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Biome stability and long-term vegetation change in the semi-arid, south-eastern interior of South Africa: A synthesis of repeat photo-monitoring studies

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ABSTRACT

We synthesize recent literature concerned with the nature, extent and rate of vegetation change in the Albany thicket, Grassland and Nama-karoo biomes of the semi-arid, south-eastern interior of South Africa at a range of spatial and temporal scales in relation to local and global drivers. The change in cover of three main growth forms (grasses, dwarf shrubs [<1 m] and tall shrubs [>1 m]) at the community, ecotone and biome levels was analysed using field surveys and repeat photography spanning 27 to >100 years. There has been an increase in grass and tall shrub cover and a decrease in dwarf shrub cover across the region over time. Vegetation composition and cover has been most stable in the Albany Thicket biome while Azonal habitats across the region have changed the most. The Grassland biome has experienced a significant increase in the cover of grasses and tall shrubs and a significant decline in cover of dwarf shrubs. Total cover and the cover of grasses have increased significantly in the Nama-karoo biome. We interpret these patterns as evidence for a south westwards shift in the Grassland/Nama-karoo biome boundary in the second half of the 20th century. Although there has been relatively little change in the boundaries between the Albany Thicket and adjacent biomes, several species with subtropical biogeographic affinities have increased in cover and abundance over this period in all biomes investigated. Drivers of the observed changes include rainfall amount and seasonality, temperature, land use and elevated CO_2 concentrations in the atmosphere.

1. Introduction

Significant changes in vegetation cover and composition are predicted at a range of spatial scales throughout the world due to shifts in climate and land use, as well as to rising concentrations of CO_2 in the atmosphere (De Baan et al., 2013; Ellis, 2011; Leadley et al., 2010). How likely are these predictions, particularly since future projections are based on an imperfect understanding of the environment? And how can we evaluate these scenarios (e.g. Midgley et al., 2008) which have an important influence on environmental policy and conservation management? One approach is through an analysis of the historical trajectories of environmental change which provides the ecological cornerstone for the assessment of future projections (Costanza et al., 2012). Knowledge of the past is necessary to define starting conditions and establish the direction and rate of change over time, including the interactions and feedbacks at multiple spatial and temporal scales (Leuzinger et al., 2011; Luo et al., 2011). This enhances our ability to predict the likelihood of extreme events and develop strategies for minimizing their impacts as we grapple with global change (Peters et al., 2004). It is only by integrating all aspects of environmental change through space and time that we can understand and disentangle these intricacies (Peters et al., 2006).

Here we synthesise the results of three recent studies investigating the long-term historical changes in the vegetation of the semi-arid, south-eastern interior of South Africa (Fig. 1). In this region different biomes and vegetation types (Mucina and Rutherford, 2006) occur on a range of land forms and interact along gradients of temperature and moisture in response to different types and intensities of land use. The biomes of the semi-arid, south-eastern interior, which include the Albany thicket, Grassland and Nama-karoo as well as several azonal habitats, were ranked amongst the least-protected ecosystem types in South Africa's recent national biodiversity assessment (Driver et al., 2012). The Grassland biome, in particular, is classified as a highly threatened terrestrial ecosystem type which has suffered substantial loss of habitat over the last 100 years. Azonal habitats, which usually comprise either perennial or ephemeral riverine ecosystems, are also highly

