest over the long term.
- At a higher level, individuals are organized into monitoring networks which operate at a sub-catchment level. They liaise closely with facilitators and waterway managers. They have access to more sophisticated monitoring equipment and improved access to the scientific community. This level of monitoring encourages long term commitment from volunteers.
- The Acheron River sub-catchment in Goulburn Broken is a successful example of a high level community monitoring project. It has operated for four years and now comprises sixteen volunteers who regularly test water for eight parameters (including E coli) at thirty one sites along the Acheron River and its tributaries. New monitors are recruited to the network to complement the existing the monitoring program.
- To improve understanding of water quality issues, the Acheron Network meets regularly with facilitators, industry and waterway managers to discuss results and receive feedback on collected data. This contact also ensures the monitors are skilled in correct sampling and testing procedures.
- Interpretation of monitoring data can be a challenging task. A clear representation of water quality in the Acheron system was needed to help monitors understand their data. We developed a format that utilized annual medians and colour coding to indicate water quality along the length of the waterway. One example of turbidity in the Acheron River and tributaries is attached.

What are the implications of your findings?

- Valuable data sets can be gathered if a good spread of monitoring sites across a sub-catchment is a priority.
- Data interpretation is more legitimate where it is based on strategically collected long term data.
- The data collected by community networks should be complemented with water quality data gathered by Waterwatch co-ordinators and Agencies.

- Some monitors initially show interest in testing for parameters that require expensive testing equipment that may not be particularly relevant to catchment strategies. These people, if attracted into the program, can often develop an interest in other water issues that are important at the catchment level.
- The format of reports and the regularity of report production is vitally important if groups are to properly interpret their data.

Summary

- Community water monitoring programs can achieve much more than simply an awareness of water quality issues.
- If data collection is a priority, a strategic program targetting selected sites with regular and event sampling, is necessary.
- A strategically designed monitoring plan is also vital if monitoring is to show improvements in water quality at sites where on-ground works are being undertaken by the community and Waterway Managers.
- A carefully designed reporting format will help to maintain the interest of community monitors over the long term. Volunteers need frequent contact with facilitators to maintain interest in water monitoring.
- Our colour coded report format has provided a clear summary for community water monitoring networks of their monitoring activities.

Acheron River Turbidity (NTU) Medians

Site	Year				
	1998	1999	2000	2001	2002
ACH001 at Acheron Gap					*2
ACH002 at Feiglins Rd					*6
ACH003 off Old Coach Rd				4	
ACH004 at Granton & Marysville Rd				6	*6
FIS015 Fishers Ck few km u/s Acheron river			4	4	*10
ACH005 at Buxton Bridge				*8	*8
ACH010 at Passing Lane at Buxton				*10	*6
WIL010 Wilkes Ck at Fruit Salad footbridge			8	4	*5
TAG010 Taggerty river - Lady Talbot Dv			8	2	2
STE003 Steavenson river – Yellow Dog Rd			3	*2	8
STE005 Steavenson river – Bartons bridge			8	2	5
STE015 Steavenson river - Retreat Rd bridge			*4	6	6
KPL005 Keppel Ck at Cerberus Rd bridge			8		*6
KPL010 Keppel Ck u/s Steavenson river confluence			17		*11
STE019 Steavenson river at Buxton			13	16	15
STE020 Steavenson river at Buxton			11	6	4
LST015 Little Steavenson b/f fish farm at Buxton				6	*5
DRN710 Outlet from fish farm at Buxton				9	*7
LST019 Little Steavenson river at Buxton			10	8	*5
ACH015 at Taggerty		12	9	12	11
LIT005 Little river at Cathedral Lane					5
BLA005 lackwood Ck in Cathedral Lane					22
LIT025 Little river b/f confluence with Acheron R. - Taggerty		5	6	3	3
YEL020 Yellow Creek ***at Taggerty b/f confluence with Acheron river***		28	30	21	18
ACH020 2km d/s from Taggerty		15	15	18	18
SWA010 Swamp Ck u/s Acheron R. Taggerty				18	
CON025 Connellys Ck at McColls Rd bridge			28	22	20
ACH025 at bridge b/f confluence with Goulburn	10	8	12	12	11

Rating: <10 NTU Excellent, <12.5 NTU Good, <15 NTU Fair, <22.5NTU Poor, >22.5NTU Degraded

