3 Research Program

DIRECTOR OF RESEARCH: PROFESSOR BARRY HART

CHIEF ECOLOGIST: PROFESSOR SAM LAKE

Prof Sam Lake
Chief Ecologist

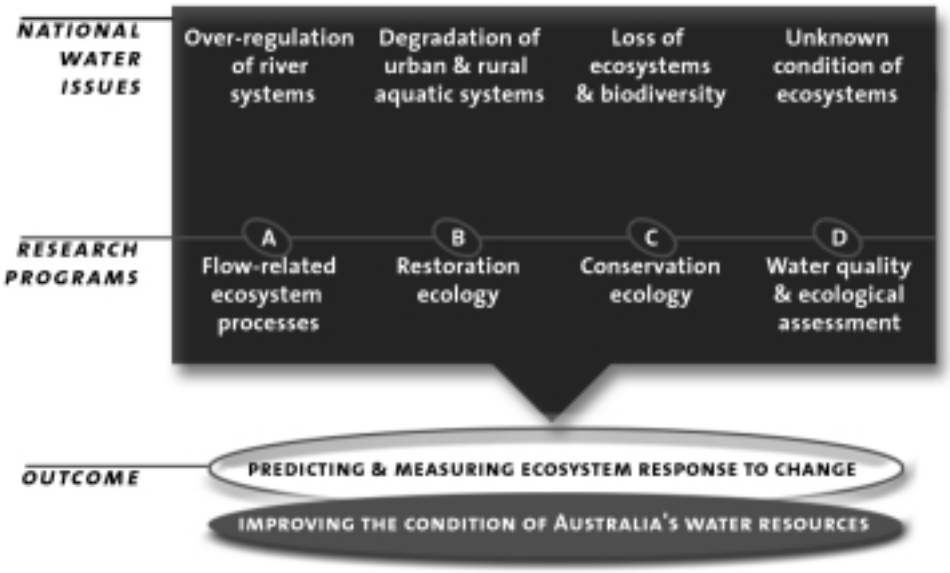
The CRC for Freshwater Ecology undertakes research within four research programs. During the past year, the Centre has undertaken two main activities within the research programs:

i) completion of the integrated projects developed during 1997/98;

ii) development of proposals for research over the next 3-6 years. These proposals will commence from July 2000.

PhD research projects have made major contributions to research in all program areas. These projects are listed under Chapter 4, Education and Training.

3.1 Links between Research Programs and national water issues



3.2 Program Advisory Committees

Program Advisory Committees (PACs) have been established for each research program to strengthen the links between industry needs and the Centre's research programs. The PACs have met and reported to the Board.

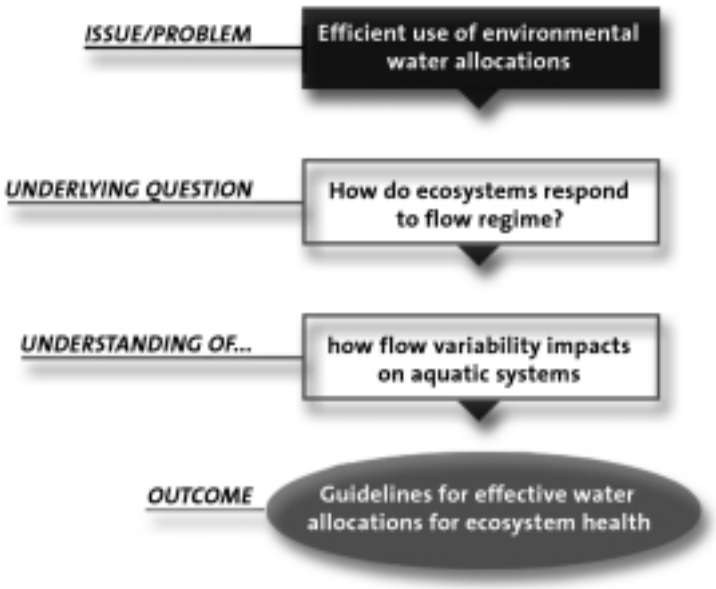
Previous page:
Collins Creek, a reference site for the AUSRIVAS models.
Photo: P Sloane

3.3 Program A Flow-Related Ecological Processes

Program Leader: Dr Gerry Quinn

The extreme variability of Australian rainfall means that occasional large flows and long periods of low flows dominate our aquatic systems. Many of our management operations limit this variability in order to produce reliable water resources. CRC research seeks to understand how flow variability impacts on freshwater ecosystems. Through understanding the impact of water regime—volume and variability—on ecological functions and attributes we are then able to study the impact of regulation on habitats, biota and ecological processes. A third and vital area of research is to measure ecosystem response to 'environmental flow' management.

Program Issues and Outcome



Dr Gerry Quinn
Program Leader

Program Objectives

- Determine the sensitivity of aquatic ecosystems to flow regulation and water abstraction.
- Determine how options for flow management will affect Australian aquatic ecosystems.
- Develop tools for assessing the success of environmental flow allocations.

A1 Role of flow in determining natural ecological processes in rivers and streams

ECOLOGY OF LOWLAND RIVERS

Project Leader: Dr Ben Gawne

Project Team: Prof Angela Arthington, Dr Darren Baldwin, Dr Bruce Cheesman, Mr Iain Ellis, Dr Ben Gawne, Dr Paul Humphries, Mr Zygmund Lorenz, A/ProfBill Maher, Mr Daryl Nielsen, Dr Rod Oliver, Dr Gavin Rees, Dr Russ Shiel, A/Prof Martin Thoms, Mr Garth Watson, Dr David Williams, Mr Ian Lawrence and Ms Helen King.

Aim:
To determine the sources of organic carbon to lowland rivers and provide recommendations for the management of lowland river systems.

Progress:
An essential step toward understanding the functioning of lowland rivers is to determine what carbon sources comprise the base of the food web. This project has generated a model of the major sources of organic carbon in a single reach of river. We have built the model from data on the amount of organic carbon contributed by the many different types of plants (algae, reeds, floodplain plants) which make up the base of the food web. Other components of the project have contributed data on the way in which plant material is decomposed or consumed by bacteria, fungi and invertebrates, and examine the relationship between invertebrates and fish. We chose three sites along the River Murray, near Albury, Barmah and Mildura, in the hope that the model will apply to the entire river, rather than just a small section. The model will provide us with insights into the way lowland rivers function in order that we can make better predictions about how changes in management have affected our rivers.

A report is currently being prepared from this work.

A mayfly larvae, part of the food web in lowland rivers. Family: Baetidae.

IMPORTANCE OF FLOOD FLOWS TO THE PRODUCTIVITY OF DRYLAND RIVERS AND THEIR FLOODPLAINS.

Project Leader: Professor Stuart Bunn

Project Team: Mr Frank Walker, Dr Peter M. Davies, Prof Stuart E. Bunn, Thorsten Mosisch, Michelle Winning, Fiona Balcombe and Steve Balcombe

Aim:
To assess rates of primary production on floodplains of rivers of the Channel Country and compare these with known terrestrial rates of production in the surrounding landscape.

Progress:
This comparison will be used to determine how important this production is to both aquatic and terrestrial food webs and to estimate the importance of floodplain inundation for landscape-scale productivity. The project will also identify and produce a quantitative model on the likely consequences of changing patterns of floodplain inundation, occurring through water harvesting and other forms of flow regulation. A number of sites on the Paroo, Warrego, Cooper and Diamantina Rivers were sampled during the "dry" (November 1999) for soil samples and to assess suitability for access during the flood conditions. During March 2000, a significant flood in Cooper Creek resulted in floodplain inundation near Windorah. This flood event was sampled on two occasions. Measures of water quality and benthic and pelagic metabolism were taken, together with samples of invertebrates and fish for food web analysis. These preliminary data suggest that there is potential for substantial aquatic primary production on the floodplain (associated with the growth of planktonic and benthic algae). Given the extent of the floodplain, this may represent a substantial source of carbon for consumers. The on-going stable isotope analyses (C and N) will show have much of this production remains in floodplain soils and how much is distributed through the macroinvertebrate and fish food webs.

Researchers measuring aquatic primary production on the Cooper Creek floodplain. Photo: R Ashdown

Researcxhers dragging nets for work on food webs. Photo: R Ashdown

DOWNSTREAM TRANSPORT OF LARVAL AND JUVENILE FISH

Project Leader: Dr Craig Schiller (NSW Fisheries)

Project team: Mr Michael Rodgers (NSW Fisheries), Keith Brehney (NSW Fisheries) and Mr Ian Wooden (NSW Fisheries).

Aims:

To assess the transport of larvae and juveniles fish downstream in the Murray River.

To predict which weirs will have significant impacts on movements of fish.

Progress:
This project was undertaken on the River Murray. Drifting larvae and juveniles have now been recorded for a number of species, including Murray Cod, Golden Perch, Gudgeons and Carp.

We have found that significant numbers of Murray cod larvae and juveniles, plus a large number of eggs, were present in the drift. This suggests that, contrary to published literature, this species does have a pelagic dispersal phase. The drifting Murray cod larvae were 8 - 13 mm in size, suggesting that larvae enter the drift soon after hatching and disappear at 10-14 days of age. We observed low abundance of larvae immediately below weirs yet numbers increased downstream of weirs. This suggests that for Murray cod weirs are impacting on drift and trapping larvae in weir pools. These findings are highly significant and contradict published knowledge of the reproductive process and population dynamics of this species. The final analysis and reporting of these findings is now being undertaken. It is likely that these findings will have important ramifications for future management of Murray cod.

