Climate Change Adaptation Research Grants Program
- Terrestrial Biodiversity Projects

Project title:
Optimal habitat protection and restoration for climate adaptation.

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Lead organisation: University of Queensland

Objectives:
Our overarching project goal is to move beyond predicting the impacts of climate change to delineating the best options for climate adaptation via optimal protection and restoration of habitat. Specifically, our objectives are to (i) predict the future distributions of habitats that are critical for long term persistence and effective adaptation to climate change of threatened terrestrial Species of National Environmental Significance, (ii) model optimal protected area placement and where necessary, restoration of critical habitats for those species most affected by a changing climate, taking into account variation in costs, benefits, and likelihoods of success, and (iii) deliver a comprehensive plan for optimal protected area creation and habitat restoration across Australia by providing spatially explicit time-slice maps of where and when habitat restoration is needed to minimize extinctions from climate change.

Project design and methods:
Distributions and compositions of entire Australian ecosystems will shift dramatically over the coming century and beyond. Existing assemblages will be disassembled and reassembled. Protected area establishment and where necessary, habitat restoration projects must be sited in places that make sense given distributional shifts that are likely to occur under future climate regimes, but we do not yet have the tools to do this. Selecting species and ecosystems on which to focus is a daunting task. At the very least, we can focus on those species already listed as threatened nationally for which consolidated distributional information and threat profiles is already available. Restoration is a particularly complex option to model, since (i) it can be very valuable for restoration of connectivity or even provide sites for assisted colonisation of future habitats that may not currently exist, (ii) it can be very expensive, (iii) this expense can be offset by rapidly evolving opportunities for carbon market financing adding a second layer of complexity to the economics of decision-making, (iv) cleared areas tend to have little existing legislative protection and do not typically attract much protected area effort and (v) there is great uncertainty about where to restore and to which state habitat should be returned. We will develop a coherent, integrated and efficient deployment of protection and restoration activity with an eye to the future distributions of species, enabling Australia's biodiversity to adapt to future climate change. Our three project objectives:

(1) Predict the future distributions of critical habitats for terrestrial Species of National Environmental Significance.
Future conservation actions must match the distribution of future critical habitat. We will predict future distributions of Species of National Environmental Significance, under different future climate scenarios, and identify critical, high suitability and likelihood of occurrence habitats within those distributions. The distinction between a species' distribution and the key habitat that requires protection is important because species are not distributed evenly across the land surface and climate adaptation plans that do not recognise this fact could direct scarce resources to the wrong places. We will separately model the future distributions of species and their habitats, and then identify places where future habitat overlaps with areas predicted to be highly suitable for species. We have already produced maps and analysis of protected area gaps for existing distributions of threatened species, but these provide an incomplete guide to effective climate adaptation, since they are based on current not future potential distributions. Using maximum entropy modelling, we will model the relationship between climate and the current distributions of threatened species in Australia using point records derived from the Atlas of Living Australia. Projecting this relationship onto seven alternative future climate scenarios we will use ensemble modelling to generate consensus models of future species distributions based on climatic suitability, edaphic and topographic predictors. Within these distributions, suitable habitat will exist in some areas and not others. We will model this using an analogous process we recently applied globally by generating predictions about the future distribution of habitat using 60 vegetation subgroups mapped by NVIS. Overlaying places where future climatic conditions are predicted to be highly suitable for threatened species onto those places where

appropriate habitat will occur in the future, we will identify candidate areas for protection and restoration for climate adaptation. The first are locations where suitable habitat will occur and the species is also predicted to be present, but where there are no protected areas. The second are locations where suitable habitat will occur and the species is also predicted to present, but from where vegetation has been cleared. In achieving this objective, we will discover the locations of candidate sites for protection and restoration under future climate scenarios for the whole of Australia. The goal is to conserve habitat for each species to recover to the point it can be safely de-listed due to reduced long-term extinction risk. By delivering a map of two major climate adaptation options (protection and restoration), we establish a foundation for action.

(2) Model optimal protection and restoration of critical habitats for species most affected by a changing climate, taking into account variation in cost, benefit, and likelihood of success

Prioritizing the establishment and restoration of protected areas involves a great many uncertain (and highly variable) costs. Similarly, the success of restoration and the expected conservation benefits of both restoration and preservation are generally highly uncertain, making optimization of investment in conservation via restoration a difficult proposition. Nonetheless, incorporating this variability and uncertainty into plans for climate adaptation is critical because ignoring such uncertainties will result failure to meet objectives, disappointment in prioritization and conservation processes, and possibly avoidable extinctions. To derive optimal investment strategies for protecting and restoring critical habitats for species most affected by a changing climate, we must first synthesize existing information about the costs, benefit, and likelihood of success of a suite of possible restoration and protection options. Moreover, quantifying the variation in, and uncertainty about those key decision variables is a critical step in developing robust prioritization strategies for climate adaptation. A key innovation of this project is the development of probability surfaces representing the chance a given restoration approach will be successful in a given location based on statistical models that synthesises restoration success data. This builds on existing work by the research team in quantifying restoration success probabilities using Bayesian Belief Networks. The integration of broadly mapped restoration success probability estimates is a critical, yet novel aspect of this research that will advance climate adaptation and improve conservation planning by factoring in a key element of uncertainty. Because predictions about expected benefit, probability of success and conservation costs tend to be highly uncertain, the role of a coherent uncertainty analysis approach to prioritization will be paramount in this and the next stage of the project.

(3) Deliver a comprehensive plan for optimal protection and restoration across Australia by providing spatially explicit maps of where and when habitats need to be protected or restored to minimize extinctions from climate change

Protection and restoration will be crucial tools as we adapt to climate change, because they restore functionality to landscapes by maintaining or increasing protected habitat area, quality, and connectivity. But how should we implement these actions across a climate-affected landscape? Because these adaptation activities will occur in a mosaic of land uses, many of which are contrary to conservation objectives, effective adaptation will need an to resolve conflict between activities and identify the outcomes of trade-offs to balance these competing interests. Using the candidate sites for restoration and protection generated by objective (1), and the models for optimal restoration developed in objective (2), we will use Marxan with Zones to prioritise the allocation of restoration and protection across future landscapes. Successful climate adaptation will depend a combination of these activities, but they have very different cost benefit implications across space. We will evaluate four management zones, namely (i) protection by purchase and gazettal as a protected area without restoration, (ii) protection without purchase through covenants without restoration, (iii) passive restoration and (iv) active restoration both secured by protection without purchase through covenants, specifying that a proportion of each threatened species' future distribution is overlapped by high quality habitat. Because our prioritisation allows for some zones to contribute more to achieving conservation targets than others, we will use probability of success measures modelled in objective (2) to weight the benefit of each zone. We will compare the results of the prioritisation analysis with those of existing corridor conservation projects across Australia, and also explore ways of minimising the geographic distance over which species and habitats muct move to coincide with climate adaptation measures. The third component of this project will deliver a comprehensive plan for optimal protection and restoration across Australia by providing spatially explicit maps of where and when habitat protection and restoration are needed to minimize extinctions from climate change.