Note: results in italic with * indicates <5 data sets used to interpret results

Biological control for the suppression of willows in Australia

Jean Louis Sagliocco[1] and Eligio Bruzzese [1,2]
[1]Department of Primary Industries, PO Box 48, Frankston, 3199,
[2]CRC Australian Weed Management
(eligio.bruzzese@dpi.vic.gov.au)

Abstract:

- The national strategic plan on willow management has identified biological control as potentially the most cost-effective control method for invasive willows. This project examined the feasibility of biological control as a management option for willows.
- The study concentrated on six widely naturalised and particularly invasive species: *Salix cinerea*, *S. alba* var. *vitellina*, *S. fragilis* var. *fragilis*, *S. rubens*, *S. nigra* and *S. viminalis*. Organisms having potential for biological control of willows were identified through a literature search.
- This study identified that a large number of candidate natural enemies of the targeted weedy willows are available in Europe and North America.

Key Findings

- Several thousand references were examined. Organisms already recorded attacking desirable willow species such as weeping willows were excluded from the results.
- The study revealed that one bacterium, 51 fungal pathogens and 2 nematodes are already present on *Salix* species in Australia. The extent of their impact on different species of willows is not known.
- The study revealed that a large number of additional fungal pathogens, mites and insects are available in the area of origin of willows in Europe and North America. Many of these are likely to be host specific and therefore of interest as potential biocontrol agents.

What are the implications of your findings?

- The study has identified candidate biological control agents for weedy willows that will allow:
  - direct targeting of the sexual reproduction of willows through the attack of male and female flowers
  - indirect targeting of sexual and clonal reproduction by weakening trees through destruction of buds, defoliation early in the season and the use of galls as energy sinks
  - the reduction of current biomass by attack on buds, leaves and stems
- Benefits of biocontrol of willows as a management option:
  - Gradual willow replacement with other riparian flora and not extensive disturbance
  - Gradual nutrient release into streams and not massive inputs in winter
  - Reduced herbicide use in riparian areas
  - 50% reduction in management costs or greater in the long term

Summary

- The national strategic plan on willow management (ARMCANZ 2001) has identified biological control as potentially the most cost-effective control method for invasive willows.
- Biological control has considerable potential as part of an integrated management strategy for these riparian weeds.
- A large number of potential biocontrol agents have been identified through the literature as attacking willow species in their area of origin in Europe and North America.
- Biological control of willows has enormous scope as no members of the willow family (Salicaceae) are native to Australia.

Further Reading

- ARMCANZ, ANZECC and Forestry Ministers (2001). Weeds of National Significance, Willows (*Salix* taxa excluding *S. babylonica*, *S.* x *calodendron* and *S. reichardtii*) Strategic Plan. Agriculture & Resource Management Council of Australia & New Zealand,Australian & New Zealand Environment & Conservation Council and Forestry Ministers, National Weeds Strategy Executive Committee, Launceston.
- SAGLIOCCO, J.L. and BRUZZESE, E. (2002). Invasive willows in Australia: could they be targets for biological control? Proceedings 13th Australian Weeds Conference, Perth, Australia, 8-13 September 2002. Pp 415-417.

Water quality in the re-use dams on a dairy property in northern Victoria

Aravind Surapaneni1,3, Damian M Barnett2, Alvin D Milner1, and Roger W Wrigley2
1Department of Primary Industries (DPI), Research and Development Division,Tatura 3616
2 Dookie Campus, Institute of Land and Food Resources, The University of Melbourne, Dookie College 3647
3aravind.surapaneni@dpi.vic.gov.au

Project Details

In recent times, re-use dams are being used to reduce the amount of nutrients exported from dairy farms in drainage water and also as an alternative source of irrigation water. This project measured a range of water quality parameters in 3 re-use dams on a high intensity dairy farm (up to 6 cows/ha) near Numurkah in Victoria, during the 2002-03 irrigation season. The 3 re-use dams collect water from various sources on the farm. These include (i) surface run-off from paddocks irrigated with channel water and re-use water, and (ii) dairy shed wash down water. Each dam was sampled approximately two hours prior to irrigation. Water samples were collected on ten separate occasions between 7th January and 28th March 2003. On each occasion two samples were collected, one from the top of the dam (0.3 m from surface of the dam) and one from the bottom of the dam (0.3 m from bottom of the dam). Measured water quality parameters included EC, pH, turbidity, temperature, Total Phosphorus (TP), Reactive Filterable Phosphorus (FRP), Total Nitrogen (TN), Nitrates+Nitrites (NO_x), Total Kjeldhal Nitrogen (TKN=TN-NO_x), Suspended Solids (SS), major cations, and chloride.
The dairy farm under investigation did not receive P fertilizers since January 2002. The project therefore measured soil P status (Olsen-P) at the end of the 2002-03 irrigation season. Soil samples (0-10 cm depth) were taken from paddocks that were irrigated with different quality waters.