IN-STREAM PROCESSES IN THE BARWON-DARLING RIVER

Project Leader: Associate Professor Martin Thoms

Project Team: Dr Fran Sheldon, Vic Hughes

Aim:
To determine flow requirements for dryland rivers by investigating relationships between flow variability, habitat complexity and ecological functioning.

Progress:
Surveys of the Barwon-Darling have highlighted the complex nature of the river channel. The river is composed of a series of inset floodplains or benches. These features trap and store large quantities of organic material and once wet, release dissolved carbon into the water. We have determined the flows required to wet these surfaces and as a consequence have been able to determine the impact of water resource development on the natural wetting and drying processes. This information is then used to construct a series of hypothetical curves summarising ecological response to hydrological change. The use of 'benchmark curves' is then proposed as a methodology for assessing the likely ecological response of river systems to increased hydrological change.

This information is important in establishing environmental flow regimes for the Barwon-Darling River system. Journal articles and a summary report are available from this project.

FLOODPLAIN / WETLAND PROCESSES IN THE LOWER BALONNE RIVER SYSTEM

Project Leader: Associate Professor Martin Thoms

Project Team: Ms Heather McGuinness, Dr Fran Sheldon, John Foster and Ms Sarah Cartwright.

Aim:
To determine the role of different habitats in trapping carbon and nutrients from flood water.

Progress:
This study will generate criteria for identifying key habitats, in terms of their storage, exchange and production of carbon and nutrients, in semi-arid lowland floodplain systems. The criteria will be used for land management and the setting of flow requirements.

The river and floodplain environments of the Lower Balonne system have been surveyed and characterised. As a result, nine major floodplain regions have been recognised. For each of these regions, the long-term storage of carbon and other nutrients, the inundation character and how it has changed with water resource development, the effects of flooding on nutrient availability and how water resource development has influenced the transfer of carbon and nutrients between the river and the floodplain are all being examined. In order to do so, remotely sensed imagery, discharge data, surface sediments and a series of sediment cores are being utilised. The information obtained from this project will contribute to the Lower Balonne Floodplain Management Strategy.

Further work in this area will be undertaken in the project, Habitat Fragmentation and Environmental Flows. This project will quantify the impact of water resource development on the Condamine-Balonne river by exploring the nature of habitat heterogeneity on the floodplain and how this influences floodplain carbon dynamics and invertebrate communities. The project will assist in identifying realistic environmental flow criteria for semi-arid zone rivers.

Scientific articles are available on the preliminary results from this study.

Great Egret in a billabong.
Photo: A Tatnell

RIPARIAN VEGETATION-PRODUCTIVITY AND ECOLOGY

Project Leaders: Dr David Williams and Ms Lisa Evans

Project Team: Ms Lisa Evans, Dr David Williams and A/Prof Martin Thoms

Aim:
To understand the factors which determine the composition of riparian vegetation along large rivers and to quantify the contribution this vegetation makes to the riverine organic matter.

Progress:
Riparian vegetation is potentially a significant source of carbon for the riverine food web. However, since the makeup of riverine plant communities is affected by inundation patterns, river management may change the yield of carbon derived from floodplain vegetation.

This project, based in the Murrumbidgee, Goodradigbee and Abercrombie Rivers, has examined the influence of inundation and flow on performance of the major plant species. Inundation period and current velocity have been found to affect plants – some species had a positive growth response to exposure to a period of flow compared to still water inundation. These results were found to correlate with the field distribution pattern of species. The duration of inundation was found to affect plant species in a similar way to velocity.

Hydrological analysis of a range of field sites has been conducted and will be used as input for a vegetation prediction model. So far it appears that variables relating to substrate, climate and hydrology will be the best predictors of vegetation distribution in these rivers.

These findings have implications for riparian vegetation rehabilitation in the matching of species to physical characteristics of the riparian zone, and for prediction of the impacts of engineering works that lead to changes in the flow regime.

Low flows in the Murrumbidgee.
Photo: K Markwort

A2 Flow manipulation in regulated lowland rivers

EFFECT OF FLOW MANIPULATION ON THE BIOTA OF A LOWLAND RIVER

Project Leader: Dr Paul Humphries

Project Team: Dr Paul Humphries, Dr Jane Growns, Mr Robert Cook, Mr Luciano Serafini, Mr Adam Richardson, Prof Sam Lake, DR Gerry Quinn, Mr John Hawking, Terry Court and Frank McKinley.

Aims:
To investigate how biota respond to changes in flow regimes by altering the operation of Lake Eppalock to restore seasonality, variability and duration to the flows in the Campaspe River.

Progress:
This project is investigating the response of fish, macroinvertebrates and habitat to an experimental flow change in the highly regulated Campaspe River. Current regulated flows provide little water for environmental purposes outside the irrigation season. The proposed flow change involves releasing 25% of incoming flow between May and October of each year, when a specified storage trigger level is reached. Comparisons with the less regulated Broken River will provide greater confidence that any responses detected are due to the experimental manipulation. The experimental flow change was initially due in May 1998, but due to the driest period in 100 years, this has been delayed until May 2001.

Western Chanda Perch, Ambassis castelnaui. *Photo: G Schmida*

We have now completed almost 5 years of fish and 3 years of macroinvertebrate sampling. Novel techniques for sampling fish larvae and macroinvertebrates have been developed and a new hypothesis for the relationship between flow and fish recruitment in lowland rivers has been established based on the work in the Campaspe and Broken Rivers. The state of the fish fauna in the Campaspe River is extremely poor, with dominance by introduced species evident. Macroinvertebrate communities have been found to be strongly influenced by the degree of flow regulation in the Campaspe River, with the upper section, which receives the bulk of irrigation water, effectively acting as an upland stream.

The project team have utilised the results from this research to input into allocation of flows for the environment in the Campaspe River through an expert panel and the Victorian Bulk Entitlement Process.

Scientific articles are available on the preliminary results and new methods from this study.

BILLABONG-RIVER INTERACTIONS DURING HIGH FLOW

Project Leader: Dr Terry Hillman

Project Team: Prof. Alistar Robertson, Dr Adriene Burns, Ms Helen King, Mr Garth Watson, Mr Daryl Nielsen and Dr Terry Hillman.

Aims:
To assess the transfer of biota between the river channel, billabongs and floodplain.
To determine whether the connection between river and billabong during floods resets the billabong ecosystem and inoculates the river with carbon, algae and microorganisms.

Progress:
This project was originally planned for billabongs on the Murrumbidgee River near Wagga Wagga, NSW. Background physico-chemical data and surveys of the biota were undertaken during dry periods. Because of the extended dry period we were unable to get sufficient flows to join the river and billabongs even after negotiating a 'top-up' release at the end of the irrigation season. As a last resort a second river system has been selected for the study — the Edward River. Manipulation of Stevens Weir is expected to produce appropriate flow conditions to join the river to selected billabongs during the study period. The Murrumbidgee Community Reference Committee on Environmental Flows had planned to use two years of its contingency water to 'create' the 'flood'. If environmental conditions are conducive, this discretionary allocation may still be used to create high flows in the Murrumbidgee and therefore allow the study to continue in both rivers.

MEASURING THE EFFECTIVENESS OF ENVIRONMENTAL WATER ALLOCATIONS

Project Leader: Dr Gerry Quinn

Project Team: Dr Michael Reid, Dr Gerry Quinn and Dr Terry Hillman

Aims:
To develop monitoring programs to detect changes in response to environmental water allocations.

Progress:
This project initially produced a monitoring program to test the effectiveness of proposed indicators. The second stage of this project is trialling the monitoring design and indicators developed in Stage 1 and will be complete by September 2000.

A report is available on the monitoring program developed for stage 1 of this study.

FLOW CHARACTERISATION

Project Leader: Dr Jane Growns

Project Team: Dr Ben Gawne, A/Prof Martin Thoms and Dr Paul Humphries

Aims:
To characterise natural flow regimes using ecologically relevant statistics.
To determine how flows have been changed in response to water resource development.

Progress:
This project used hydrological variables to characterise flow at 107 stream gauging stations in south-east Australia. We found differences in the data between intermittent and permanently flowing stations and between regulated and unregulated stations. The differences included much higher long-term maximum flows, 90th percentile flows and mean daily flows, and longer return intervals for the 2-year flood for regulated stations. Seasonality of flows was also different and several of the flow descriptors were less variable at regulated stations.

This work has important implications for allocating environmental flows — it should be possible to release water from dams in ways that minimise the differences in hydrology between regulated and unregulated rivers. We suggest that each river would need to be considered in the context of (i) the natural flow regimes of nearby rivers, (ii) the climatic zone in which it occurs, and (iii) the main purpose for which it is regulated.

A report is available from this work.

MEASURES AND BENEFITS OF ENVIRONMENTAL FLOWS

Project Leader: Dr Peter Gehrke

Project Team: Karen Astells and Roy Winstanley

Aims:
To develop a measure of river flow alteration that is ecologically relevant. To predict changes in fish communities in response to changes in river flow management.

Progress:
Analysis of hydrology data has identified differences between natural flow regimes and flows under current levels of water resource development. The proposed environmental flow rules in New South Wales provide a third hydrological environment. In this study we are looking at the likely changes in fish communities as a result of implementing the NSW environmental flow rules. We are constrained in our ability to model the impacts on fish communities because of a lack of temporal data on fish communities under sequential flow conditions. We are using, instead, spatial data from rivers with different flow regimes in order to predict temporal change. An important part of validating the model will be to assess the pitfalls and advantages of this approach.

Preliminary models suggest that environmental flow rules intended to create a more natural flow regime in rivers have created a hydrological condition that differs from both natural and developed hydrological conditions. It is difficult to predict with certainty how fish will respond to the new flow environment. Longer term fish data is required to determine trends in the responses of fish to changes in flow.

