10. Conservation planning for a changing climate

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Abstract

A crucial objective for the selection and spatial design of conservation areas is to promote the adaptation of species and natural processes to changing climates.

Key considerations include:

- New patterns and combinations of threats;
- Adjustment of conservation targets to account for climate-related issues; and
- Identification, protection and/or restoration of climatic gradients to promote spatial adjustments by species.

These issues are discussed with examples from regional planning in South Africa. The paper ends with a list of unresolved issues that need to be addressed if conservation planning is to deal effectively with climate change.

Introduction

Conservation planning is the process of locating, configuring, and maintaining conservation areas, areas of land, sea or freshwater that are managed for the persistence of natural values. This management includes strict reservation, a wide variety of off-reserve mechanisms, and restoration. Systematic conservation planning (Margules & Pressey 2000) identifies configurations of complementary areas that achieve explicit, and generally quantitative, objectives.

Since its origin in the early 1980s, systematic conservation planning has influenced decisions by major organisations such as The Nature Conservancy (Groves *et al.* 2002), shaped policy, legislation and conservation on the ground (Knight *et al.* 2006), and has featured in well over 200 presentations at meetings of the Society for Conservation Biology.

The field's hundreds of publications reflect not only advances in ideas, techniques and relevance, but also its short history and main limitations (Pressey *et al.* 2007). Most publications concern biodiversity pattern, that is, the elements of biodiversity that can be mapped and regarded as static (Pressey 2004). Planners have done less well at promoting the persistence of the myriad ecological and evolutionary processes that maintain and generate biodiversity (Balmford *et al.* 1998). Most systematic methods have also assumed implicitly that threats to biodiversity are absent or static (Pressey *et al.* 2004). Previous losses of biodiversity might be recognised, even perhaps the legacies of continuing loss from past threats, but the rates and patterns of dynamic threats have often not been anticipated. These limitations are being addressed, but still present important challenges to conservation planners.

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The context for conservation planning as a response to climate change is shaped by several considerations:

- The need to deal with uncertainties in predictions of climatic changes, species adjustments to these changes, and the effectiveness of planning responses;
- The potential for conservation planning to address not just adaptation but also mitigation (e.g. carbon sequestration, carbon trading, planting for biofuels); and
- Limitations on resources and space that require conservation planners to make difficult choices between conflicting conservation objectives because not all can be achieved.

Three broad aspects of conservation planning are relevant to adaptation to climate change: (1) spatial design, or the configuration of individual conservation areas and whole systems of conservation areas; (2) the application of conservation mechanisms, recognising constraints and opportunities related to tenure, land use, budgets and other factors; and (3) management, or the maintenance and monitoring of established conservation areas, recognising progressive changes within and outside these areas (e.g. fire, weeds, surrounding land uses).

Spatial design for climate change

This short paper outlines some aspects of the selection and spatial design of conservation areas to promote the adaptation of species and natural processes (Pressey *et al.* 2007) to changing climates. There are several important issues for selection and design.

First, conservation planning must address new patterns of threats (e.g. projected rises in sea level, spatial changes in agricultural suitability) and new combinations of threats (e.g. altered fire regimes combined with the spread of invasive species).

Second, conservation targets the quantitative interpretations of conservation objectives (e.g. hectares of each vegetation type, numbers of populations of rare species), will need to be adjusted to account for climate-related issues. Some of these are: altered vulnerability of species to new threats; population sizes required for genetic adaptation to climate and associated changes; and identification of populations within the ranges of species that might be pre-adapted to make the required changes for genetic adaptation and shifts in distributions.

Third, is the need for identification, protection and/or restoration of climatic gradients to promote spatial adjustments by species. These gradients vary in steepness (change in climatic parameters per horizontal kilometre). Very steep, short gradients are likely to be easiest to maintain. Long gentle gradients are likely to present serious difficulties in many regions.

