Climate Change Adaptation Research Grants Program
- Freshwater Biodiversity Projects

Project title:
Novel methods for managing freshwater refuges against climate change in southern Australia.

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Lead organisation: Murdoch University

Objectives:
To evaluate a range of novel methods for managing refuges to determine whether they could be used as part of a climate change adaptation strategy for freshwater biodiversity.

Project design and methods
Our aim is to establish direct links between refuge qualities and their ability to support biodiversity, so that refuge function can be maximised for climate change adaptation. The results of 4 sub-projects will be integrated to provide a final report that evaluates 4 methods of enhancing refuge function sub-projects 1, 3, 4) or creating new refuges (sub-project 2). At the start of the project, we will hold an enduser forum to discuss the sub-projects and receive input, especially about how project results can best be communicated to end-users. In November 2012, a second end-user forum will present project results and receive feedback from end-users, prior to preparing the final reports. We draw a distinction between refugia, which exist over evolutionary time scales, Le. more or less permanent and defined geographically so that species can adapt and persist; and refuges, which are defined functionally as providing opportunities for parts, and not necessarily all, of species life histories to be completed. These definitions are consistent with the primary and secondary uses of the term "refugium" in the Freshwater Biodiversity NARP.

4 subprojects specifically address refuges:

- SP1 addresses provision of cooler water for fish life history stage (spawning and dispersal);
- SP2 address provision of refuges from higher temperatures and extreme temperatures;
- SP3 addresses provision of refuges from extremely extensive or prolonged wetland drying;
- SP4 addresses barriers to dispersal between refuges and other areas of stream channels by fish.

The function of refuges depends on the survival traits of the species using them. As species, not assemblages, are the key respondents in climate change adaptation, this dependence may determine the ultimate biodiversity in refugia with climate change as an overarching disturbance. Examining refuges should allow us to predict the success of refugia in maintaining biodiversity. Refuges from seasonal and extreme events will be a necessary component of refugium systems, which for aquatic organisms will consist of a network of (not single) water bodies or stream channels.

Sub-project 1.
Evaluating the utility of cold-water releases (“shandying") for enhancing the resilience of riverine species.

A literature review examining native vertebrate species to determine whether targeted releases would be sufficient to sustain populations and could be realistically delivered to the required habitats. We will provide: an outline of ecological benefits and costs of coldwater releases using published research in Australia and overseas; individual case-studies where this technique has been used to preserve a species, community or habitat; and a summary of whether cold-water releases are being considered or used as a management option by various environmental management agencies in Australia. A range of potential scenarios and management actions will be developed using case studies from the literature together with discussions with different stakeholders. These scenarios and potential management actions will then be sent to other end users for comment regarding whether these scenarios are realistic and/or whether the suggested management options are feasible as future management options to tackle potential impacts of climate change.

Sub-project 2.

Riparian replanting for temperature control in streams.

The STREAMLINE model developed by Rutherford *et al.* (1997) and modified by Davies *et al.* (2004) was developed to predict daily temperature fluctuations in streams. When used in combination with digital elevation models for mapping solar radiation and maps showing distribution of stream vegetation, it can be used to identify priority areas in catchments where replanting will increase shading and decrease temperatures. This model is yet to be applied in combination with existing faunal species distribution, environmental and experimental data. Stream networks disturbed by clearing will require replanting in critical parts of the channel at currently unknown densities to function as refugia in the future In order to determine optimal shading regimes for refugia using riparian plantings, we will

(i) establish both species-specific tolerances and community-level thresholds of concern using existing experimental data as well as relationships between species distribution and associated environmental data,

(ii) create GIS spatial layers for species-specific and community-level thermal tolerances at catchment or broader scales,

(iii) develop the scenario testing capacity of the SimpSTREAMLlNE model approach adopted by Davies *et al* (2004) for developing a riparian replanting strategy that will provide relief from high temperatures for refugia biodiversity,

(iv) test this approach for selected case studies in two bioregions. This project will use existing data. Case studies are a part of the methodology. This will assist to identify priority areas in catchments where replanting will increase shading and decrease temperatures.

Sub-project 3.

Can anthropogenic refuges enhance the survival of freshwater invertebrates?

For some species, anthropogenic refuges will be absolutely critical for surviving a drying climate in both rural and urban contexts; but these refuges can also provide a model system to explore the responses of organisms in other places, because they exist now and are predictable in the landscape. We propose to examine invertebrates that survive in wetlands in an urban landscape (Perth) that have been heavily modified and have artificially maintained water levels during the summer dry period when natural wetlands dry out.

Sub-project 4.

Evaluating modifying small barriers to improve connectivity.

Removing or modifying redundant instream barriers across southern Australia may increase river connectivity and refuge access under future low flow scenarios. However, prioritisation of barrier removal or modification is required to prevent unintended negative impacts. We will review barrier removal projects globally, assess impacts of barriers across southern Australia, and develop a protocol for prioritising barriers for removal, based on their level of impact on riverine connectivity. We will test the protocol using two data bases: the location of instream barriers in south-western Australia (Department of Water) and the distribution of freshwater fishes in this region (-1500 sites).