BIOLOGICAL EFFECTS OF COLD WATER RELEASES FROM DAMS

Project Leader: Dr Peter Gehrke

Project Team: Karen Astells and Roy Winstanley

Aims:
Document the responses of native and alien fish to cold water releases from dams.

Progress:
This project used controlled-temperature channels in a specially designed experimental facility at Burrendong Dam, NSW. We were able to measure the responses of fish to the range of water temperatures experienced in regulated rivers. In addition, the distribution of fish in relation to cold water has been assessed using seasonal surveys in the Macquarie and Bogan Rivers.

Our experiments show that the low temperature of water released from Burrendong Dam retards fish growth and causes high mortality in juvenile silver perch. This strongly suggests that cold water pollution from dam releases is having a major impact on growth and survival of juvenile silver perch and other native fish in rivers. Implementation of warm-water releases from dams for both irrigation and environmental flows is likely to be a critical factor in rehabilitating rivers and native fish communities.

ROTENONE IN STREAMS

Project Leader: Ms Jan Barton

Project Team: Dr Ben Gawne, Ms Jan Barton and Ms Rhonda Sinclair

Aims:
To assess the impact of rotenone treatment on benthic macroinvertebrate communties and to make management recommendations regarding the use of rotenone for conservation actions.

Progress:
This project was based in streams in the upper Goulburn catchment where Trout were removed with the chemical rotenone in order to conserve the endangered fish, *Galaxias fuscus*. Macroinvertebrate communities were sampled for three months before and two years after the rotenone was used. At least 60% of the macroinvertebrates were dead within 48 hours of rotenone treatment and all taxa seemed affected. The streams remained significantly impacted one month later, however, after nine months we were no longer able to observe any impact. It appears that hatching from eggs, apparently unaffected by rotenone, was important to recovery.

Guidelines for the use of rotenone have been established.

PROGRAM A: FLOW-RELATED ECOLOGICAL PROCESSES~OUTCOMES

Program outcomes	3 year milestones	Progress at the end of Year 1
Better understanding of the link between flows, ecological processes and biodiversity in a range ofriver types.	Improved conceptual and empirical understanding of the role of flow (floods and droughts) as a disturbance affecting ecological processes in rivers and streams	• Low flow recruitment hypotheis paper published andattracting much international attention • Modelling from lowland river project suggests that while floods are important they are not the dominant source of organic material to lowland rivers • Water column phytoplankton is a much more important component of lowland river ecosystems than previously thought • Conference on ecological effects of drought organised for February 2001
New tools that will lead to improved recommendations for, and evaluations of, environmental water allocations	Ecological characterisation of flow regimes in rivers in Eastern Australia including, both winter and summer rainfall systems	• Final draft of report from flow characterisation scoping study finished. • Project team for new flow characterisation project assembled and funding pending
Ability to predict the sensitivity of aquatic ecosystems to varying levels of flow regulation (or water abstraction) from models relating biotic patterns and ecological processes with flow attributes	Assessment and development of designs for (i) monitoring the effects of environmental water allocations (environmental flows) to rivers, floodplains and wetlands, and (ii) experimentally testing, at realistic spatial and temporal scales, the causal links between attributes of flow regimes and specific ecological processes	• Conceptual links between flow and habitat restoration, including monitoring, established as part of a new project to commence next year • Search for suitable flow and/or habitat restoration case studies underway. • Campaspe flow manipulation project proceeding but experimental component delayed due to lack of rainfall
Develop and promote the adoption of flow restoration recommendations that could lead to measurable ecological benefits in degraded rivers	Development of interim flow restoration guidelines for lowland rivers that will lead to measurable ecological benefits in the main channel, the floodplain and associated wetlands	• Will be developed within a new project to commence next year

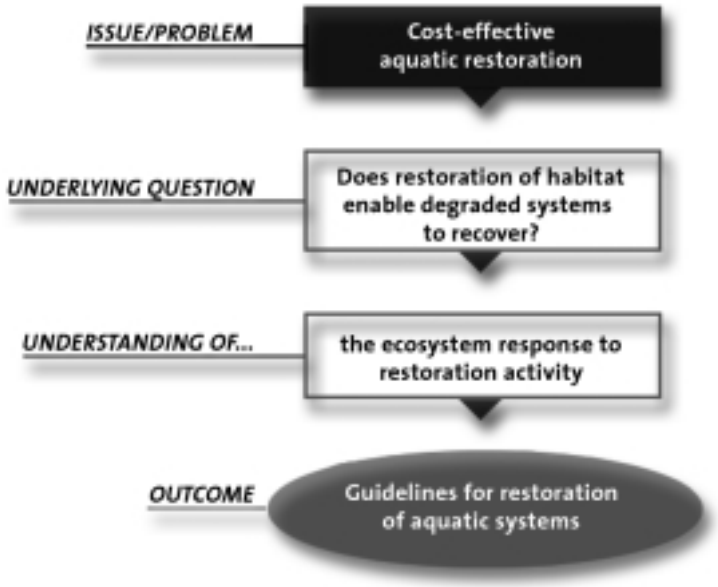
3.4 Program B
Restoration Ecology

Program Leader: Professor Stuart Bunn

Many of our streams, rivers and wetlands are in a degraded state and millions of dollars are spent each year on restoration. Unfortunately, little of the past restoration effort has been underpinned by a strong scientific base and few attempts have been made to measure environmental benefits. The core research objective of this Program is to understand the ecological processes that will facilitate the recovery of disturbed stream and river ecosystems. In doing so, we can ensure that future restoration projects are undertaken in ways that maximise the environmental benefits achieved for the money spent.

Prof Stuart Bunn
Program Leader

Program Issues and Outcome



Program Objectives

- Understand the processes that will facilitate recovery of disturbed systems.
- Develop innovative approaches to waterway restoration.
- Establish several case studies as adaptive stream rehabilitation experiments.
- Facilitate the integration of river restoration practice into total catchment management.

The Restoration Ecology Program addresses three broad themes:

B1 Physical habitat restoration
B2 Habitat fragmentation and connectivity
B3 Monitoring restoration success

B1. Physical habitat restoration

A key assumption of most river and riparian restoration activities is that if you rebuild or recreate habitat, then organisms will return and condition will improve. We will use rigorous scientific experiments to test whether recovery of degraded streams and rivers is constrained simply by the availability of suitable habitat. We will also capitalise on current or planned restoration activities to showcase practical and cost-effective methods for river and riparian rehabilitation.

RESTORATION OF DEGRADED RURAL STREAMS: THE GRANITE CREEKS PROJECT, NORTH-EAST VICTORIA

Project Leader: Prof P. S. Lake

Project team: Dr. Jennifer Davis (CRCCH), Dr. Barbara Downes, Ms Alena Glaister, Dr.Brian Finlayson (CRCCH), Dr Ian Rutherfurd (CRCCH), members of Granite Creeks Landcare Group, Justin Sheed and Wayne Tennant of Goulburn-Broken Catchment Management Authority, Mr Pat Feehan of Goulburn-Murray Water, plus casual assistance from several research staff and students.

Aims:

To determine the levels of sediment input into streams from catchments of the Strathbogie Ranges.

To assess the effectiveness of adding habitat structure (timber) in restoring degraded streams (notably sand-slugged streams), and whether distance from potential sources of colonists affects restoration.

To develop feasible and rigorous means to monitor and assess stream restoration.

Robyn Glaister mapping snags along Creighton's Creek using GPS

Sites: Streams in the area between Euroa and Avenel in north-central Victoria

Progress:

We selected five streams in the Granite Creeks Catchment, which represent both sand-affected and unimpacted streambeds, for comparison of their fauna, catchment condition, channel morphology, wood amounts, and hydrology. Jennifer Davis has reviewed the history of European settlement and land use practices for the Granite Creeks Catchment, and has carried out an extensive geomorphological assessment appraisal, covering both the "upland hill country" and the "flats". This assessment describes the history of sediment dynamics and catchment erosion, the locations and extent of sediment degradation and aggradation, the current geomorphological condition of the creeks and the probable causes of sediment erosion and movement. The widespread erosion in the catchments of the creeks appears to have been synchronised with European settlement of the area. The movement of the sediments onto the "flats" has lead to the development of slow-moving and extensive sand slugs. Her report stressed the necessities of preventing further erosion in the upland catchments and of providing habitat structure in the lowland sand-impacted sections.

The project team carried out a major sampling survey for invertebrates, both those dwelling in the sediments and those living on logs, across both sand-impacted and reference creeks. This exercise has revealed that for both species richness and total abundances levels did not differ significantly between creek sections in general, but that levels of both parameters were significantly lower in the upstream sand-impacted sections than in the downstream non-impacted sections. Note the difficulties in isolating the impacts of sand from possible upstream-downstream effects. Species composition of the benthos differs significantly between upstream sand and downstream clay sections. Measurements of oxygen concentrations over summer suggest that in the pools of the clay sections, the benthic fauna may be stressed by low oxygen levels.

Interestingly, the species richness and abundances of the log fauna did not differ between sanded and unimpacted sections, but there were significant differences in species composition. Thus for the invertebrates of the sanded sections, the aims of restoration are to increase species richness and faunal abundance in the sanded sections for the sediment benthos, and to achieve the successful colonization of added timber structures by log-dwelling invertebrates. For the fish, the aims are to increase the densities of native fish that dwell in very low densities in the sanded sections, and to prevent the invasion of exotic fish from the downstream clay sections.

