Climate Change Adaptation Research Grants Program
- Freshwater Biodiversity Projects

Project title:
Identification and characterization of freshwater refugia in the face of climate change.

Principal investigators: Dr Jeremy VanDerWal
Lead organisation: James Cook University

Objectives:

A) identify, characterize and map the biophysical environments that will enhance the persistence of freshwater biodiversity across Australia providing an invaluable resource to better inform climate change adaptation actions; and
B) inform the selection and implementation of appropriate adaptation actions for the protection of freshwater refugia.

Freshwater ecosystems have very high biodiversity relative to their areal extent. They are particularly vulnerable to climate change because of their limited extent, their limited connectivity and, in much of Australia, their susceptibility to drying resulting from the vagaries of temperature and rainfall. The possible impacts of climate change on fresh waters must be assessed in relation to changes in both temperature and riverine networks (e.g., flow and linear connectivity) and their interactions with existing stressors (e.g., impoundments, agriculture, urbanization) and the surrounding landscape (e.g., topographic features and riparian vegetation). Here we propose to:

1. *Define a typology of refugia for freshwater ecosystems.*
   This will include a literature review in addition to a PI and stakeholder workshop to identify, review and synthesize existing knowledge on the biophysical attributes of freshwater ecosystems that are likely to act as refugia that will enhance the persistence of freshwater biodiversity into the future.

2. *Identify the spatiotemporal extent and quality of freshwater refugia under a range of future climate scenarios.*
   This will bring together knowledge, data, novel analysis and state-of-the-art modelling techniques to identify the location, extent and quality of freshwater refugia now and into the future. This will be done, where possible, across Australia at spatial and temporal scales necessary to inform adaptation actions at the local, catchment and regional scales. Calibration and validation of refugia identification will utilize biodiversity datasets in several fine-scale case studies across the country.

3. *Inform the selection and implementation of appropriate adaptation actions for the protection of freshwater refugia*
   Using a consistent approach across Australia, a decision tree and broad spatial optimisation framework will be created to inform the selection and implementation of appropriate adaptation actions to protect and enhance freshwater refugia at catchment and regional scales under a range of scenarios.

Project design and methods

1. Define a typology of refugia for freshwater ecosystems

Project members and other experts will be brought together for a workshop within the first two months of the project to identify, review and synthesize the ways in which different biophysical landscape attributes enhance persistence of freshwater species under climate change. This will include an assessment of the different types of relevant environmental change and ecological responses, and the potential for different landscape features to be incorporated into on-ground adaptation efforts. The outputs will include a report, and potentially a review paper, on a typology of freshwater refugia with commentary on ecological and management potential; and a scoping of the information required to identify and quantitatively assess different refuges. These outputs will complement the typology of terrestrial refugia being developed in the NARP-funded terrestrial refugia project. We will also use this workshop to collate the datasets and analytical scripts across the group and to refine the details of the

analytical approach described below. This initial meeting will be crucial in planning detailed analyses and the Principal Investigators and staff responsibilities and timelines. The workshop will provide the post-doctoral fellow and PIs with detailed analytical milestones and timelines to ensure delivery of results in the short time-frame of 15 months.

2. ***Identify the spatiotemporal extent and quality of freshwater refugia***

   This objective will integrate existing knowledge, data and well-established methods with new analytical tools and algorithms to assess current and future changes in the biophysical environment representing refugia for freshwater biodiversity. Arguably, the collaborations between ARI, ACTFR and TRaCK have the best current knowledge of freshwater systems in dry and wet northern Australia. These groups have developed and tested novel analysis and modelling techniques based on these catchments; where possible, this project will seek to extend this work to enable consistent identification of refugia across Australia. The activities of this objective will, in part, be driven by the outcomes of the workshop (described above), but are expected to include:
   - Compilation and development of necessary spatial datasets and
   - Identification of spatiotemporal refugia.

3. ***Inform the selection and implementation of appropriate adaptation actions for the protection of freshwater refugia***

   The results of the preceding work phases will be synthesised here to produce a rules-based decision tree for identifying the most appropriate adaptation options at appropriate scales with respect to the physical, biological, climatic, management and landscape context of particular refugia. In order to guide decision-making at larger scales, a broad spatial optimisation framework will also be developed to provide recommendations to a range of relevant stakeholders, including State agencies (environmental water managers, National Parks, etc.), Catchment Management Authorities, landholders, etc., for prioritising where particular types of adaptation actions are likely to provide the greatest degree of protection to refugia across the range of projected climate change scenarios. This work will involve stake holder input, building upon the already fruitful relationships of CTBCC, ARI and ACTFR, and associated governing agencies.

Analysis

Modelling and analysis at fine spatial and temporal scales across Australia is data and computationally intensive. To ensure completion of all modelling and analysis, VanDerWal will assist and train project members to enable them to distribute processing across high performance computing facilities located at JCU and UQ available through National Computational Infrastructure (NCI), Queensland Cyber Infrastructure Foundation (QCIF), JCU and UQ.