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River Restoration

Project 6A: Development of Flow-Ecological Response Models

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This project is being undertaken jointly by the CRCs for Catchment Hydrology and Freshwater Ecology.

Project Objectives

In conjunction with the CRC for Freshwater Ecology Project A250 (Development of Flow-Ecological Response Models) we will:

- Review conceptual and quantitative models of biotic response to flow alteration.
- Produce the 'River Analysis Package' (RAP) software for testing biotic response to flow alteration. The River Analysis Package will contain three modules:

  > The Hydraulic Analysis module will be used to describe instream habitat in terms of key hydraulic parameters and to construct time series of available hydraulic habitat under alternative flow scenarios.

  > The Time Series Analysis module will be used to interrogate the daily time time series of available hydraulic habitat for alternatie flow scenarios as well as provide a range of time series manipulation and visualisation tools for environmental hydrology applications.

  > The Ecological Response Models module will use the Time Series Analysis module and Hydraulic Analysis module to predict hydraulic habitat change in response to flow alterations.

Background

CRC for Catchment Hydrology catchment-scale models developed in other projects will be able to predict how hydrology, channel form and water quality will change over time. This project will convert hydrological and channel changes into probable ecological consequences. It is directed at helping water resource managers to predict the ecological consequences of hydrological change under a broad range of future scenarios, and to design optimal environmental flow strategies for existing water infrastructure.

The project aims to develop and validate models relating flow patterns at various temporal scales to biological and ecological response (linked via the influence of flow on hydraulic habitat). These models will be developed for use by stream managers to define optimal environmental flow regimes for available water in eastern Australian rivers and plan associated physical restoration activities. The specific objective is to produce software and predictive models that will be integrated into the CRC's Catchment Modelling Toolkit to predict critical ecological consequences of alternative flow scenarios and channel changes. Where appropriate, these models will be integrated with existing models used for water planning (e.g. REALM, IQQM and the Murray-Darling Basin Commission's (MDBC) Environmental Flows Decision Support System (DSS)) in partnership with the agencies using these programs. These models will be also support the development of protocols for monitoring the ecological benefits of environmental flows.

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Over the last decade, there has been considerable improvement in methods of characterising and modelling stream habitats and its temporal variability. However, there has been very limited validation of the biological significance of these habitat models in Australia. Drawing on the expertise within the two CRCs, this project provides a major contribution to quantifying flow-ecology relations. Managers will be able to use the models developed in this project to provide quantitative predictions of the biological consequences of land and water management decisions. Such models will be a powerful tool for communicating consequences of management decisions to stakeholders and provide a sound basis for planning environmental flow regimes. They will also be an important component of the integrated modelling capability of the CRC for Catchment Hydrology.

Methodology

This project requires the staged development of flow-ecological response models. We will begin with conceptual models identified from the literature and expert opinion, and develop these into testable hypotheses which will be used to develop a rules-based model of biological response to flow change that is applicable over a large spatial scale (eastern Australia). The testable hypotheses will also be used to develop statistically based (probabilistic) models of biological response to flow in specific catchments by using existing biological, hydrological and hydraulic data sets. Where possible, outputs from the project will be incorporated into stand-alone software and contribute to the compilation of tools/methodologies used for environmental flow studies.

The first task of the project is to compile existing conceptual models of biotic response to flow change. Conceptual models of flow-biota interactions at different temporal scales will be sourced from the available literature, expert opinion and results of studies by collaborating parties (CRC for Freshwater Ecology, Department of Natural Resources, Mines and Energy, Qld, the Murray-Darling Basin Commission, Department of Land and Water Conservation, NSW, Natural Resources and Environment, Vic and the Environment Protection Agency). The specification of time and space scales at which these interactions are likely to be strongest will be based on explicit consideration of the ecological processes involved. The conceptual models will be refined to produce specific testable hypotheses of biotic response to flows. The key output from this task is the identification of ecologically relevant flow metrics and the appropriate biota metrics. Subsequent tasks of the project are directed at testing these hypothesised biological responses to flow and in producing quantitative models to help predict the likely biological response to alternative flow scenarios. The compilation of conceptual models and associate testable hypotheses will be circulated for peer review amongst relevant project personnel and stakeholder groups.