Thus from the preliminary study, we now have extensive knowledge of the fauna in the sand-impacted and unimpacted sections of the creeks. Restoration work will now concentrate on two creeks. We (CRCFE, CRCCH and Goulburn-Broken CMA) intend to design and construct timber structures that will hopefully be resilient to the disturbance of shifting sand. These structures will be placed into sites in sandy stream sections. The sites

will be either close to already present wood accumulations or at varying distances from wood accumulations. Colonisation by fish and invertebrates will be monitored, as will the sand-dwelling benthos close to and far from the timber structures.

Achievements include a major report titled "Stream degradation and sand slug development: Granite Creeks, central Victoria" by Jennifer Davis and Brian Finlayson, being prepared for publication by the centre. For conference proceedings, please see chapter 7, Publications.

RIVER REHABILITATION THROUGH RE-SNAGGING

Project Leader: Mr Simon Nicol

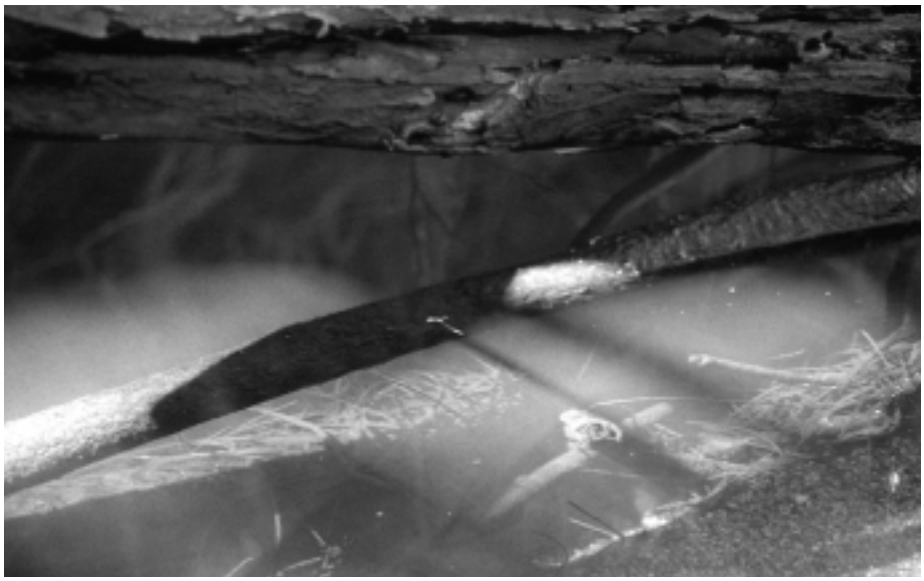
Project Team: ***DR*** John Koehn and Jason Lieschke.

Aims

Investigate the relationship between the degeneration of physical habitat and the biological condition of river systems; define measurable rehabilitation objectives and develop design criteria for re-snagging.

Progress:

In two past investigations into the ecology of large fish species in the Murray River, it has been identified that large woody debris is an important provider of physical habitat. Consequently, adding large woody debris to rivers (re-snagging) is currently considered a realistic option for providing physical habitat for many species. This project will provide information on the effectiveness of re-snagging for the rehabilitation of native fish populations and suggest ways in which such activities be undertaken.



Snags provide a variety of habitats for plants and animals. Photo: A Mostead

HYDROLOGIC MANIPULATION AS A POTENTIAL CARP CONTROL STRATEGY

Project Leaders: Dr Ben Gawne and Mr Glenn Wilson

Aim:
To evaluate the role of hydrological factors in determining the timing and success of recruitment of carp in the Murray-Darling Basin.

Progress:
Carp are widely believed to be a major agent of environmental degradation in Australia's lowland rivers. This project is designed to collect information on the spawning ecology of carp and assess the viability of hydrologic manipulation as a control technique. The findings will be used to develop management strategies to reduce carp numbers through minimising their reproductive success.

This project is divided into four parts: (i) sampling juveniles from the Darling and Murray River wetlands to determine spawning-timing profiles, (ii) collecting post-juvenile fish along Darling, Murray and Macquarie Rivers to examine patterns in age-structure, (iii) studies of the tolerance of eggs to salinity and desiccation, and (iv) establishing an experimental pond facility on the Darling Anabranch for examining mechanisms that limit carp recruitment.

The findings from this project show that hydrology influences the timing and success of carp spawning events. From this data we will make recommendations on the use of flow manipulation to control carp numbers.

A report is being prepared from this project.

Controlling carp in our rivers.

B2. Habitat fragmentation and connectivity

Physical restoration of stream habitats will be pointless if ecological recovery is constrained by the ability of aquatic plants and animals to recolonise disturbed sites. To be able to predict how quickly disturbed systems will recover, we need to know how aquatic organisms disperse (i.e. what mechanisms they use) and how far can they can move.

THE ROLE OF DISPERSAL AND RECRUITMENT IN STRUCTURING STREAM INVERTEBRATE POPULATIONS

Project Leader: Associate Professor Jane Hughes

Project Team: Prof Stuart Bunn, M. Hillyer and Dr Richard Marchant.

Aims:
To answer the questions: Are patterns of genetic differentiation among larval populations of insects the result of limited in-stream movement and recruitment resulting from only a few matings? Is adult flight an effective mechanism for large-scale dispersal of stream insects across areas where the terrestrial habitat is fragmented?

Progress:
Recent work on genetic variation in populations of stream invertebrates has challenged accepted views about dispersal and recruitment in streams – suggesting that recruitment is the result of only a few matings and in-stream movement is limited. This project will test these ideas by sampling streams where species have synchronous larval development and mass emergence of adults, and where in-stream movement (by drift) is thought to be high. The importance of aerial dispersal may have been over emphasised because past studies have focused on areas of continuous adult habitat. The effectiveness of aerial dispersal where the adult habitat is fragmented will also be determined.

B3. Monitoring restoration success

Most restoration projects are undertaken with the broad goal of improving "health" or "condition", and success can only be measured in terms of both biodiversity and key ecosystem processes. The Centre has an important role to play in the development of practical and cost-effective indicators of success of restoration activities. To a large extent, this work will be undertaken in Program D, as part of the overall goal of developing and testing new methods for ecological assessment. However, an important question to be addressed in the Restoration Ecology Program is whether it is possible to restore key ecosystem processes (e.g. primary production, nutrient cycling) without completely restoring all elements of the biological communities.

SEDIMENT - NUTRIENT PROCESSES

Project Leader: Dr Ron Beckett

Project Team: Mike Grace, Mike Harper, Bill Maher, Graeme Esslemont, N Hill, Gavin Rees and Darren Baldwin

Aim:
To test whether sediments play an integral role in determining nutrient concentrations and fluxes in Australian freshwater systems.

Progress:
The central hypothesis in this project is that suspended and bottom sediments have a pivotal role in determining nutrient concentrations and fluxes in freshwater ecosystems. In the project, we examined the importance of phosphate adsorption, particle coagulation and precipitation processes that occur in the water column, determined the rates of key microbial processes in sediments that lead to release of nutrients from sediments and the major factors involved in processing the carbon that drives sediment microbial process.

We showed that modelling water column adsorption processes requires only limited and relatively simple measurements of dissolved and total phosphorus measurements. Factors such as iron and organic carbon content cause a shift in the particle adsorption capacity. Novel techniques were developed to measure impact of shear on particles and subsequent settling rates. Anoxic conditions lead to a release of phosphate from sediments. The extent of release was variable with different sediments and could be strongly affected by type and concentration of carbon and sulfate and history of the sediment. We showed that typical rate constants could not be used to accurately model sediment processes, but would require the use of Monod-type kinetics. Reactivity studies on different plant litter showed that additional nutrients for degradation was dependent on the plant material. Reactivity studies also generated degradation rate constants necessary for modelling processes. Findings from this project, and refinements to established models, have been used in the development of a new quantitative model for sediment nutrient processes. The computer model is currently undergoing initial testing and validation.

A final report is being prepared for this project.

ECOLOGY OF THE YARRA RIVER

Project Leader: Dr Peter Breen

Project Team: Dr Chris Walsh, Dr Mike Grace and Dr Sophie Bourgues.

Aim:
To evaluate the impact of urbanisation on the Yarra River.

Progress:

This project has looked at the patterns occurring in the community structure of aquatic macroinvertebrates. We also looked at patterns in community function using indicators such as sediment denitrification potential, water column production and respiration, benthic production and respiration, and gross river production and respiration.

The patterns in the macroinvertebrate data suggest that impacts due to urbanisation can be observed above the natural downstream changes that occur in streams. We have found noticeable discontinuities in the data for community composition below tributaries that either deliver nutrients from wastewater treatment plants or runoff from highly urbanised catchments.

Dobsonfly larvae, an aquatic macroinvertebrate.

Denitrification potential was used as a measure of nutrient cycling in the Yarra River. In general the potential denitrification rates were high compared to literature values, the highest being measured in urbanised reaches. The potential rates at all sites appeared to be limited by nitrate. While nutrient cycling was not carbon limited, gross river primary production was generally low and appear to be limited by phosphorus in the rural sections and by light availability (e.g. turbidity) in the urban sections. Although water column production and respiration was very low, results from benthic enclosures indicate that production of benthic algal biofilms may be quite high and represent an important local source of primary production.

The results from this project are starting to build a picture of the relationship between community structure and function in the Yarra River. Importantly the project is also studying denitrification and evaluating if it can be managed in-stream to reduce nitrogen loads from urbanising catchments like the Yarra.

A final report is being prepared from this project.

