In addition to the practical outcomes of the research, it is also providing an opportunity for scientists to test their level of understanding of stream ecosystems and their functioning. The project is expected to act as a stimulus for new ideas and theories, thereby contributing to the science of aquatic ecology.

And the practical side of the Whatawhata project is a significant contribution towards mitigating the adverse effects of agriculture on our waterways. The foreword from *Towards Sustainable Agriculture* puts it thus:

"Water quality is a very sensitive and accurate indicator of environmental health. As New Zealand actively seeks to develop more sustainable agricultural systems and practices, it is increasingly important that all involved in the management of our resources - landusers, regional authorities, Iwi and others - have the necessary information to help them make wise decisions on matters which impact on water as well as on other national resources." ■

Bryce Cooper, John Quinn and Rob Davies-Colley are scientists at NIWA in Hamilton. They are working on the Whatawhata project as part of a large team involving many of the science staff at NIWA, Hamilton.

"BNZ": a tool for catchment planning

Bryce Cooper

A recently-developed computer model holds promise as a management aid for integrated catchment planning.

INTEGRATED CATCHMENT PLANNING is by no means new in New Zealand. Before the formation of Regional Councils, Catchment Boards (set up as part of the Soil Conservation and Rivers Control Act 1941) had responsibility for devising water and soil management plans for large rural areas in their respective regions. Today, with an increasing amount of scientific information available, documenting and predicting the impact of sediment, contaminant and nutrient inputs into inland and estuarine waters, within the context of integrated catchment planning, assumes a new importance.

A very large proportion of New Zealand's land surface is given over to pastoral farming. This has created problems arising from both point-source and non point-source inputs into drainage waters. It is a major challenge for management agencies to implement measures to reduce the impact of such inputs. This situation is brought sharply into focus given the onus placed on today's Regional Councils, via the Resource Management Act, to promote sustainable use of natural resources.

Implementing catchment-wide management plans can be expensive, but with full information, it is possible to optimise cost-efficiency. Therefore, before making any decisions on strategies, it is important to be aware not only of the impacts of pastoral/agricultural activities, but also of all the "control" options and their associated benefits.

BNZ: Basin - New Zealand

NIWA has developed a catchment-scale simulation model, as an aid to water resource planning. Basin - New Zealand (BNZ) predicts the relative benefits of various options to control the effects of runoff. It has the potential both to realise cost savings, and to provide a rationale for justifying expenditure on the chosen option.

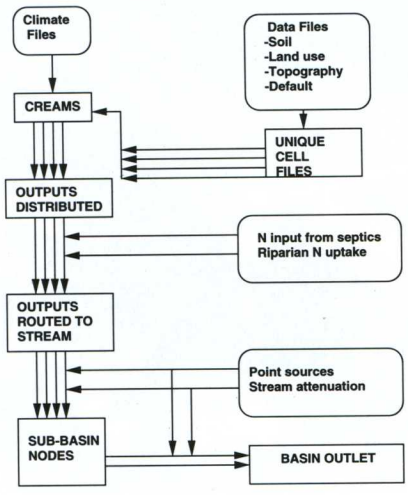
Several physically-based mathematical models have been designed specifically to predict the impact on water quality of land management practices. One of the most frequently used is the Chemicals, Runoff and Erosion from Agricultural Management Systems (CREAMS) model. This was developed by the United States Department of Agriculture to provide a basis for deciding on "best management practices". Modified versions of CREAMS have been developed as catchment-scale pollution models. However, the specific water management needs of New Zealand require a model with greater capabilities.

The first step in BNZ's evolution was to select the CREAMS-based model most appropriate for New Zealand conditions. A model was required that could predict water, sediment and nutrient losses from pastures, together with the impacts on these losses of management practices such as grazing density, buffer strips, and soil fertility. In addition, it had to be capable of producing useful results at a catchment scale, and accommodating inputs from point sources, riparian nitrate removal processes, nitrate leaching from septic tank seepage and fields, and stream attenuation processes.

A model was selected which uses CREAMS to generate spatial runoff of water, sediment and nutrients within a catchment.

Before testing the model, the hydrology and nutrient submodels were modified, and a

Structure of BNZ model.



number of inputs adapted to provide a better reflection of New Zealand conditions. A special requirement was that the model should be capable of simulating the effects of retirement of riparian strips from grazing - a practice specifically referred to in the Resource Management Act.