Key Findings

Water quality

- In general there is a tendency for water quality responses to be higher in the re-use dam located close to the dairy shed.
- No major differences exist between the water samples taken from the top and bottom of each re-use dam.
- 84% of the water samples were above a guideline value of 0.5 mg/L for total N.
- All water samples were well above a guideline value of 0.5 mg/L and 0.05 mg/L for total P and FRP, respectively.
- 68% of the samples were above a guideline value of 20 NTU for turbidity.
- All samples were below the recommended maximum salinity (0.8 dS/m) of irrigation water to be used on permanent pasture.
- All samples were well below the guideline value of 3 for Sodium Adsorption Ratio (SAR), which is a measure of irrigation water sodicity hazard.
- In general there was a decreasing trend in water quality over time, although these trends are not statistically significant.

Soil P status

- There was a wide variability in Olsen-P across all 51 irrigated paddocks over the entire farm, ranging from 8-88 mg/kg.
- The mean Olsen-P in 12 paddocks irrigated with channel water was 16 mg/kg (range 8-25 mg/kg).
- The mean Olsen-P in 9 paddocks irrigated with typical re-use dam water (surface run off from channel water irrigated paddocks) was 35 mg/kg (range 24-49 mg/kg).
- The mean Olsen-P in 4 paddocks irrigated with water from re-use dams that were close to the dairy shed was 70 mg/kg (range 40-88 mg/kg).

Implications and Future Research

- There are environmental implications of nutrient (N and P) rich re-use dam water leaving the dairy farms.
- Use of irrigation water (with variable nutrient levels) from various sources on dairy farms, results in uneven distribution of nutrients (especially P) across the farm.
- To avoid levels of Olsen P reaching over and above the most profitable Olsen P targets (18-22 mg/kg), re-use dam water might have to be channelled uniformly across the farm.
- Application of P fertilizers on paddocks with Olsen P higher than 22 mg/kg might warrant economic justification.
- A framework for appraising the impact of dairy intensification and management on nutrients entering the re-use dams should be developed.
- Guidelines for applying re-use dam water to pastures within a high input farming system should be developed to provide safe, longer-term economical and sustainable run-off disposal systems.
- Clearly defined policy recommendations that target options to reduce nutrients entering the re-use dams should also be developed.
- Good codes of dairy farm soil management to enable nutrient levels not exceeding environmentally responsible threshold values should be developed.

Summary

- Re-use dam water in high intensity dairy farms should be retained on the farm to avoid downstream environmental impacts.
- Soil Olsen-P levels should not exceed the levels required for maximum production.

The River Murray Yarrawonga to Echuca Action Plan

Christopher F Dwyer
Earth Tech Engineering
P.O. Box 165, Wangaratta, 3676.
Ph 03 57223300, Email: chris.dwyer@earthtech.com.au

Abstract

The River Murray between Yarrawonga and Echuca is a national icon containing features including the Barmah Lakes and the world's largest River Red Gum forest. The river is however highly modified. River regulation, wetland regulation, camping and grazing are impacting on the rivers natural values. River regulation has directly caused a reduction in the natural variability of the flow regime. Flows are consistently high through summer with reduced peaks at other times.

Despite recent initiatives, the scope for improving flow variability is constrained by the demands of water users. In any case, modifications to the flow regime alone will not achieve all desired outcomes – a more comprehensive approach is needed.

To achieve this an Action Plan has been prepared by a partnership of stakeholders who wish to improve environmental values whilst protecting the social and economic values the river provides. This plan has identified seven innovative programs addressing Vegetation Management, Channel Stability, Community Engagement, Wetland Management, Water Quality, In-Stream Habitat and Cultural and Heritage Management. Each program has strategies, which provide a targeted program maximising the potential to improve environmental values. Importantly, the technical information available needs continued development, while measures are being taken to enhance community support, improve institutional arrangements and secure funding for ongoing works, monitoring and research.

