Climate Change Adaptation Research Grants Program
- Terrestrial Biodiversity Projects

Project title:
The architecture of resilient landscapes: scenario modelling to reveal best practice design principles for climate adaptation.

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Lead organisation: CSIRO

Objectives:
- To identify overarching design principles for biodiversity management in multi-use landscapes that
  a. maximise population size & resilience of native species & reduce those of invasive species
  b. are likely to accomplish the above regardless of the type of ecosystem, precise effects of climate change on native vegetation, & degree of future change in land use
- In the process, to develop new integrated approaches to modelling vegetation community change & associated species' responses
- To work with practitioners to ensure design principles are practical to implement & are used to improve adaptation management in the Great Eastern Ranges (GER) Initiative

Project design & methods:

STEP 1 Develop design principles: Several landscape-scale conservation projects are underway in Australia each of which is underpinned by a set of design principles that are considered socially and economically feasible to implement. However, because design principles are more conceptual than management actions, practitioners are often not explicit about the design principles they rely on. For example, one design principle may be to improve habitat quality adjacent to existing protected areas, yet practitioners may talk about management actions such as fencing and grazing management. Thus, we will elicit design principles currently in use based on practitioners' responses to hypothetical design questions. Samantha Low Choy from QUT has been pioneering elicitation of experts' underlying conceptual models (Low Choy et al. 2010), and will lead this unique component of the project. We anticipate that the list of design principles will include increasing the extent of protected native vegetation (i.e., increasing the National Reserve System), increasing habitat quality through both on and off-reserve management, increasing landscape connectivity, and various combinations of the above implemented in both an opportunistic fashion (randomly across the landscape) as well as based on simple spatial prioritisation rules.

STEP 2 Develop scenarios: Conservation management needs to maximise benefits for biodiversity in *future* multi-use landscapes, but we are uncertain what those future landscapes will be like. Thus, we need to develop plausible scenarios of future change to incorporate such uncertainty in our modelling. We will convene a cross-disciplinary panel to develop a realistic set of scenarios for native vegetation and land-use change under climate change. The panel will include experts in ecology, agricultural land-use change, carbon sequestration, governance issues, and practical on-ground implementation. Panel members will include authors of recent analyses of land-use change under climate change (e.g., authors of Polglase et al. 2008 and Nelson et al. 2010 as well as a proposed PI ARGP Project). An example of a scenario might be native vegetation change associated with CSIRO mk3.5, 2050, A1FI, high sensitivity climate projection (a business-as-usual scenario) plus a 30% increase in cropping and a 15% increase in farm forestry for carbon sequestration with the latter two changes occurring only in lower elevation parts of the landscape.

STEP 3 Model current vegetation: To model landscapes in the future based on scenarios of change, we must first construct models of the landscapes as they are now. We will do this by integrating Generalised Dissimilarity Modelling (GDM; Ferrier et al. 2007) with vegetation maps/species records in three case-

study landscapes of several thousand km^2, some of which are partnership regions in the Great Eastern Ranges (GER) Initiative. GDM models compositional dissimilarity and thus whole ecological communities rather than individual
species, allowing for continuous variation across a landscape. The result is a map showing where species compositions should be similar to each other and where they should be different, without specifying what the ecosystems or species are. Thus, we will also incorporate up-to-date vegetation mapping and species records, including land uses, into the modelling process so we will be able to relate components of the GDM maps to particular ecosystem types (e.g., grassy woodlands, dry sclerophyll forests, agroforestry, etc.). Kristen Williams (CSIRO) has already performed GDM modelling for most of the GER as well as the Australian continent and will lead this component of the project along with Simon Ferrier, the original developer of the technique.