PROGRAM B: RESTORATION ECOLOGY~OUTCOMES

Program Outcomes	3 year milestones	Progress at the end of Year 1
An improved understanding of the constraints to recovery of disturbed aquatic ecosystems and the processes that can facilitate rehabilitation	Development and validation of innovative and practical monitoring tools so that the success of rehabilitation of streams and rivers can be quantified in ecological terms	• Population genetic tools used to estimate dispersal capability of common stream invertebrates in SE Qld streams.Sampling of selected taxa in Victorian streams commenced. • Sampling techniques developed and tested for monitoring recovery of LWD habitats in degraded lowland streams • Commenced design and testing of a monitoring program for riparian rehabilitation in SE Qld as part of the SEQ Regional Water Quality Management Strategy
To ensure that public funds invested in restoration of degraded ecosystems result in the maximum environmental benefit possible	Initiate demonstration sites aimed at showcasing practical, cost-effective and ecologically sound methods for the rehabilitation of rivers and wetlands Contribute to the development of "best management practice" for the cost-effective and ecologically sound rehabilitation of rivers and wetlands	• Contribution to the production of technical guidelines on Riparian Management (with CRCCH & LWRRDC). • Selection of potential study sites in SE Qld as part of the SEQ Regional Water Quality Management Strategy

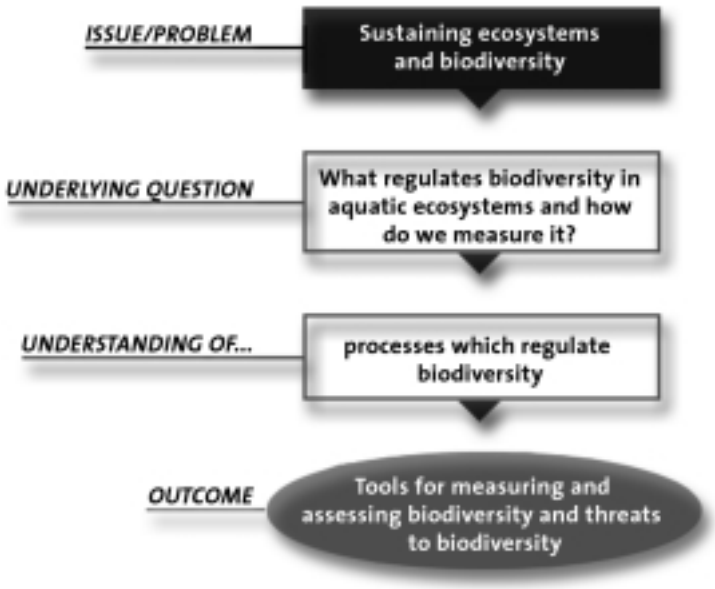
Snags provide important habitat for water birds such as these ibis. Photo: B van Aken, CSIRO Land and Water

3.5 Program C Conservation Ecology

Program Leader: Associate Professor Arthur Georges

Assoc Prof Arthur Georges
Program Leader

Program Issues and Outcome



Program Objectives

- To assess biodiversity in freshwater ecosystems and the processes that regulate it.
- To identify and understand threats to biodiversity.
- To develop and evaluate responses to human-induced pressures.

A Biodiversity Assessment and Regulation

B Conserving Biodiversity

ULTRAVIOLET RADIATION AND AMPHIBIAN DECLINES

Project Leader: Dr William Osborne

Project Team: Mr David Hunter, Dr Ken Green (National Parks and Wildlife Service)

Aim:
Examine sensitivity of amphibians to ambient levels of ultraviolet radiation.

Progress:

There is international concern that elevated levels of ultraviolet B radiation, resulting from ozone depletion, are likely to effect organisms living at high elevations. Organisms in the early stages of embryonic development that are confined to clear, shallow pools are most likely to be at risk. In the last decade there have been alarming losses to alpine frog populations, both in Australia and overseas. This project examines whether these concerns may be related to the sensitivity of declining species to increased UV-B radiation.

The project is located in the Snowy Mountains including the Murrumbidgee, Murray and Snowy River catchments. It is researching the reproductive and behavioural characteristics of declining and non-declining amphibians in natural water bodies that may make them more susceptible to UV-B radiation. The field work component of this research has been completed and results are being analysed prior to publication.

Journal articles are available from this work and results clearly indicate that a declining Alpine species, the Alpine Tree Frog, is highly sensitive to UV-B radiation.

CARP CONTROL METHODS

Project Leader: Dr Craig Schiller (NSW Fisheries)

Project Team: David McGill (NSW Fisheries) and Matthew McInttosh (NSW Fisheries)

Aim:

Develop methods for reducing carp abundance in enclosed water bodies; assess the effect of this on reduction in adult numbers on the survival and growth of juveniles.

Progress:

This project, based in billabongs in the Murrumbidgee and Murray catchments, focuses on carp removal and research into development of large-scale carp harvesting methods. We are also looking at what effect such harvesting has on the growth and survival of juvenile carp. This will provide an indication of the longer term impact of such methods.

Over 165 wetland sites have been inspected and of these 21 were surveyed using electrofishing. The effectiveness of large-scale harvesting techniques were tested in Lake Cargelligo. Three study billabongs, two on the Murray River and one on the Murrumbidgee River, have been partitioned into smaller experimental units and carp populations are being manipulated. Ecological changes associated with changes in carp density have been measured in the study billabongs. We are currently analysing the results from this work.

RECRUITMENT ECOLOGY OF NATIVE FISH

Project Leader: Dr Peter Gehrke

Project Team: Dr Craig Schiller and Mr Ian Wooden

Aim:
To develop a model of fish recruitment and criteria for managing nursery habitats.

Progress:
This work was undertaken on rivers, lakes, creeks and floodplains in the Paroo, Darling, Murrumbidgee and Murray catchments. We found that floodplains were the most common habitat used by recruiting fish, supporting the common perception of floodplains as nursery habitats. Stocking of floodplain habitats with large numbers of hatchery-reared larvae does not appear to enhance natural recruitment.

Golden Perch, Macquaria ambigua. *This project found that the recruitment of Golden Perch declined because of changes to flow.*
Photo: P Humphries

The report on this project shows that fish recruitment is impacted by flow management. There are few high flows in the Darling River and therefore floodplain habitats downstream of Menindee are not inundated regularly - this limits opportunities for native fish recruitment in this area. We found that the recruitment of Golden perch and Bony herring declined because of changes to flow however carp recruitment increased.

Carp recruitment was strong in all catchments. Temporary creek and floodplain habitats consistently provided stronger recruitment than permanent river or lake habitats. Carp are therefore likely to benefit from increased floodplain inundation frequency in a similar way to native fish species.

The Paroo River.
Photo: A Tatnell

Development of water resources in the Murray-Darling Basin has not been ecologically sustainable in the context of maintaining biodiversity. This provides strong ecological support for the MDBMC cap on diversions and for NSW Water Reforms as a process for conserving biodiversity. Implementation of environmental flow regimes that mimic as closely as possible natural inundation patterns is recommended to maximise recruitment potential for native fish and to restore biodiversity.

A report is being finalised on the outcomes of this work.

THE DISTRIBUTION, ABUNDANCE AND MANAGEMENT OF THREATENED FISH IN THE MURRUMBIDGEE RIVER CATCHMENT, WITH SPECIAL REFERENCE TO THE ENDANGERED TROUT COD

Project Leaders: Dr Craig Schiller (NSW Fisheries), Dr Mark Lintermans

Project Team: Mr Ian Wooden (NSW Fisheries), Mr Michael Rodgers (NSW Fisheries) and Mr Mark Jekabsons (Environment ACT).

Sites: Murrumbidgee River

Aims:

To determine the distribution and relative abundance of Trout cod in relation to habitat and position in the river and to identify habitat preferences.

To develop Trout cod management guidelines for State/Territory/Local government agencies and monitor the effectiveness of stocking and threatened species recovery programs.

Progress:

This project uses sample sites in the Murrumbidgee river between Burrinjuck Dam and Yanco Weir.

The field work has been completed and analysis has commenced. Early analysis indicates that mid-stream snags as well as bank snags are important. Some trends are already apparent in Trout cod habitat associations in the Murrumbidgee River and the project has recorded the smallest (and possibly youngest) sexually mature Trout cod female found in the wild. Preliminary data analysis indicates strong trends in Trout cod habitat associations. Evidence so far suggests that in the middle section of the Murrumbidgee River, smaller-size classes of Trout cod are associated with high flow near single-stemmed, medium-to-large timber snags orientated in the same direction as water flow.

Most recent findings:

- Trout cod prefer higher flow areas (at micro & macro scales)
- Strong association with medium to large snags/large woody debris that occur singly (not in "clumps")
- Prefer snags in mid-stream (compared with shore-based snags)
- Linked with preference for higher flows
- Prefer snags oriented into flow (i.e. long axis of snag is at 0° to main flow)
- In middle Murrumbidgee, Trout cod are most abundant in stocked areas and regions with abundant suitable snags.