Examples of spatial design for climate in South Africa

Some examples of spatial design for climate change come from an exercise in conservation planning in the Cape Floristic Region of South Africa, a global biodiversity hotspot (Fig. 1). The planning exercise targeted parts of the region believed to be important for promoting the adjustment of species distributions to a changing climate (Cowling *et al.* 2003; Pressey *et al.* 2003). These included major riverine corridors crossing mountain chains to allow dispersal and provide climatic refugia, upland-lowland gradients (Fig. 1a), and macroclimatic gradients (Fig. 1b). The approaches in the Cape region were refined during later work in the Thicket Biome of South Africa (Fig. 2a) with the design of major conservation corridors (Fig. 2b) based on climatic gradients, representation of vegetation types and species, existing protected areas, threats, constraints, and opportunities for conservation (Rouget *et al.* 2006).

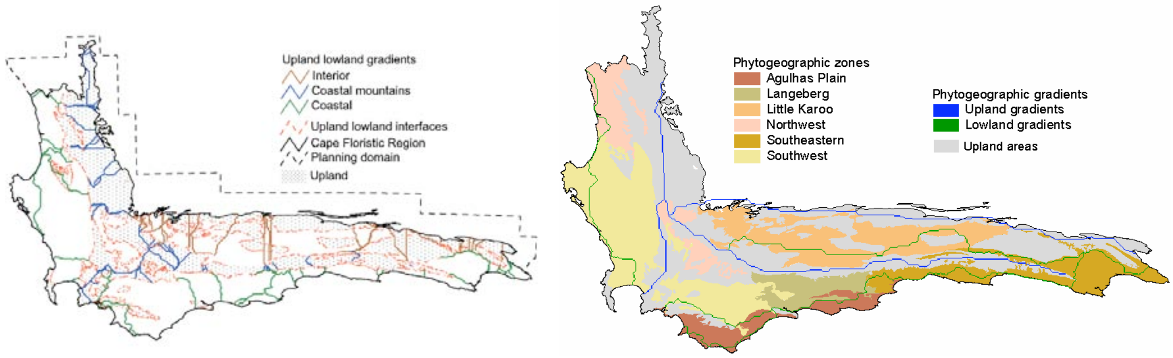

Fig. 1. (a, left) Upland to lowland environmental gradients in the Cape floristic region of South Africa; and (b, right) Macroclimatic or phytogeographic gradients (reprinted with permission from Blackwell Publishing)