To optimise the environmental outcomes of each program, other initiatives being carried out within the Murray-Darling Basin, such as those outlined in the Living Murray document to determine environmental flow requirements for the Murray, will also be taken into account.

Key Findings - When developing a Management Plan do not fall into the trap of drawing conclusions early:

- Rather than providing prescriptive physical actions based on first impression inspections, a management plan should identify strategic actions that can develop over time
- Delve deep and draw out all information
- From the available data, consultation and inspections determine a common vision for the waterway, based on the values of that waterway
- Prepare issue specific programs that can develop as information becomes available, and can develop at different rates if necessary
- Do not let a lack of knowledge stifle the planning process, rather let it be the impetus for progress

The Biology and Control of Arrowhead (Sagittaria graminea)

Dr. Giles Flower
Aquatic Plant Services
Goulburn-Murray Water
PO Box 16, Tatura Vic 3616
gilesf@g-mwater.com.au

Abstract

Arrowhead is an aquatic weed with the ability to cause great damage in irrigation systems and natural waterways. Introduced from the USA, it has spread from a few infestations to hectares of irrigation, where it causes difficulties in passing required flows requested by customers due to greater heading in the channels and natural waterways in Victoria and NSW. The aim of this project is to investigate control, as well as increase knowledge of the biology and ecology of the plant, giving more chance of finding alternative control measures to incorporate with herbicides in an integrated control program.

Specific aims include:

- to identify optimum timings, doses and techniques for herbicidal control;
- to identify controlling factors in arrowhead growth, such as light, water depth etc.;
- to describe arrowhead growth in the field and identify characteristics that control that growth.

Trials include:

- effect of timing, rate and follow-up treatments on control with 2,4-D, glyphosate and amitrole formulations;
- effect of some residual herbicides on control;
- effect of light, water source, temperature and water depth on germination, establishment and growth;
- channel structure and arrowhead population structure.

Key Findings

- Arrowhead control with foliar herbicides is variable, due to inability to penetrate the rhizomes. This results in removal of standing biomass, but a re-shooting of plants from surviving roots and rhizomes.
- Effectiveness of foliar herbicides increases with better timing and application. Arrowhead grows vigorously between March and May, with increased herbicide efficacy during this time.
- Some soil-applied herbicides show promise, with arrowhead control exceeding 12 months. Care must be taken with residual herbicides to reduce potential for off-target damage. Most residual herbicides are not registered for arrowhead control in irrigation water.
- Arrowhead is widespread in the River Murray, particularly between Echuca and Torrumbarry, is present in the Goulburn River, Ovens River, Broken Creek, Nine Mile Creek, Boosey Creek and various natural waterbodies. Control programs are underway in some of these areas.
- Arrowhead seed floats for up to three weeks before sinking. Arrowhead requires light, inundation and temperature around 21ºC to germinate.
- Arrowhead rosette plants, formed first after germination, will become emergent plants if water levels are not too high. In irrigation, rosettes do not hinder flow as much as emergent plants, so reconfiguring the channel cross-section should be encouraged to minimise emergent populations.

What are the implications of your findings?

- The cost to the irrigation industry to manage arrowhead with foliar herbicides may be reduced with careful planning of spray programs. Although occasional sprays may be required to maintain hydraulic capacity, one of the keys to better control is timing.
- If a residual herbicide that maintains control of arrowhead for an extended period can be registered, this will also save on spray application. This may have the added benefit of herbicide application being undertaken between seasons, rather than disrupting operations in-season.
- Arrowhead is an important weed in natural systems, as well as irrigation systems, and should not be overlooked in these systems. Natural and irrigation systems are linked, so control in one is affected by control in the other.
- Information on biology of arrowhead may, with further research, elucidate an alternative control method. It may also be used to predict the presence, extent and spread of arrowhead problems, in natural systems and in irrigation systems.
- Further research into arrowhead should include better ways of incorporating the information gained from this project into control programs. The large cost to develop classical biological control methods make this a viable alternative.