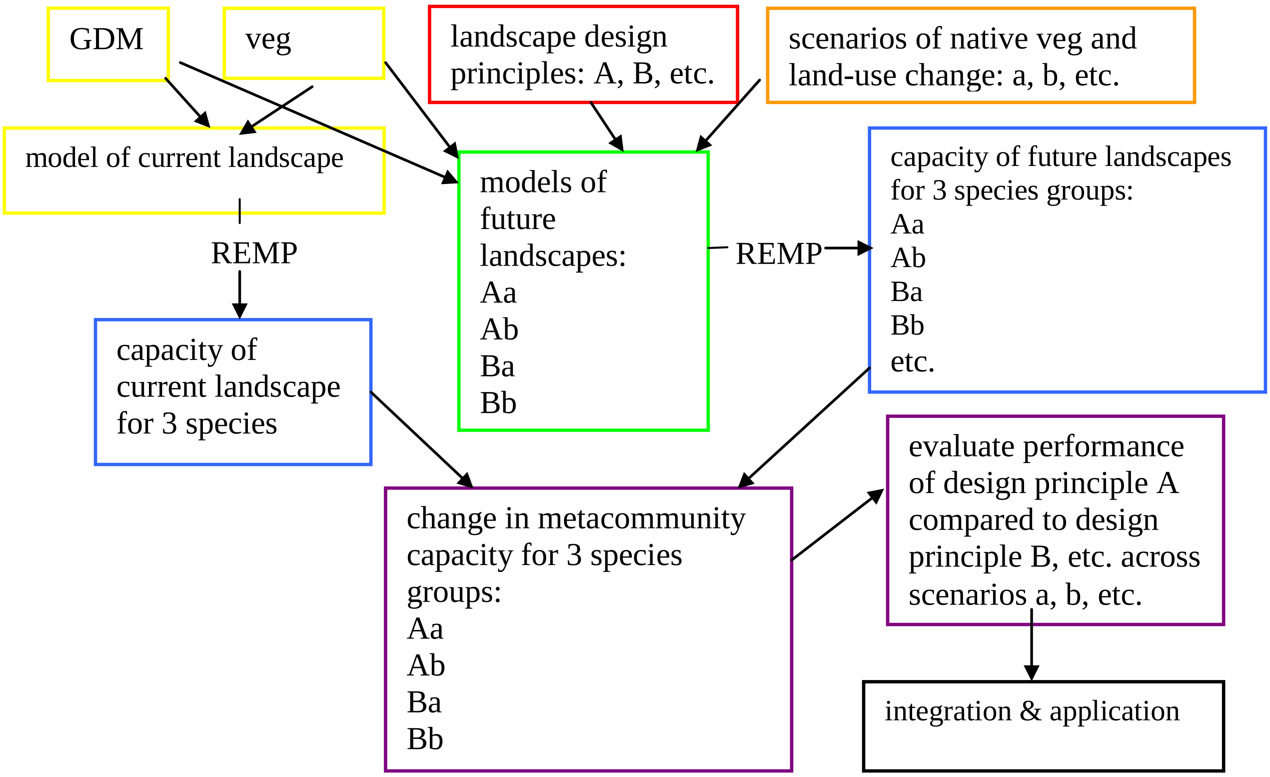

Figure 1. Flow diagram showing the key steps of the project and how they interact. Step 1 is shown in red, step 2 in orange, step 3 in yellow, step 4 in green, step 5 in blue, step 6 in purple, and steps 7 & 8 in black.

STEP 4 Model future vegetation and land use based on scenarios: We can then model how these landscapes will potentially change in the future based on our climate and land-use scenarios as well as conservation management based on our different landscape design principles (e.g., increasing habitat extent, etc.). The result will be a series of models of future vegetation in each case-study landscape with several models for each landscape design principle, each of which incorporate different climate and land-use change predictions. Land-use change and the effects of conservation management will be modelled by selecting portions of the landscapes and altering their composition, for example from pasture to agroforestry. We will model the effect of climate projections on native vegetation using characteristic dominant species and knowledge of plant physiology. These two approaches will then be merged to produce future landscape models. Kristen Williams will lead this component of the project with Mike Austin as they have an existing collaboration incorporating plant-based ecological processes into large-scale ecological and planning models.

STEP 5 Calculate landscape capacity to support species groups associated with each scenario: Scenario-based models of future landscapes give an indication of what future landscapes might look like, but do not provide a measure of how such changes will impact the resilience of native species. To do that, we will expand on a new technique called Rapid Evaluation of Metapopulation Persistence (REMP; Drielsma & Ferrier 2009). In REMP, a landscape vegetation model is related to habitat suitability and movement permeability for a particular species, which then permits the computation of the metapopulation capacity (i.e., total predicted population size and number of different populations) of that landscape for that species. However, maximising resilience of native ecosystems for climate adaptation depends on maximising metapopulation capacity for whole communities of species – 'metacommunity capacity'. The REMP approach can be extended to take a significant step in this direction by modelling groups of species that respond to landscapes in similar functional ways (see Doerr et al. 2011), rather than just individual species. We will use a Bayesian framework to combine data and expert opinion to specify two functional groups of native species considered particularly susceptible to climate change and one group of invasive species, then specify habitat suitability and movement permeability information for these species groups. We can then use REMP to calculate the capacity of current and future landscapes to support each functional group. While expert opinion will play a strong role in specifying which functional groups we model, we anticipate that one is likely to be sedentary territorial woodland species (e.g., small woodland birds and mammals) while another is likely to involve native plants. This component of the project will be jointly led by Michael Drielsma, the original developer of REMP, and Erik Doerr, who has particular expertise in landscape permeability and species' functional responses to multi-use landscapes.

STEP 6 Evaluate which design principle(s) are best across all scenarios and all landscapes: For each potential future landscape, we will calculate the difference between its capacities to support species groups and those of the current landscape. Successful design principles will be considered those that increase capacity to support native species groups and maintain or decrease it for the invasive species group. However, to be robust to uncertainties in climate and land-use change, a design principle must be successful for all scenario-based future versions of that landscape. Furthermore, to have general applicability, a design principle must be successful and robust as describe above across all three of our case-study landscapes. We will evaluate whether any design principles are so globally successful. If not, we will explore whether some are successful for particular species groups, particular ecosystem types, or particular scenarios of future change, such that rules-of-thumb could be defined for achieving best-practice climate adaptation.

STEP 7 Work with practitioners to apply design principles and develop information packet: Finally, we will work directly with on-ground practitioners in the case-study landscapes to develop specific strategies to implement our best-practice design principles. Practitioners will contribute extensive local and practical knowledge to identify the specific on-ground actions (e.g., weed management, strategic grazing, etc.) that can be used to achieve particular design principles (e.g., increase habitat quality). This approach will form the basis of an information packet on practical landscape-scale conservation for climate adaptation, the content and structure of which we will develop in concert with practitioners to ensure it meets their needs.