Climate Change Adaptation Research Grants Program
- Freshwater Biodiversity Projects

Project title:
Predicting water quality and ecological responses to a changing climate: informing adaptation initiatives.

Principal investigators: Dr Fiona Dyer
Lead organisation: University of Canberra

Objectives:

1. Link climate attributes to water quality models to determine the probability, extent & magnitude of water quality changes
2. Develop a Bayesian network model to link the projected water quality and quantity changes with ecosystem changes with a particular focus on the probability of adverse biological effects.
3. Use the Bayesian network models to inform adaptation initiatives
4. Determine the transferability of the model framework to other regions.

Project design and methods

Our focus will be on the Upper Murrumbidgee River Catchment (MURK) which is the source of the Act's water. The MURK provides a unique opportunity to construct a scientifically robust and management-relevant case study. Water resource managers are actively considering adaptation initiatives to secure future water supply for human consumption while maintaining and improving ecological condition. Sub-catchments encompass a range of hydrological and ecological conditions that make much of the science directly transferable to other regions. As a case study, it encapsulates the issues faced by water resource management agencies across Australia and the approach developed will have national relevance. The focus will be on the development of water quality and ecological response models at the spatial resolution of the hydrological models already developed by our partners. Specific project objectives are outlined below.

1. Link climate attributes to water quality models to determine the probability, extent and magnitude of water quality changes

Define statistics for a plausible range of climate futures.

Four plausible climate scenarios will be selected and used to produce daily time series of flow using existing hydrological modelling work undertaken by members of our team and our partner agencies. The climate scenarios will be used within a daily weather generator (such as EARWIG 33) to provide statistics regarding temperature and the frequency and duration of dry spells and intense events. The climate scenarios will also be used to define the change in frequency and intensity of bushfire events based on work by. The climate model scenarios will be contextual and used as a type of sensitivity analysis to identify where tipping points in the climate and associated hydrologic response reside. The plausible range of scenarios will be used to revise historical records including by methods such as scaling rainfall, temperature and if necessary changing the autocorrelation of rainfall. The scenarios that result in ecological and water quality thresholds being exceeded will be identified. There is a sufficient length of rainfall and hydrological record with wide climate variation within the case study region to also assess the sensitivity of the predictions to substantial climate variability especially rainfall and temperature. The long period of record and the wide range of hydrologic conditions means that the hydrologic model can be parameterised based on observed data. Future land use scenarios and projected water demands will be developed in consultation with our industry partners, ACTEW and the ACT government. They will take into account projected increases in population, the implications of climate changes on the use of water as well as adaptation initiatives being considered for ensuring future water security and environmental outcomes. This allows us to consider both climate mediated changes in flows and the impact of changes in regulation and diversion that arise from adaptation initiatives. These 'local scenarios' will be nested within each climate scenario.

Link future scenarios to water quality changes

Initial conceptual modelling identified the key water quality attributes for ecological responses as temperature, dissolved oxygen, pH, salts (both calcium and sodium), nutrients and fine sediment. It is these parameters that will be the focus of the water quality modelling. Probabilistic water quality modelling will be undertaken using extensive water quality data sets collected by our CI's and partner organisations, supplemented where necessary by the results of studies elsewhere in Australia and the strategic collection of data for this project. In May 2012, preliminary data will become available from a parallel project designed to understand the relationships between flow, stratification (dissolved oxygen [DO] and temperature) and Murray cod habitat in the Murrumbidgee River. Historical data sets will be used to generate frequency distributions of the measured quantities (with a focus on ecologically relevant thresholds) as well as the duration of periods where concentrations are above/ below thresholds. These frequency distributions will be linked to statistics of flow (including groundwater/surface water contributions), climate (precipitation and temperature) and landscape attributes (including geology, land use, riparian vegetation and fire). Preliminary regression modelling of salinity recently completed for the Molonglo and Yass River systems will also be used within the water quality modelling framework.

Model verification

Preliminary analysis of data sets has indicated the need to capture within event data for water quality, particularly salinity and fine sediment transport to verify initial models. Opportunity exists to augment sampling of special environmental flow releases from Tantangara Dam in spring 2011 to provide key event based data to verify the models. Salinity and turbidity loggers will be deployed at existing monitoring sites to capture the behaviour of the flow releases augmenting monitoring that is collecting temperature and DO data. In addition, macroinvertebrate sampling will be conducted following the flow releases and responses used to verify the macroinvertebrate models.

2. Develop a Bayesian network model to link the projected water quality and quantity changes with ecosystem changes with a particular focus on the probability of adverse biological effects.

This project will focus on the issues of nuisance plant growth (excessive growth of nuisance algal species and macrophytes) and changes in fish (including EPBC listed species) and macroinvertebrate communities within the UMRC. Bayesian network models will be constructed that link the projected water quality and quantity changes with ecological responses. The Bayesian network will capture our existing knowledge of the relationships between environmental conditions and ecological response. Additionally, it is expected that the project will be able to draw on data collected as a result of a parallel project conducting experiments to define thresholds of Na and Ca salts for aquatic biota in the Molonglo River system. Assumptions regarding the Bayesian network structure will be tested, including the aggregation of variables and the discretisation of states. Uncertainties and sensitivities will be identified throughout the network and effort directed to key parts of the network requiring improvement. The rivers of the UMRC will be classified into several ecosystem types depending on their landscape/landuse context and management objectives. This spatial data will be linked to the Bayesian network models and used to frame the scenario testing.

3. Use the Bayesian network models to inform adaptation Initiatives

The Bayesian network models developed in this project will be used to test proposed adaptation initiatives for future water security and waste water management for water quality and ecological response. The models will also be used to evaluate the probability that current water regulation will protect ecological communities and identify the priorities (both spatially and ecologically) for adaptation initiatives based on the probability of adverse water quality effects on ecological communities in the UMRC.

4. Transferability of the model framework to other regions.

The transferability of the modelling framework to other regions will be tested using long-term data previously collected from the Goulburn Broken region. A workshop will be held to review and revise the ecological response models and define locally relevant thresholds for water quality attributes. The models will be populated using data sets supplied by the Goulburn Broken CMA and model tested using sensitivity and uncertainty analysis techniques to determine the confidence in the model predictions. This will illustrate how the approach (research outcomes) can be applied to other catchments.