Testing times underfoot

JANE CHAMBERS AND **GAIA NUGENT** FROM MURDOCH UNIVERSITY DESCRIBE A NEW APPROACH DEVELOPED IN WESTERN AUSTRALIA FOR MANAGING DECLINING GROUNDWATER LEVELS EXPECTED AS A RESULT OF CLIMATE CHANGE, LANDUSE CHANGE AND WATER RESOURCE DEVELOPMENT.

An innovative risk assessment framework will soon be available to help water managers identify the key factors impacting on groundwater dependent ecosystems, as well as providing targets for monitoring and management.

The framework can be modified and used for aquatic ecosystems dependent on groundwater, or surface water inputs. It is also user-friendly and applicable to different areas throughout Australia.

The research was carried out in the south of Western Australia, a biodiversity hotspot, by a team of ecologists, modellers and hydrogeologists from a range of different agencies.

Declining groundwater levels

There has been a 15 per cent decline in rainfall and a 55 per cent decline in run off in south-western Australia since 1975. Climate change projections suggest this drying trend will continue to increase in intensity and duration by up to 20 per cent across Australia and by 40 per cent in the south-west. This highlights the vulnerability of freshwater ecosystems to climate change.

Groundwater dependent ecosystems have already been impacted in the south-west by lowering of the water table, which has reduced surface expression of groundwater, water levels and flow in wetland, river and cave ecosystems.

Opposite: Quin Brook on the northern Gnangara mound, when there still used to be water in 2008. Photo courtesy of Bea Sommer.

The severity of risk in this biodiversity hotspot highlighted the need for a risk assessment and decision support framework. The research in south-western Australia, provided a 'living experiment' to validate the framework against observed changes in three case studies: wetlands of the Gnangara Mound, a section of the Blackwood River dependent on the Yarragadee Aquifer for groundwater base-flow during summer, and subsurface lakes in the Leeuwin Ridge Caves.

These ecosystems were chosen as examples of a range of ecosystem types being placed under different stresses relating to groundwater decline. These stresses included climate change, landuse change and water resource development. Ecosystems at all locations showed evidence of significant change in response to reduced groundwater levels, with the root mat communities of the Leeuwin Ridge Caves listed as a threatened ecological community.

The new framework

The framework is based on a standard Risk Assessment Framework, which consists of five steps:

1. Identify the hazard.
2. Determine exposure and vulnerability of the ecosystem.
3. Assess effects.
4. Characterise risk.
5. Manage risk.

Applications for decision support are presented at each step of the framework to improve understanding of the vulnerability of groundwater dependent ecosystems to changing groundwater levels.

In Steps 1 and 2, the likelihood of declining water over time and the associated biophysical responses are identified. In Step 3, a conceptual model is developed to describe these inter-relationships. An excellent way of assessing whether biota will be harmed is to determine the thresholds at which populations may decline in response to key environmental parameters. These thresholds define the upper and lower limits of environmental conditions in which organisms exist. Outside these thresholds the likelihood of an adverse effect on organisms increases. The final stage in characterising and managing risk (Steps 4 and 5) is to identify these thresholds.

Environmental interactions

Management of declining groundwater levels requires an understanding of the interactions between climate, hydrology, physicochemistry and the environmental requirements of biota. In Step 4, a conceptual model (see Figure 1) is used to capture these inter-relationships. Using a Bayesian Belief Network, ecosystem responses are predicted for a number of future groundwater scenarios. Where adequate information is available, the results from the Bayesian Analysis can be represented using Global Information Systems to show the spatial distribution of relative risk.

Figure 1: Once a conceptual model has been developed it forms the basis of a quantitative Bayesian Belief Network, incorporating ecological thresholds. The conceptual model can then be used for top-down or bottom-up prediction and subsequently assessment of ecological risk.

