Climate Change Adaptation Research Grants Program
- Terrestrial Biodiversity Projects

Project title:
The role of refugia in ecosystem resilience and maintenance of terrestrial biodiversity in the face of global climate change.

Principal investigators: Professor Stephen Williams
Lead organisation: James Cook University

Objectives:
Global climate change, and its interactions with other stressors, is the greatest challenge facing biodiversity conservation in Australia. An important, and relatively cost-effective, adaptation strategy will be the identification and protection of natural refugia that buffer biodiversity from the worst impacts of global change. Despite the potential importance of refugia in climate change adaptation, little is known about which refugia best promote ecosystem resilience, nor how to identify them in the landscape.

This research will maximise the protection of Australia's terrestrial biodiversity in the face of global climate change by defining a practical typology of refugial types and then identifying the location, extent and quality of these refugia in the landscape. We will quantify and map refugia that will buffer biodiversity from adverse impacts of changing temperature, drought and fire regimes and complex interactions with other processes. We will quantify the specific biodiversity assets (vegetation types, species, and genotypes) associated with each refuge and assess their relative vulnerability and likelihood of persistence across a range of future scenarios. Our research program will form the basis for systematic conservation planning enabling prioritisation of adaptation actions both in space and in time. This will ensure cost-efficient allocation of resources for refugial management and maximise ecosystem resilience whilst minimising costs.

Project design and methods
A. Defining a typology of refugial type and quality
We will organise a meeting of the project PIs to review and assess the ways in which different landscape features might enable persistence of species under climate change. This will include assessing the different types of environmental change, different ecological responses, processes leading to loss of species, habitats and functions, and the potential for different landscape features (refuges) to be incorporated into on-ground conservation to improve the survival of terrestrial biodiversity. The outputs will include a report, or perhaps review paper, on a typology of refugia with commentary on ecological and management potential, and a scoping of the information required to identify and quantitatively assess different refuges. We will also use this meeting 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 PI/staff responsibilities and timelines. The meeting will provide the post-doctoral fellow and spatial analyst with detailed analytical milestones and timelines to ensure delivery of results in the short time-frame of 18 months.

B. Identifying the spatial and temporal extent of refugia
Here we will assess the past, current and future changes in vegetation type, individual species distributions, and assemblage composition. We will then delineate the spatial and temporal extent of ecological and evolutionary refugia. This activity will, in part, be driven by the definitions of refugia provided in A, key milestones include:
Compilation (development) of all necessary information, vetted and then shared across all project members to ensure consistent use of best available information. This will include:
Species locality information sourced from personal and institutional data bases, public data bases like Atlas of Living Australia and from current projects affiliated to the project team.

State-of-the-art climate, terrain, soil and vegetation layers at multiple spatial and temporal scales. This will include products derived from satellite imagery (e.g., vegetation indices, temperature, fire scars from Landsat and MODIS), publicly available weather information (e.g., min & max daily temperature and daily rainfall from the Australian Water Availability Project), products held by project members (e.g., climates from present through the last interglacial (-120kybp» and products developed specifically for this project (e.g., downscaled climate, downscaled community compositional turnover from existing projects from the team). Software, scripts and methods to enable analysis of such work.

Modelling of past, current and future changes in vegetation type, individual species distributions and assemblage composition. This will be achieved using several well-established methods (Maxent, GDM, ANN) and new analytical tools developed for the project. This will enable an examination of the 'Grinnellian' (geographic) shift in species both over geological times (-120kybp), recent history (last 100 years) and future projected climates (this century). To ensure I enable such a milestone is met, project members will make use of high-performance computing platforms (supercomputers) available through the National Computational Infrastructure (NCI) or by Queensland Cyber Infrastructure Foundation (QC IF). This will include identification of refugia that offer some level of buffering or protection from (i) stress due to heat, drought and fire and (ii) fluctuations in the productivity of vegetation based habitat resources (especially food) that play a role in the persistence of species in the face of environmental variability on the scale of decades to centuries of the recent past, examining changes in weather suitable for species over the last 60 years based on work of members of the project team.

Here we will identify refugia as areas that are environmentally stable through time looking at multiple time scales covering past, present and future. The time scales here used to identify 'stability' will represent geological times (120kybp), recent history (last 60-100 years) and future projected climates; these timescales represent the scale of different evolutionary and ecological processes.