Trout Cod,
Macchullochella macquariensis,
an endangered native fish.
Photo: G Schmida

PROGRAM C: CONSERVATION ECOLOGY~OUTCOMES

Program outcomes	3 year milestones	Progress at the end of Year 1
New knowledge on the distribution, life history and conservation ecology of threatened freshwater biota	Organisation of a national forum on conservation of biodiversity in freshwater ecosystems, bringing together the range of perspectives from science and management	Funding to support Fenner Conference approved. Conference to run in July 2001
Advice on the likely impacts of various human-induced disturbances on biodiversity in freshwater ecosystems and the spatial scales over which they are likely to be affected	Design of experimental protocols for testing hypotheses on the processes that regulate biodiversity in natural and modified freshwater ecosystems	Project to address the issue of connectivity in dryland systems has been approved
Advice on the possible ecological effects of invasive species on native flora and fauna	Identification of primary threatening processes for aquatic biodiversity	Symposium on invasive species to be included as key element in Fenner Conference
Principles and recommendations for assessing the biodiversity values of freshwater systems	Develop principles for the assessment of biodiversity in freshwater ecosystems	Project to address this milestone under development in collaboration with Sydney Catchment Authority

High flows in the Murrumbidgee River, ACT. Photo: K Markwort

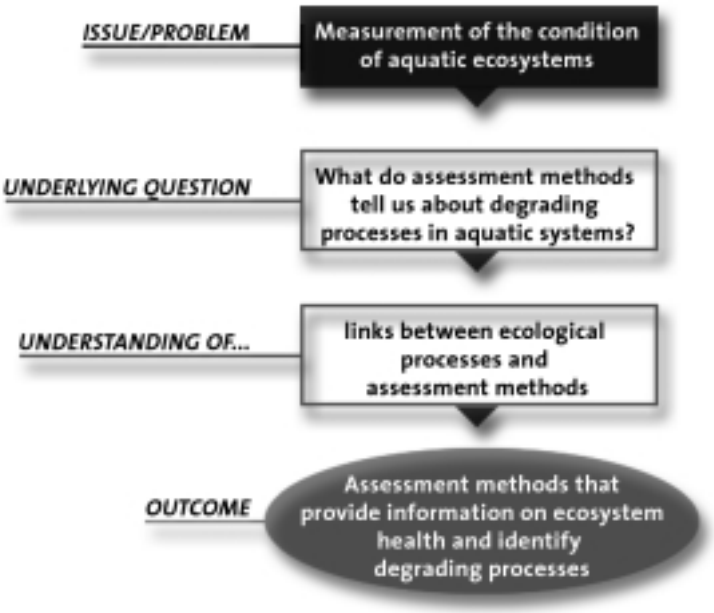
3.6 Program D: Water Quality and Ecological Assessment

Assoc Prof Richard Norris
Program Leader

Program Leader: Associate Professor Richard Norris

Resource management and environmental protection agencies have an increasing need for high quality information relating to the ecological effects of their operation. Most river management agencies in Australia are moving towards more ecologically based management. However, there have been few useful techniques available that can be rapidly employed to assess the effectiveness of the management process. There is now renewed interest in the use of more qualitative techniques, primarily because of the high cost of quantitative approaches. The centre is developing innovative methods for assessing river health particularly using macroinvertebrates, fish, microbes, algae and habitat.

Program Issues and Outcome



Program Objectives

- To determine the ecological response of rivers and related wetlands to stressors.
- To develop and test ecological risk assessment procedures for application to fresh water systems.
- To develop the ecological basis for determining reference conditions against which comparisons to determine damage or change are often made.
- To determine the effectiveness of various bioassessment approaches to provide information on the condition of the aquatic communities and ecosystem processes.
- To determine the relationships between ecological processes and outputs from bioassessment methods.

D1 Ecological response to damaging agents

ALGAL SUCCESSION AND BIOMASS IN BURRINJUCK RESERVOIR

Project Leader: Mr Ian Lawrence

Project Team: Ms Myriam Bormans (CSIRO Land and Water), Dr Rod Oliver, Ms Gail Ransom, Dr Brad Sherman, Dr Phillip Ford (CSIRO Land and Water), Dr Bob Wasson (Centre for Resource and Environment Studies, ANU).

Aim:
To identify factors determining algal growth and composition in reservoirs.

Progress:
This research has established that the phosphorus which is driving the algal growth in Burrinjuck Reservoir is derived predominantly from internal sources. This occurs because organic loading to the reservoir, from external sources, creates reducing conditions in the bottom waters. When the reservoir is low due to increased drawdown, the transfer of the nutrient rich bottom waters to the surface waters, where it is available to algae, is significantly increased. The form of nitrogen discharged to the inflows to the reservoir may also substantially modify the reducing conditions, and is a key determinant of algal composition.

These findings have implications for the management of water abstraction, rate of draw-down, and management of inlets to reservoirs. In addition, reduction in the discharges of organic material and specific forms of nitrogen from the catchment will assist in managing algal blooms.

We have held a series of workshops with reservoir and catchment managers to explore the range of techniques and information needs to better manage algae in reservoirs.

The final report from this project and the report from the Reservoir Manager's workshops are available at http://freshwater.canberra.edu.au

THE NIFT ASSAY FOR IDENTIFYING LIMITATION OF PHYTOPLANKTON GROWTH

Project Leader: Dr Rod Oliver

Project Team: Ms Gosia Przybylfka and Mr Zygmunt Lorenz

Aim:
Confirm that the NIFT (Nutrient Induced Fluorescence Transient) assays for nitrogen and phosphorus limitation are reliable and test the suitability of commonly used fluorometers for performing the assay.

Blue-green algae in Burrinjuck Reservoir. Photo courtesy DLWC

Progress:

This project investigated the hypothesis that cell growth limited by nitrate-nitrogen would show NIFT responses to the addition of either ammonium or nitrate, whereas those growing on an ammonium source would respond only to ammonium. This is based on the knowledge that cells taking up nitrate transform it into ammonium before use.

The results of the project were contrary to expectations. The cyanobacterium, *Microcystis*, showed a NIFT response to the addition of ammonium but not to nitrate when grown with either ammonium or nitrate-N. In contrast, the diatom *Aulacoseira*, gave NIFT responses to the addition of either ammonium or nitrate irrespective of the form of nitrogen. As expected, nitrogen fixing *Anabaena* did not give a NIFT response for nitrogen limitation despite the absence of combined inorganic nitrogen. This study shows that the NIFT assay does not readily identify the source of nitrogen (ammonium or nitrate) being utilised.

Testing of the effects of sample storage on the NIFT response were undertaken so that appropriate sampling regimes could be recommended. During sample storage in the dark the NIFT responses changed at different rates and it was concluded that measurements are most reliable if made immediately on fresh samples.

The results confirmed that although nitrogen limited algae from the major groups gave different NIFT response patterns to nitrate additions, the technique could still reliably distinguish between nitrogen and phosphorus limitation.

ALGAL AVAILABILITY OF PHOSPHORUS

Project leader: Dr Rod Oliver

Project Team: Mr Shane Perryman, Ms Helen Gigney and Mr Zygmunt Lorenz

Aim:

To determine the bioavailability of phosphorus from different sources; to develop a sediment transport model that predicts the impact of the form of phosphorus on downstream algal blooms.

Progress:

Nutrient measurements and flow data were used to calculate the loads of the various forms of phosphorus from an upland catchment, a sewage treatment plant (STP) and an irrigation return drain in the Goulburn River, Victoria. The largest cumulative load was from the STP plant despite long periods without discharge. Conventional wisdom is that nutrients released from STP plants are in forms readily available for algal uptake. This is not the case with the Shepparton STP where more than 75% of the phosphorus is in particulate form. This is a result of the long retention in treatment ponds prior to release, which allows algae and other aquatic organisms to grow in the effluent.

Annual total phosphorus loads from the Acheron River and Rodney Drain were of similar magnitude to each other and about one quarter that of the STP. Due to fluctuations in discharge and resulting differences in the forms of phosphorus delivered by the sources, a distinct periodicity was evident in loadings to the river. This will be important if available forms of phosphorus are being delivered at times when environmental conditions are suitable for algal growth.

The impact of these loadings on the downstream reach depends on whether phosphorus is accumulated within or transported through the reach. The first component of a combined transport and P-speciation model has been developed to estimate the changes in exchangeable phosphorus concentrations downstream of a source. The model combines the phosphorus input from a source with the upstream phosphorus concentrations and calculates the resultant concentration of the various phosphorus forms. The exchange between suspended particles and the dissolved phosphorus pool is estimated using a partitioning coefficient derived from adsorption-desorption isotherm experiments. This is used in conjunction with the suspended solids measurements to derive the dissolved phosphorus concentration. The dissolved phosphorus concentration is then used to estimate the exchange of dissolved phosphorus with the bed.

D2 Innovative bioassessment methods

BIOLOGICAL ASSESSMENT OF RIVER HEALTH

Project leader: Associate Professor Richard Norris

Aims:

- Investigate AUSRIVAS O/E taxa response to varying the sample size (i.e. amount of habitat sampled).
- Investigate responses of biological assessment outputs to common impacts e.g. mining (ACT at Captains Flat), sewage effluent, forestry, urbanisation, agriculture (NSW South Coast) and dams.
- Evaluate effects of invertebrate sorting methods (Lab-sort vs Live-pick) on AUSRIVAS model predictions.
- Provide supporting research on long-term variability of invertebrate assemblages in rivers.

Progress:

Component: Responses of biological assessment outputs to common impacts and sorting methods.

Project team: Ms Sue Nichols

Bioassessment precision using macroinvertebrates: effects of area sampled and replication.

The assumption underpinning many biological assessment programs is that a macroinvertebrate sample will provide representation of the macroinvertebrate assemblage at a site, which is adequate to make an accurate site assessment compared to reference sites and is also appropriate for the intended analytical methods. The AUSRIVAS model is one such rapid biological assessment method developed for Australia's National River Health Program.

This study investigates the differences in taxa numbers and composition between replicated macroinvertebrate samples from 5, 10 and 20m riffle transects of a site in the Thredbo River and assesses the adequacy of a 10m transect for biomonitoring. Replicated macroinvertebrate samples from a 10m x 0.35m collection area only, at both trace-metal affected and reference sites, on the Molonglo and Queanbeyan Rivers, were used to assess the precision and accuracy of predictive model results.

Sue Nichols collecting macroinvertebrate samples from a site impacted by mining on Coppers Creek.