Summary

- The information presented here is a small part of what is a complex and wide-ranging project. Further information is available from the Aquatic Plant Services (APS) at G-MW.
- Improved practices in herbicide use and research into alternative herbicides can improve the efficiency and success of herbicidal control of arrowhead in irrigation and natural systems.
- The spread of arrowhead is not just an issue within the irrigation industry, but also to the environment in general, due to its spread through natural systems. It's continued availability in retail outlets, although being reviewed, is of particular concern for these systems.
- We are continuing to refine integrated arrowhead control measures. The information from this project will help us to better predict arrowhead growth and to develop new ways of minimising its impact (such as looking at channel design and its effect on arrowhead growth).
- GBCMA is amongst several groups contributing to this research, being conducted by Goulburn-Murray Water. Other APS staff who have been involved at various stages in the project are Roger Baker, Lou Breewel, Mark Finlay, Laurie Jackel, Kevin Krake and Jim Wilding, as well as many other G-MW staff.

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Downstream movement of adult Murray-Darling fish species

J. P. O'Connor, D. J. O'Mahony and J. M. O'Mahony
Arthur Rylah Institute for Environmental Research,
123 Brown Street, Heidelberg, Victoria, 3084.
Justin.O'Connor@dse.vic.gov.au

Abstract:

Impediments to fish migration are regarded as a major problem in the sustainability of native fish communities in the Murray-Darling Basin. However, there has been little specific research in Australia on impediments to downstream fish movements. The ecology of downstream fish movement, the extent of downstream fish movement past weirs and the impact of weirs on downstream fish movement remain largely unknown. This project (funded by AFFA) was undertaken to investigate the impact of weirs on the downstream movement of adult Murray-Darling fish species with the particular aims of:

1. Determining the ecological function of downstream movement for adult golden perch (using radio-telemetry) so as to fully appreciate the impacts that weirs may be having on this species.
2. Assessing the physical and behavioural impact of weirs on downstream fish movement, where:

- physical impacts were assessed by direct sampling of fish moving downstream over a weir and,
- behavioural impacts were assessed using radio-telemetry to assess the behaviour of downstream moving fish.

Key Findings

- Golden perch undertook only small distance movements in winter of both years of the study. However in spring of one year of the study, on increasing water temperature and river discharge there was a large increase in the distance of fish movement. Ten fish undertook large distance downstream movements (mean=49 km). Five fish undertook large distance upstream movements (mean=18 km) while 4 fish undertook movements of typically less than 3 km. Following these movements most fish consequently returned to the vicinity of their previous locations. It is suspected that these movements are spawning related.
- Assessment of the downstream movement of fish over a low and medium head weir within the basin indicated that fish were not injured or killed as a result of that downstream descent.
- Assessment of the behavioural impact of weirs on downstream moving fish indicated that most fish were reluctant to pass downstream over a low and a medium head weir indicating that these weir types are acting as barriers to downstream movement.

What are the implications of your findings?

- The downstream spawning movement of 10's of kilometres undertaken by golden perch highlights the importance of providing unobstructed downstream passage for this and other species. Murray cod, for example, also undertake downstream movements after an initial upstream spawning movement.
- Given that the weir types tested in this project are acting as barriers to downstream movement it should be a priority to address these problems as these weirs may be isolating populations of fish upstream of these barriers. Further to this, managers are currently expected to provide upstream fish passage facilities with no regard for returning these fish downstream.
- Overseas studies have indicated that fish are reluctant to enter areas of increasing velocity such as those that occur at weir crests. Future research should consider ways of overcoming these problems via the use of flow manipulation and/or trialing physical structures that are currently been tested overseas which reduce water velocity at the weir crest and may allow for the increased passage of fish downstream.

River & Catchment Health:

Presenting current research in the Goulburn Broken Catchment

Summary

- The movement patterns of the native fish species from the Murray-Darling basin are probably more complex than we previously believed
- We need to begin to seriously consider the impacts of weirs as barriers to downstream fish movement as while it is often quite obvious that weir walls pose a barrier to upstream fish movement, it is usually less obvious that these structures may pose barriers to downstream fish movement.
- Studies on the effectiveness of flow manipulation and physical structures that may allow for the increased passage of downstream moving fish need to be undertaken particularly given the large number of upstream passage facilities currently being fitted to barriers with no regard for returning these fish downstream.10 pt Arial.

Further Reading

- J. P. O'Connor, D. J. O'Mahony and J. M. O'Mahony, 2003. Downstream movement of adult Murray-Darling fish species. Freshwater Ecology. Arthur Rylah Institute for Environmental Research.