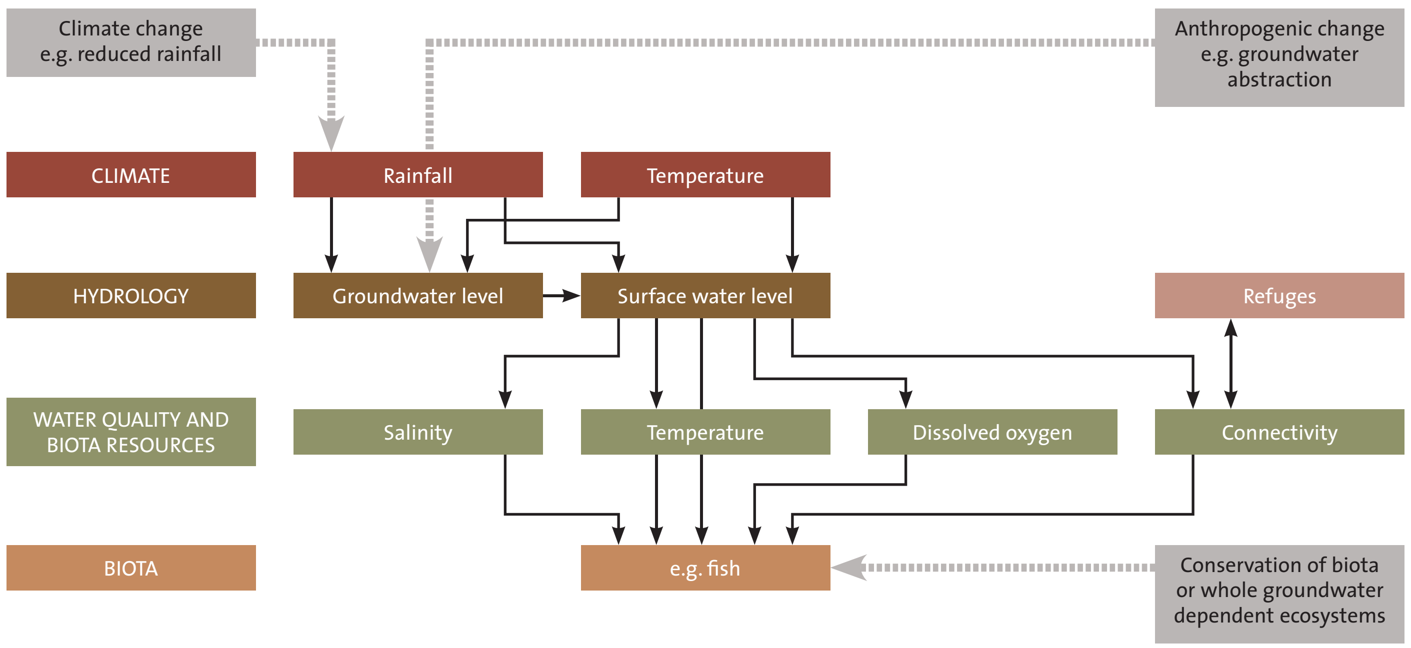
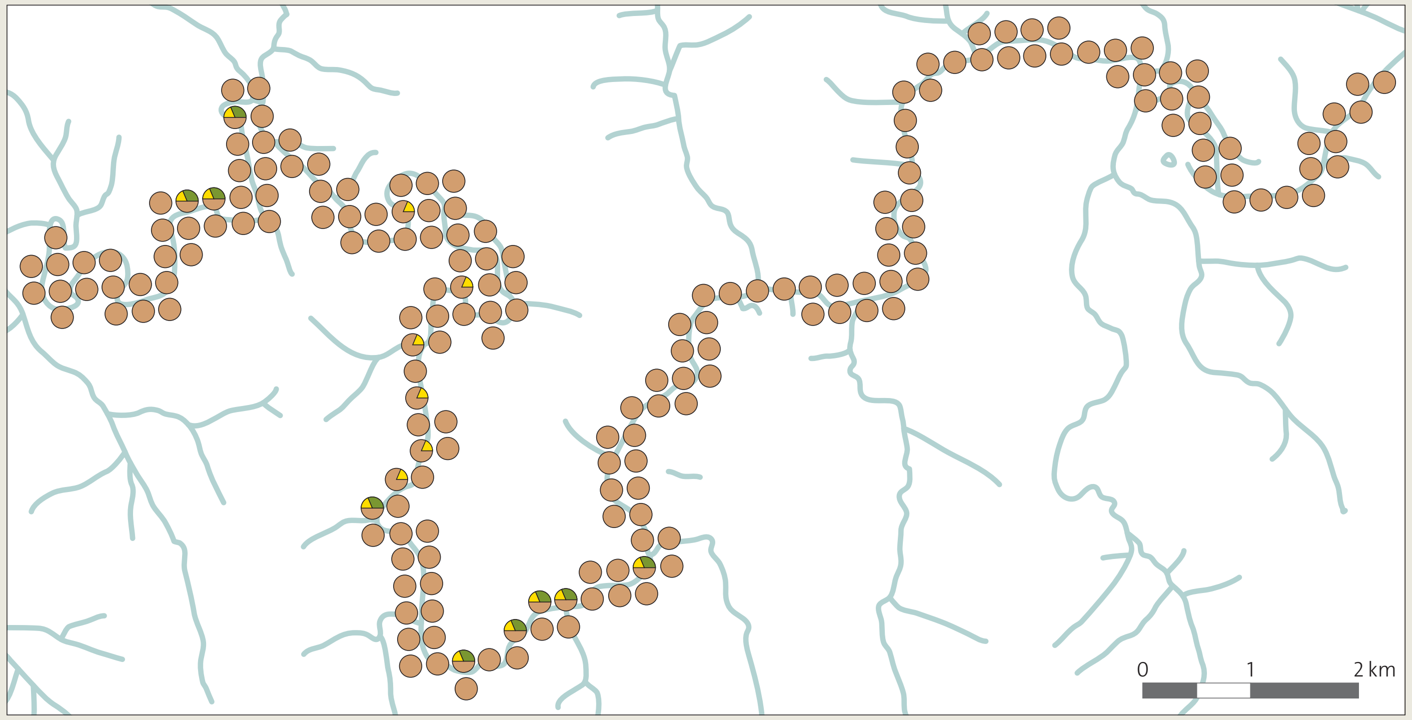
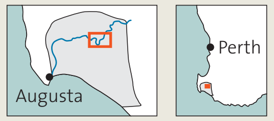