The relevant flow metrics identified in the testable hypotheses will be combined into time series analysis software. The software will analyse daily flow data (and channel morphology) to produce summary flow metrics (hydrologic and hydraulic) to allow testing of the hypothesised biotic response to flow. The flow software will be a windows based application that will allow the user easy interrogation of daily time series data. In this way the software is not simply a tool for this project but will be suitable for application to a broad range of environmental flow and more traditional hydrologic studies.

The Ecological Response Models module will be an additional software module compatible with the flow metric calculation software. The intention of the rules-based model is to produce a set of broadly applicable concepts of how biota is likely to respond to alterations in the hydrologic regime. The rules-based model will provide an indicative direction of change rather than specific quantification of changes in biota metrics. The purpose for the rules-based model is to ensure that

the project provides some guidance on environmental flow requirements of regions not specifically considered in the development of quantitative predictive models. The rules-based model would build on the concepts used to develop the MDBC's Environmental Flow DSS and the Flow Events Method developed in the River Restoration Program's earlier research (1999-2003). The Ecological Response Models will provide a structure to capture the range in knowledge of biological response by representing the predicted response in terms of the 'confidence' in the underlying models. Where our understanding of biological processes is high, our confidence in their predicted response to flow change is also high. For ecosystem components that are relatively poorly understood, we would anticipate a low 'confidence' in the predicted response. By representing the confidence of response in this way we can ensure that all relevant ecosystem components are considered, and that our understanding of how each ecosystem component responds is not overstated.

Using the statistical techniques identified by the biometrician panel, the conceptual models will be tested and quantitative flow-biota models developed for south east Queensland using a data set consisting of four years of quarterly sampled fish data from the Mary River catchment (Griffith University data). These data will be used initially because of the high temporal resolution of sampling at the each site. Hydrological conditions at these sites represent a broad range from perennial to ephemeral systems. The streams have good water quality, so the potential confounding influence of water quality should be minimised. The spatial applicability of models developed from this initial fish data set will be tested by using fish data sets from the Albert and Logan Rivers in south east Queensland and data supplied by MDBC and CRC for Freshwater Ecology

Flow-biota models for macroinvertebrates will be constructed in parallel to the development of the flow-biota models for fish. Species-level macroinvertebrate data and expertise will be supplied by Victorian EPA. The macroinvertebrate data is of a similar quality to the fish data with many repeat samples through time to allow the effect of short and medium term hydrological change to be separated from long term hydrological effects. The flow-biota models for macroinvertebrates will be tested by using species-level data supplied by Melbourne Water to the Urban Stormwater Quality research program. The testing of flow-biota macroinvertebrate models will be jointly undertaken between these two programs.

The quantitative flow-biota models (both fish and macroinvertebrates) will be incorporated into software that will form part of the Catchment Modelling Toolkit. The quantitative flow-biota models are likely to be region specific.

Three software modules will be produced by the above component of the project:

1. Hydraulic Analysis
2. Time Series Analysis
3. Ecological Response Models

A key application of the models developed in this project is in environmental flow planning as part of water allocation decisions. Several existing analytical tools are available to support environmental flow studies including the Flow Events Method and the MDBC's Environmental Flow Decision Support System (EFDSS). As part of this project we will consider the appropriateness of different frameworks, methods, and tools for environmental flows in Australia. We will review the needs of technical people involved in environmental flow investigations, and the needs of those involved in environmental flow decision making. The review will be based on the literature and workshops with technical and policy staff within state agencies. We will review these needs in the context of the apparent convergence of approaches in environmental flow assessment occurring world-wide and recommend the suite of modelling, analysis and assessment tools required for medium and large environmental flow investigations (1000s to 10,000km^2 basins).

Project Team

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For further information

http://www.catchment.crc.org.au/riverrestoration