River & Catchment Health:
Presenting current research in the Goulburn Broken Catchment

The effects of sheep grazing on the Grey and White Box grassy woodlands in the Dookie district.

Steve Hamilton
University of Melbourne, Dookie College, Victoria, 3647.
Email: steveh@unimelb.edu.au

Abstract

This study examines the impacts of livestock grazing and cropping on a White and Grey Box woodland in northern Victoria. Permanent vegetation quadrats were established within the now named Dookie Bushland Reserve, and were evaluated in 1992 when agricultural land uses ceased and conservation management was instigated. Further evaluations were conducted in 1994, 1995 and 1997.

Results indicate that grazing over a 27 year period up to 1992 had contributed to significant declines in the number and cover of indigenous species, and had resulted in the significant increase in the number and cover of introduced species. The loss of shrub species and juvenile eucalypts with increased agricultural impact was also observed. Some species were promoted in establishment and cover by increased grazing, while others were intolerant or were reduced in abundance. Lesser impacted sites had exhibited a significant level of re-establishment of indigenous species five years after the removal of livestock grazing.

An Investigation into Farm Management Investments for Reducing the Impact of Dryland Salinity in the Dryland Section of the Goulburn-Broken Catchment Area

Lindsay Trapnell
Farmanomics Research and Consulting
PO Box 286, Benalla, Victoria, 3672, Australia

Abstract

Overclearing of native vegetation has resulted in a serious disequilibrium of the hydrologic balance in the dryland section of the Goulburn Broken Catchment Area. There is therefore an imminent need to invest in large-scale revegetation. The aim of this study is initially to determine the optimum area of revegetation and its place in the landscape that will reduce recharge to groundwater and leakage of salt to waterways and streams yet permit sufficient runoff to enable environmental flows of high quality water to enter the Murray River. This will be achieved by using a hydrologic model developed by the CRC for Plant Based Management of Salinity together with known data about the water use efficiency of various plant species such as Eucalypts and other indigenous species, horticultural tree crops, and deep-rooted perennial pasture species. The next step will be to evaluate the economic and financial effects on farm businesses of implementing those discrete revegetation strategies at the least cost to landholders, and where grants are required to attract adoption, these too will be provided at the least cost to the contributors.

River & Catchment Health:

Presenting current research in the Goulburn Broken Catchment

Quantification of Ecological Benefits associated with Wetland Rehabilitation along the Murray River Floodplain.

Aaron Kevin Troy
La Trobe University
Albury-Wodonga Campus
"DEME" PO Box 821, Wodonga Victoria, 3689

Abstract

Project design - Replicate wetlands will be restored and water quality and macroinvertebrate community structure will be analysed using a modified Before After Control Impact (BACI) study design using time-site interaction effects analysed by analysis of variance. The modification incorporates multiple control and impact sites to increase the power of the study and also to increase the capacity to distinguish between differences due to human impact (non seasonal flows) and those due to natural changes. A number of wetlands, which are currently exposed to high and low flooding regimes, will be returned to near natural flooding regime.

Aims/Objectives - The outcome of the project will be to provide statistically valid quantification of the results of the rehabilitation works, and determine the value for money associated with environmental works.

- Using several performance indicators such as:
  - Abundance and diversity of key macrophyte and macroinvertebrate populations.
  - Improvement in water quality.
  - Changes in indigenous flora and flora utilisation.
  - Abundance and diversity of frogs, native fish and waterbird populations.

  (May also be included, pending ethics approval)

Treatments – Paired and replicated wetlands from both high and low flooding regimes will sampled over two years compiling one year of Before manipulation (Return to Near Natural Flooding) data and one year of After data.

Key Findings

- Project has just commenced – Sites have been selected and literature review has been completed.

What are the implications of your findings?

- Potential implications of findings.
  - Is wetland rehabilitation economically viable?
  - Does manipulation of the hydrology change the ecological conditions of the study wetlands (If Yes, Great! If No, Where do we go now?)
  - Are their clear ecological benefits associated with the rehabilitation of wetlands along the River Murray floodplain?
  - Important for Future studies and management of rare wetlands.

Summary

- Opportunity to study a Before and After Manipulation with replicates under two different hydrological regimes will provide statistically valid evidence of related changes rather than purely descriptive.
- Care should be taken when extrapolating results from one wetland to another, as there is a large potential for site-specific changes.