For further information please contact:

Dr Heather Hunter
CRC for Catchment Hydrology
Natural Resources, Mines and Energy
80 Meiers Road
Indooroopilly, QLD 4068
heather.hunter@nrm.qld.gov.au

Land-use Impacts on Rivers

Project 2D: Modelling and Managing Nitrogen in Riparian Zones to Improve Water Quality

Project Leader: Heather Hunter (Natural Resources, Mines and Energy, Qld)
Deputy Project Leader: Christy Fellows (Griffith University)

Project Objectives

- Develop a model to predict denitrification in riparian zones, for incorporation into the Catchment Modelling Toolkit's catchment water quality models.
- Develop a catchment-scale methodology for identifying riparian zones intercepted by shallow groundwater flows.
- Apply a catchment water quality model that incorporates these features in selected catchments in south east Queensland and assess the relative potential for riparian zones to moderate nitrogen fluxes.
- Assess key issues for management of nitrogen in riparian zones and develop new management guidelines that take account of denitrification processes.
- Communicate research information to key stakeholders

Background

Nitrogen management is a major challenge facing water quality managers in many parts of Australia. Recent research highlights the importance of nitrogen as the nutrient limiting primary production in some coastal waters (e.g., Moreton Bay; Dennison and Abal, 1999; Port Phillip Bay; Murray and Parslow, 1999) and riverine systems (Mosisch et al., 2001). In these situations, an increased delivery of nitrogen is likely to boost algal growth to the detriment of ecosystem health (Bunn et al., 1999). Increased stream loadings of nitrogen are now recognised as a significant impact of upstream land use in catchments (e.g. Hunter and Walton, 1997).

There is currently a recognised lack of reliable information available to managers to support their decision-making on nitrogen management issues (Hart and Grace, 2001). This is compromising the effectiveness of the very considerable investments now being made in riverine restoration to improve water quality.

Riparian buffer zones, particularly those on low order streams, offer the potential for reducing nitrogen entry to waterways, from both surface runoff and shallow groundwater flows. While much of the nitrogen entering streams is attached to sediment in runoff, a significant proportion is often transported in a dissolved form as nitrate. Fluxes of nitrate through the riparian zone are intrinsically linked to water movement (both over and through the soil) and are also strongly influenced by biological processes occurring in that zone. The process of denitrification (microbial conversion of nitrate to nitrogen gas) is particularly important because it effectively removes nitrogen from the riparian zone to the atmosphere. Riparian zone denitrification can have an important impact on downstream water quality when significant amounts of nitrate-enriched groundwater are transported at shallow depths through carbon-rich, anoxic riparian soils, at flow rates that allow enough time for the denitrification process to occur.

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Project 2D:
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Project focus

1. Developing the 'Riparian N Model'

Continued progress on field and laboratory experiments will yield a 'Denitrification Kinetics Module'. This module will describe denitrification kinetics and will offer a number of alternative mathematical models for describing denitrification processes (e.g. simple first order kinetics or more advanced options). This module will act as the 'Denitrification Engine' in the proposed 'Riparian N Model'.

The 'Riparian N Model' will be incorporated into a catchment scale water quality model to account for denitrification in riparian buffer zones. Spatially, it will be compatible with the system of nodes and links used in EMSS (Environmental Management Support System); with the riparian zone defined as the length of a link multiplied by the width of the riparian zone. Temporally, a daily time step is proposed. We envisage that the model will be implemented in two different ways, for ephemeral and perennial streams.

A 'bucket' model is proposed for use in ephemeral streams that have a soil profile likely to promote a perched water table system. The riparian zone on both sides of the stream is represented by a bucket, which fills up during stream flow then drains to field capacity when flow ceases. When the perched flow ceases, the drained subsurface water is added back as surface flow downstream, with a reduced nitrogen load.

In perennial streams, the dynamics between the stream and the riparian zone will influence the denitrification process. In this system, a 'denitrification index' approach will be employed. This index represents a denitrification rate, which is dependent on the stream flow condition and the rooting depth of riparian vegetation. The latter correlates to the soil organic carbon profile, and the former affects the extent of anoxic conditions in the riparian zone through inundation. The riparian zone width will depend on the topography of the area - this defines the lateral extent of riparian vegetation (and thus of carbon-enriched soil).

The suggested model will be calibrated for Project 2.5's (CRC Project 1999-2002) current site in south east (SE) Queensland and further tested at another location in SE Queensland. In a companion project, (funded by Land and Water Australia and the Murray-Darling Basin Commission) the geographic scope of the research will be extended by applying the methodologies developed to contrasting catchments in Victoria and Western Australia.

2. Identify Target Areas for Riparian Restoration

A spatially explicit, catchment-scale investigation will be made of the potential risk to stream water quality from shallow groundwater inflows of nitrogen. It will also aid the process of site selection for broader-scale catchment testing of the Riparian N model. Combined digital overlays of topography, soils, riparian vegetation and land-use will identify areas where riparian restoration/management should be focussed. The technique will be tested in selected catchments in SE Queensland to produce maps of stream reaches with the potential for inflows of nitrogen-enriched groundwater. The method will be implemented through the TIME environment (See Project 1A).

3. Importance of Riparian Zones in Catchment Nitrogen Budgets

After incorporating the Riparian N Model into a catchment scale model, the latter will be applied for a selected SE Queensland catchment in order to assess the impacts of riparian zones on overall catchment nitrogen budgets. Scenario runs will evaluate the impact of changing riparian zone condition on catchment nitrogen loads. The relative contributions of surface and subsurface flows to catchment nitrogen loads over different seasonal conditions and the implications for water quality management will also be assessed.

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4. Communication and Training

Information from the research and modelled scenarios (above) will be assessed with respect to their implications for riparian zone management of nitrogen fluxes. Existing guidelines for riparian zone management will be reviewed and a complementary guidelines module written to incorporate key management issues arising from the research. The module will include a conceptual model that integrates key riparian zone processes and management impacts.

In addition to the guidelines, a range of training and information products will be produced over the course of the project. This will occur through involvement in Development Projects, technical seminars and reports for key stakeholder groups, and scientific publications and presentations for other researchers.

These products and activities will also contribute to the Coastal CRC's projects aimed at providing decision-making tools and information for effective management and ecosystem health of coastal wetlands (www.coastal.crc.org.au).

Project Team

Project Leader

Heather Hunter, (Natural Resources, Mines and Energy, Qld)

Researchers:

David Rassam, (Natural Resources, Mines and Energy, Qld)

Christy Fellows, (Griffith University)

Robert DeHayr, (Natural Resources, Mines and Energy, Qld)

Carol Conway (Griffith University)

Daniel Pagendam (Natural Resources, Mines and Energy, Qld)

Nerida Beard (Griffith University)

Michael Daly (Natural Resources, Mines and Energy, Qld)Stuart Bunn, (Griffith University)

Philip Bloesch, (Natural Resources, Mines and Energy, Qld)

For further information

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

http://www.toolkit.net.au