There were no significant differences in the average number of taxa recovered from the 5, 10 or 20m x 0.35m collection areas at either family- or species-level taxonomic resolution. The average number of macroinvertebrate families and species found in any one collection from the Thredbo River site was 60% and 46% (respectively) of total taxa recovered from all collections. The species-level abundance data conveyed the most information about the macroinvertebrate assemblage and family-level presence/absence the least. The 5m samples often clustered together indicating that they were somewhat different from the others. However, the overall differences were small and the predictive model used for biological assessment of river condition was robust to the observed difference in taxonomic composition. All but one of the 15 collections from the Thredbo River site provided an identical AUSRIVAS site assessment.

There was little difference between total abundance estimates regardless of collection area. Lower Oligochaeta numbers in the collections from the larger areas and that total abundance estimates were most variable in the 20m collections, may indicate that

animals were escaping capture. Despite frequent washing of the net during collection, net-clogging rather than the area sampled may be controlling sampling effort (and thus number of individuals collected). The use of a larger net or mesh size may help alleviate the problem.

Predictive model results had good accuracy and precision (overall O/E taxa SE = 0.04). On most occasions a single macroinvertebrate sample collected from 10m of habitat accurately assessed the biological condition of both test and reference sites.

In a suitably homogeneous section of river a 5m collection may adequately replace a 10m sample for biological site-assessments. However, since most of the differences detected between the various areas sampled showed that the 5m collections varied from the 10 and 20m collections, a 10m transect is recommended.

River bioassessment: effects of field live-pick and laboratory sub-sampling of invertebrates.

The aim is to determine if there are significant differences between the site assessments provided by different models which were created from data derived from either lab-sorting or live-picking. This study will not attempt to establish a relationship between the magnitude of the impact and the degree of biological impairment as assessed by the models. The findings will have particular implication for 'across-border' monitoring programs were different invertebrate sub-sampling methods have been used and also provide an indication of model robustness to the effects of sampling methods (i.e., can a valid

Live-pick and lab-sorting sub-campling of macroinvertebrates

assessment of site condition be provided by using lab-sort data in a live-pick model). The evaluation of the predictive models will provide useful information to aid the development of the most sensitive method for detecting and assessing human influence on our waterways.

Some analysis is still required before writing up is complete but preliminary findings indicate that live-pick and lab-sort methods do not produce significantly different O/E taxa ratios when run in the appropriate models. However, models are sensitive to the methods i.e., lab-sort data cannot be run in live-pick models. The models detected a range of impacts of varying magnitudes but the lab-sort O/E taxa ratio range was greater than the live-pick range, possibly indicating greater sensitivity of the lab-sort method.

Mining adit at Captain's Flat, NSW, flows into the Molonglo River. Photo: P Sloane

Component: Bioassessment: are predictive model outputs related to a pollution gradient?

Project team: Mr Philip Sloane

Along with good independent trace metal data, this work assesses the O/E model outputs relative to a gradient of trace metals from Captains Flat. Under this component of the project Philip Sloane has his honours project written up ready for publication submission.

Component: Impacts of dams on water quality

Project team: Dr Richard Marchant and Genevieve Hehir

Sites immediately below nineteen dams in Victoria and NSW were sampled for macroinvertebrates using rapid bioassessment protocols. Specimens were identified to the lowest taxonomic level. The AUSRIVAS predictive models (combined seasons) for macroinvertebrate composition were applied to the results and O/E scores calculated. The mean O/E score for Vic was 0.46 for the genus model and 0.63 for the family model; for NSW the mean score at the family level was 0.57. There was no significant difference between family level scores in the two states. Many of the same taxa (that were predicted to occur) were missing at all sites and there was no correlation between O/E score and degree of hydrological deviation below the dam; nor was there any association between the score and whether the dam released surface or bottom water. Thus these dams all seemed to cause much the same disruption to the fauna with only certain taxa able to recolonise the reaches below dam walls. The limited recolonisation may well be caused by dams acting as barriers to drift, a prominent route for invertebrate colonists.

Component: Temporal stability in benthic invertebrate communities in south-eastern Australian streams and implications for the use of predictive models.

P***roject team:*** Mr Leon Metzeling, Mr David Robinson, Dr Stephen Perriss, A/Prof Richard Norris, Ms Sue Nichols, Dr Ken Thomas and Dr Richard Marchant

Analyses have been completed on long term data sets of benthic invertebrates from four catchments in south-eastern Australia. The data sets were of two types - semi-regular sampling over time (Wimmera and Thredbo) or intensive periods of sampling separated by more than a decade (Latrobe and Yarra). In each case, the samples were collected using the same equipment throughout, with the exception of the Thredbo where there was a change in sampling method in 1994. Most sites were considered to be reference sites with little change to their catchments over the sampling period.

The results indicate significant changes over time for most sites when using species level, qualitative data but show little change over time when using family level, binary data. Changes in species taxonomy could lead to some of these differences but these have been accounted for in the data sets wherever possible. Natural variability or changes in response to large-scale climate features (eg. ENSO or flow regimes) could both contribute to the observed changes. The comparative temporal stability of the family level data, which is similar to the type of data used in predictive models such as AUSRIVAS, raises questions as to the use of old reference site data in such models.

BIOLOGICAL ASSESSMENT USING DIATOMS

Project leader: Dr Peter Newall

Project Team: Ms Nina Bate

Aim:
To assess techniques for using diatoms to indicate nutrient status, water quality or environmental change; to contribute to a national diatom database and sampling protocol.

Progress:
This project has resulted in papers on the use of diatoms as biological indicators and has contributed to the "Illustrated Guide to Common Stream Diatom Species from Temperate Australia" (CRCFE). This follows on from a guide to the common genera published in 1999 and will be of great benefit to water resource agencies intending to use diatoms in water quality assessment. We have recommended a minimum number of valves (200) to be counted for rapid bioassessment and this should assist in the use of diatoms as water quality indicators. We have compared macroinvertebrate and diatom species assemblages in characterising water quality across several sites in the Kiewa River, Victoria.

Publications and guides are available on this work.

RIVPACS FOR URBAN STREAMS

Project Leader: Dr Peter Breen

Project Team: Dr Chris Walsh, Ms Sue Nichols, A/Prof Richard Norris, Mr Leon Metzeling and John Gooderham

Aim:
To develop and test an urban RIVPACS model and protocol.

Progress:
The project has demonstrated that successful urban AUSRIVAS models can be constructed. The models were however limited by the availability of reference sites and results were no better than those from the Victorian regional model. The project has highlighted some issues about data compatibility, but more importantly about the problem of reference sites for urban streams.

A final report is being prepared for this project.

BIOLOGICAL ASSESSMENT PROJECTS

Project leader: Associate Professor Richard Norris

Sue Nichols testing alkalinity of water samples for AUSRIVAS models.
Photo: P Sloane

Project team: Ms Sue Nichols, Ms Nerida Davies, Ms Julie Coysh, Ms Gail Ransom, Centre for Resource and Environmental Studies, ANU (Janet Stein, John Stein, Henry Nix)

I. Support and completion of Australia-wide assessment of river health models.

Aim:
To test and refine AUSRIVAS models for all states and territories in Australia.

Progress:
The centre has been liaising with all NRHP agencies in Australia to obtain relevant macroinvertebrate and environmental data and to determine the needs for model development and refinement. Significant interaction with agency staff to assist with training, data management and model development has ensured that all agency staff are actively involved in site classification, decisions on site groups and familiar with modeling techniques. Phase 1 of the project has resulted in construction of 6 new models for the ACT, Victoria and Tasmania and production of sampling documentation, now available on the AUSRIVAS website. Phase 2 of the project will result in new models and documentation for Queensland, Northern Territory, New South Wales, South Australia and Western Australia.

Nerida Davies taking water samples for the Alps project. Photo: P Sloane

II. Australian Alps Stream Health Monitoring Project

Aims:

To sample macroinvertebrates at approximately 95 sites across the Alps.

To carry out the Index of Stream Condition at these sites.

To develop an AUSRIVAS model for the Australian Alps.

To design an ongoing monitoring program for Alps Streams.

Progress:

The macroinvertebrate fauna and a wide range of habitat features were sampled and measured at 95 sites within the national parks of the Australian Alps in January and February 2000. Seventy-nine reference (minimally impacted) sites were used to provide baseline conditions against which test sites can be compared and assessed. Sixteen test sites (with suspected or known impacts) were sampled and assessed using AUSRIVAS. The habitat and macroinvertebrate data collected from the reference sites was used to develop an Alps summer riffle AUSRIVAS predictive model. The Alps summer riffle AUSRIVAS predictive model and a description of the methods is available on the Internet (Coysh et al. 2000, http://ausrivas.canberra.edu.au/ausrivas). The findings of the project including model development and the Index of Stream Condition are discussed in the final report.