This modified version of CREAMS performed well when applied to a grazed pasture hillslope. It provided good predictions of measured water, sediment and nutrient losses over 20 months. Also, it gave a good simulation of how a riparian strip affected runoff quality over 22 months. In addition, these initial tests identified other changes to the model that would further improve its predictions.

As a result of this research and testing programme, BNZ became a reality. In broad terms, it is a simulation model which divides the catchment into grid cells, of user-defined size. It uses information on topography, land use and soil type to make predictions of nutrient loss from each cell. It then routes these through the riparian zone, along the streams to the catchment outlet. The spatial component allows targeting of control measures to those cells where nutrient and/or sediment loss is predicted to be high. This targeting is an important aid to managers seeking to optimise the cost-efficiency of any catchment-wide plan.

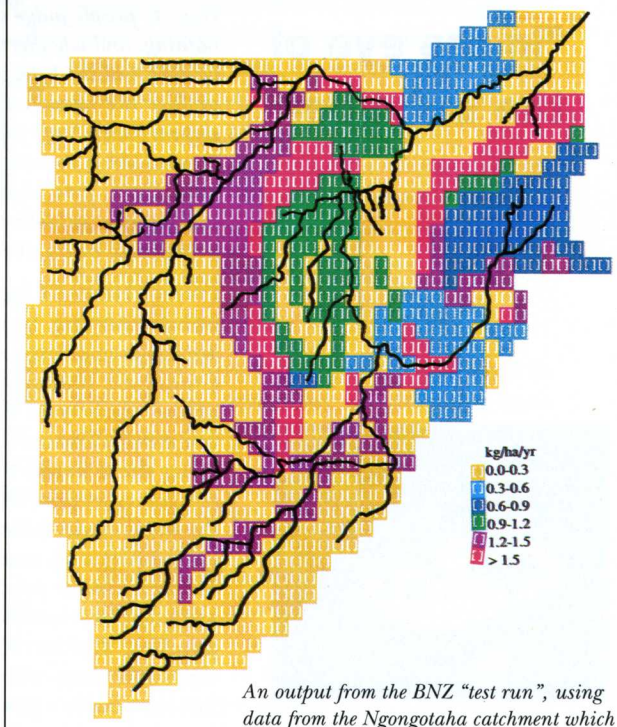
A test for BNZ

The predominantly pastoral Ngongotaha basin, which drains to Lake Rotorua, provided a suitable testing ground for BNZ's capabilities. The deterioration of Lake Rotorua as a result of nutrient inputs from both point and non-point sources prompted remedial action by the Bay of Plenty Regional Council. Measures to control the inputs included the preservation of forest remnants on steep ground, retirement of riparian areas and erosion-prone hill slopes from pastoral agriculture, together with some tree plantings along stream edges, protection of wetlands from drainage, and restrictions on urban development. Implementation began in 1982 and was largely completed by 1986. Both before and after riparian management, the Ngongotaha stream was intensively monitored by NIWA for sediment and nutrient loads. Using these data it was possible to test the model's performance, by generating predictions using the "before" data, and comparing the model outputs with the actual "after" data.

So, is BNZ capable of making useful predictions about the effects of schemes aimed at reducing the runoff of pollutants in a catchment? In fact, the model generated realistic estimations of the size and direction of changes in pollutant losses following management changes in the Ngongotaha catchment. It also indicated that processes in the riparian zone and stream channel processes do seem to modify pollutant losses between the edge of field and the basin outlet.

Potential planning tool

Basin - New Zealand has the potential to be a valuable planning aid for resource managers for implementing catchment-wide management plans. Enabling managers to predict the effects of alternative management scenarios allows them to make realistic assessments of the benefits and cost-effectiveness of each. However, catchment water quality modelling systems, such as BNZ, should be regarded as constantly-evolving management tools. Research into the processes involved in pollutant runoff into waterways, and its subsequent transport downstream, is continually yielding new information. As new research findings come to hand, they can be incorporated into updated versions of the model, to produce improved predictions. ■



An output from the BNZ "test run", using data from the Ngongotaha catchment which drains to Lake Rotorua. This diagram shows the model's predictions of annual losses of phosphorus from the catchment under a pre-retirement scenario.

Further reading

Cooper, A.B. and Bottcher, A.B. 1993. Basin scale modelling as tool for water-resource planning. *Journal of Water Resources Planning and Management 119:* 306-323.

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