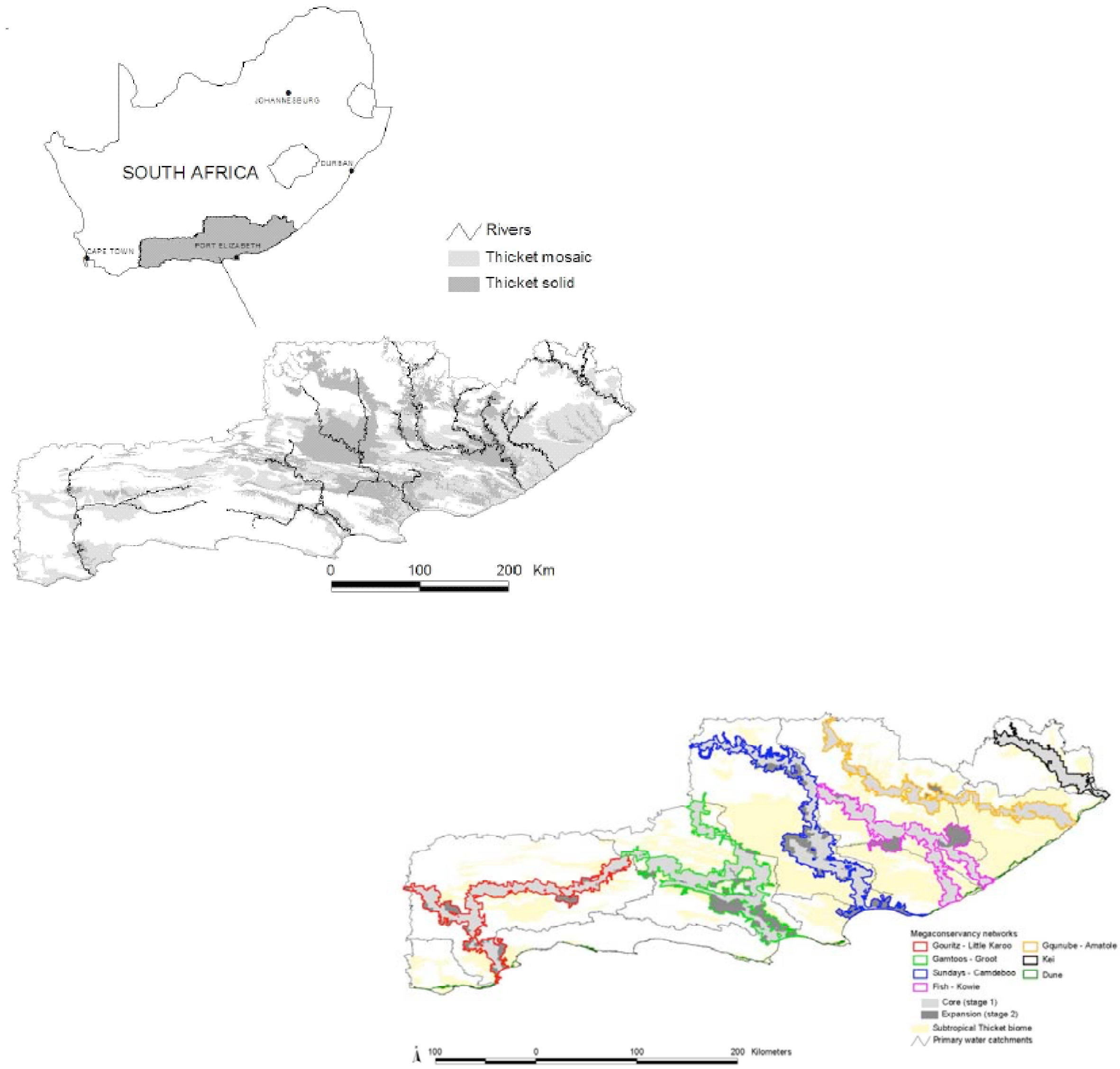

Fig. 2. (a, top) The Thicket Biome of South Africa; (b, bottom) Large-scale conservation corridors in the Thicket Biome designed to achieve several conservation objectives, including promoting the adjustment of species distributions to climate change (reprinted with permission from Blackwell Publishing).

Other aspects of spatial design are now also receiving attention. For several reasons, much of this work has also focused on the Cape Floristic Region. The reasons include its global significance for biodiversity, narrow endemism of many plant species, steep climatic gradients, and very good biological data, at least for some plant groups such as the Proteaceae. Williams *et al.* (2005) addressed the problem of species-specific design for climate change, recognising predicted range shifts each decade, dispersal distances per decade, and the need to plan for adequately connected patches of native vegetation to allow for range shifts.

Planning ahead for climate change

Hannah *et al.* (2007), working both in the Cape and Mexico, demonstrated the efficiencies of planning ahead for climate change, rather than planning for biodiversity patterns as they are now and then later adding further conservation areas to deal with range adjustments. Work is also underway to understand how patch dynamics such as fire (Syphard *et al.* 2006) and coral bleaching (Hughes *et al.* 2007) might respond to climate change and how the spatial design of conservation areas will need to take these altered dynamics into account.

Some remaining challenges for selection and spatial design include:

- The variable effectiveness of corridors or spaced patches of native vegetation along climatic gradients in terms of dispersal rates of species and the possible need for translocating plants and animals;
- The variable effectiveness of corridors or spaced patches of native vegetation along climatic gradients in terms of their inherent suitability for dispersal interacting with the effectiveness of management mechanisms and restoration;
- Important questions about how planners should respond to the inevitable uncertainties of predicting the directions and magnitudes of climatic changes and biological responses;
- The need to address spatial design for climate change in generalised ways because actual responses to climate change can be predicted only for a small minority of species;
- The inevitable lateral gaps between corridors or sequences of patches of native vegetation along climatic gradients mean that not all species will be located near them and have access to them, especially in regions, such as the Cape Floristic Region and South-Western Western Australia, that have many localised endemics;
- The need for difficult tradeoffs between multiple conservation objectives, of which design for climate change is only one, competing for limited resources and space (Pressey *et al.* 2007). These tradeoffs are exacerbated by the need to commit substantial resources to protect or create entire corridors or sequences of patches of native vegetation that are functional for species range shifts.

There is considerable potential to address these challenges in Australia and to develop and implement planning approaches here that promote the persistence of biodiversity in the face of climate change.

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