Figure 2: Spatial risk assessment for fish in the Blackwood River shows a bleak outlook and identifies only limited potential refuges under climate change projections for 2030 CMid Scenario from the South West Sustainable Yields project (CSIRO 2009).



FISH HEALTH MODEL. Scenario CMid
Probability that fish health is GOOD
Probability that fish health is INTERMEDIATE
Probability that fish health is POOR

FISH HEALTH
Good: All parameters within 75% range for both species.
Intermediate: One parameter out of 75% range for one species.
Poor: Three parameters out for acceptable range or one out of range.



Blackwood study area

The benefit of this approach is that it can be used to identify ecosystem consequences of declining groundwater levels due to increased abstraction or climate change (a top-down approach), or the critical thresholds at which a change in groundwater levels will result in some predicted environmental or biological response (a bottom-up approach). A top-down approach could include specific scenario testing, for example the effect of withdrawing 45 megalitres of groundwater or the projected fall in groundwater levels due to climate change.

If it is not possible to quantify future changes to groundwater levels, then different scenarios can be assessed to identify the minimum groundwater level below which ecosystems are likely to be impacted. This can be used to inform policy conditions such as groundwater extraction licences, or planning decisions.

The bottom-up approach could be applied if there is concern for a particular species, functional groups of biota, or guilds of biota such as plants or frogs. As part of this approach, spatial mapping of risk can provide key information for the maintenance of freshwater biodiversity (see Figure 2).

From its beginnings in the south of Western Australia as a framework for groundwater dependent ecosystems, this approach is flexible enough for application to a range of ecosystems and purposes across Australia. It empowers people to manage aquatic ecosystems effectively, hopefully ensuring their survival into the future.

FOR FURTHER INFORMATION
Gaia Nugent — g.nugent@murdoch.edu.au

BLACKWOOD RIVER. PHOTO COURTESY OF STEVE BEATTY.

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