III. AUSRIVAS Mapping and Reference Site Screening Module

Aims:

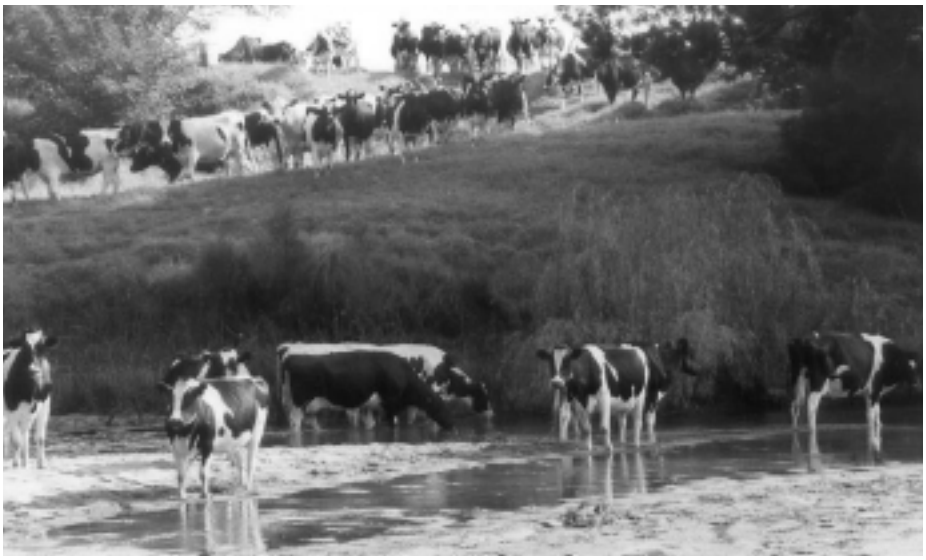
To develop a mapping and reference site screening module for AUSRIVAS.

To develop map-based outputs for both AUSRIVAS bioassessment results and catchment impact indices for use at a range of mapping scales with a consistent mapping and graphics framework.

To use and extend the Wild Rivers impact database to develop a standard framework for reporting and reference site condition and to aid reference site selection.

Progress:

Many of the programming requirements for this mapping project have been completed such as designing and implementing the data and map request server, designing and implementing the http server and developing the methods for running ArcView from scripts and developing the method for remotely running ArcView. The programming associated with producing maps from ArcView, converting Wild Rivers data to a format readable by ArcView and designing the user interface are currently being investigated. This will enable the user to produce maps through the Internet that may include sites, streams, Wild Rivers indices and AUSRIVAS Bioassessment outputs.



Cattle: one of the possible impacts on catchments.

IV. AUSRIVAS software enhancement

Aims:

To complete the development of AUSRIVAS software and GUI platform to include additional functionality, interactive and interpretive aids.

To complete the development of the AUSRIVAS website, appropriate links and support to assist in establishing the permanent AUSRIVAS site.

Progress:

Phase 1 of this project is now complete and has resulted in a list of proposed modifications, survey of users to determine internet access needs, design of solutions to problems based on survey results, implementation of an alternative HTTP server, design of a new AUSRIVAS internal file structure and investigation of video formats for the web based manual. Phase 2 will address implementation of proposed changes and solutions to current problems, integration with the Mapping module, and completion of modifications to the WWW site.

V. First National Assessment of River Health (FNARH)

Aim:

To produce a comprehensive assessment of water quality in the Upper Murrumbidgee River catchment.

Progress:

The ACT component of the First National Assessment of River Health is now complete, with 162 test sites and 14 reference sites assessed using the ACT autumn, spring and combined autumn/spring AUSRIVAS models. Rivers and streams in the Upper Murrumbidgee River catchment exhibited biological conditions that ranged from severely impaired (Band D)

to richer than reference condition (Band X), however, the majority of sites indicated some form of impact. The major impacts affecting test sites within the Upper Murrumbidgee River catchment appear to be chemical pollutants, trace metal contamination, nutrient enrichment, rural runoff, habitat degradation, sedimentation and river regulation. AUSRIVAS was found to be a valuable tool for highlighting biologically impacted sites along the rivers and streams of the Upper Murrumbidgee River catchment.

Additional Projects

TAXONOMIC RESOLUTION AND STREAM CLASSIFICATION

Project Leader: Mr Leon Metzeling

Aims:
To assess the influence of taxonomic resolution, habitat and season on stream classification.

Progress:
Macroinvertebrate data from 165 reference sites across Victoria, sampled under the National River Health Program (NRHP) between 1990-96, have been used to assess the interaction of different taxonomic levels, sampling seasons and habitat on stream classifications. These comparisons have also been carried out at different scales — statewide, regional and single catchment.

Environmental parameters was used to characterise groupings of macroinvertebrates at each site. In general the same interpretions were obtained for all the data sets examined at the statewide and regional scales, indicating substantial redundancy in the data sets. Within the single catchment, the patterns were less consistent with greater discrepancy between the family, genus and species groups and their subsequent characterisation. These results confirm the applicability of family level data like that used in the NRHP for broad scale classifications but such data needs to be viewed more cautiously when working within a single river system.

REGIONALISATION OF VICTORIAN STREAMS

Project leader: Mr Leon Metzeling

Project Team: Dr Peter Newall and Fiona Wells

Aim:
To classify Victorian streams into groups based on geographical regions and assess the potential of the classification for the development of biological objectives.

Progress:

Our work in the past year has been using the five regions delineated from the invertebrate data collected under the NRHP. We used the reference site data within each region to assess the options for several indicators and for developing biological objectives. The indicators we considered were regional AUSRIVAS models, the SIGNAL biotic index, number of families, number of key families and number of EPT families (mayflies, stoneflies and caddisflies).

We built AUSRIVAS models for four of the regions and derived objective values for the other indicators based on the statistical distribution of scores within the reference sites for each region. These indicators and objectives will be incorporated into the State environment protection policy covering all surface waters in Victoria.

NATIONAL ASSESSMENT OF RIVER CONDITION

Project leader: Associate Professor Richard Norris

Principal Investigators: Assoc Prof. Martin Thoms, Dr. William Young (CSIRO Land and Water)

Project team: Dr Peter Liston, Dr Fiona Dyer, Ms Nerida Davies, Mr Simon Linke, Mr Nick Bauer

Poor riparian habitat, Goodradigbee River at Wee Jasper, NSW. Photo: P Sloane

Aims:

The principal aim of the project is to develop an Australia-wide assessment of waterway condition which integrates biological, morphological, water quality, catchment and hydrological components. The Assessment of River Condition (ARC) project will provide an overarching view of the quality of rivers across Australia. It is intended to be used as both a measure of river condition and as a tool to identify management options for rivers.

This project will form a component of the National Land and Water Resources Audit (NLWRA) currently being compiled by the Federal Government, and the information will be made available through the Australian Natural Resources Atlas.

Progress:

The major project outputs will be:

- a system for assessment of river condition applicable Australia-wide.
- an Australia-wide assessment of waterway condition which contributes to the Australian Natural Resources Atlas.
- an interpretation of the results of the assessment for all major drainages, including relative priorities for management action in river systems.

The ARC will be derived from five indices based on a model of river function in which catchment characteristics affect hydrology and habitat features, which in turn influences the aquatic biota.

1. Aquatic Biota Index
2. Catchment Condition Index
3. Water Quality Index
4. Hydrology Index
5. Physical Habitat Index

The reporting unit for this project, the river reach, has been defined on a geomorphological basis and reaches are currently being determined for catchments across Australia. Data for compilation of the five indices is being derived from a range of sources; spatial remote sensed data, field sampled data and modelled values where data is lacking. Much of the data has been acquired though in some areas this project is being hampered by dependencies on other NLWRA projects that are not yet completed.

The second major component of the project is the modelling of biotic integrity for reaches in which the biota has not been sampled. This task has commenced, a modelling approach similar to the AUSRIVAS approach has been developed and is being trialed.

The project commenced in November 1999 is to be finalised by March 2001. The first two milestones of the project have been completed. The final report and third milestone, due March 2001, will comprise the completed assessment of river condition for the approximately 14,000 river reaches that will be identified across Australia.

D3 Ecological risk assessment

ECOLOGICAL EFFECTS OF DRYLAND SALINITY

Project Leader: Dr Daryl Nielsen

Project Team: Dr Terry Hillman

Recent reports have highlighted the rapidly increasing influence of dryland salinity in the salinisation of aquatic systems. In response to this issue, the centre sponsored a one-day workshop bringing together water resource managers and researchers to explore research requirements in the face of increased salinisation. Knowledge gaps were identified during an examination of past and current research. Important amongst these was the lack of information regarding sub-lethal salinity effects and their influence on ecosystem structure and functions over time.

The workshop suggested six areas of research to address these issues: a data-base of existing data-sets linking salinity and biological data; survey wetland types to assess their current condition in terms of salinity and biological integrity; investigate the relationships between salinity and survival, growth and recruitment of biota; assess the response of ecosystems to increasing salinity; establish experimental sites for experiments linking salinity with ecosystem structure and process; identify key taxa on which to focus future research and assessment.

Outputs from this workshop are being incorporated in the development of the Ecological Risk Assessment Project.

Dryland salinity. Photo: B van Aken, CSIRO Land and Water

PROGRAM D: WATER QUALITY AND ECOLOGICAL ASSESSMENT~OUTCOMES

Program outcomes	3 year milestones	Progress at the end of Year 1
Improved scientific knowledge on the ecological effects of damaging agents (including nutrients and pesticides) in Australian freshwater systems.	Development of priority areas for research in ecological response to agents that damage freshwater ecosystems.	• Research projects developed and reviewed for the assessment of nutrient processing inurban streams. • Project under consideration for the assessment of pesticides in agricultural areas. • Project developed, reviewed and accepted for funding for testing biological methods to assess ecological responses.
Improved and robust bioassess–ment methods that provide information on ecosystem health and assist in identifying the degrading processes (including habitat modification).	Integration of AUSRIVAS with other techniques for assessment of river condition.	• Project developed, reviewed and accepted for funding for comparing biological assessment methods and integrating them into monitoring programs.
New ecological risk assessment procedures and associated tools for use by water industries.	Bring in expertise in ecological risk assessment (biota and processes with inputs to ecological risk assessment over a range of scales up to catchment level).	• Project on ERA developed and reviewed. Currently being refined for final consideration for funding. • Associated project for large scale ERA is currently under consideration.