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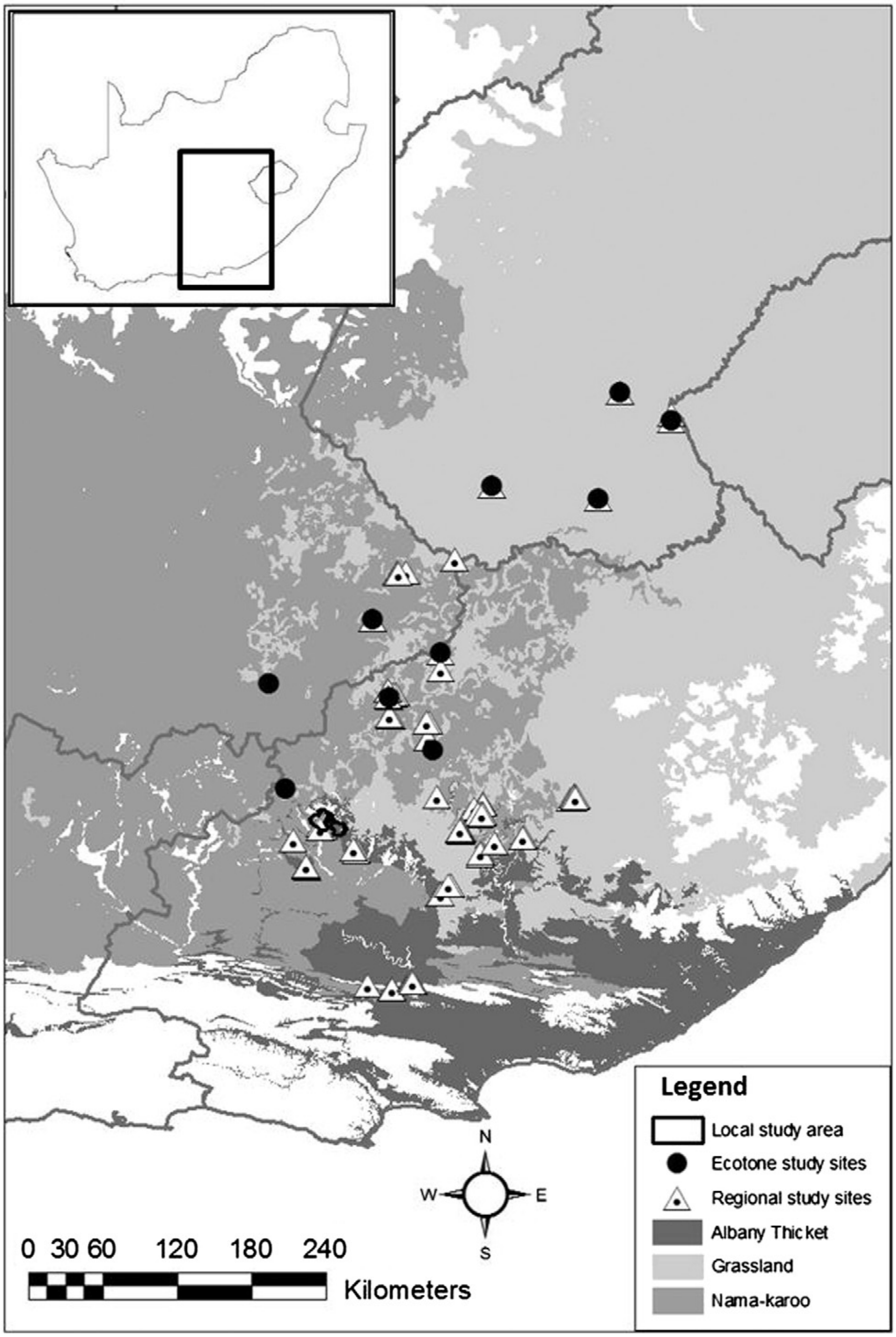

Fig. 1. The semi-arid, south-eastern interior of South Africa showing the location of the sites used for the local, ecotonal and regional studies (see Masubelele et al., 2013, 2014, In Press).

transformed and largely unprotected and therefore threatened in the study area.

This region is also expected to undergo significant change in the future in response to changes in climate, land use and an increase in atmospheric CO_2 concentration. For example, an increase in temperature and drought frequency associated with a decline in rainfall is predicted to increase aridification in the region resulting in a loss of cover and a deterioration of the vegetation particularly in the Grassland and Nama-karoo biomes (Driver et al., 2012; Ellery et al., 1991). Dominant plant growth forms, vegetation types and the boundaries of these two biomes in particular are expected to change accordingly depending on whether they occur on slopes, plains or along riverine habitats. For example, the Nama-karoo biome is predicted to contract from the west and shift north eastwards into the Grassland biome in response to a combination of aridification and rising CO_2 concentrations (Ellery et al., 1991; Midgley et al., 2002, 2008; Rutherford et al., 1996). The Grassland biome is expected to contract further as a result of the spread of savanna trees favoured by the projected increase in temperature and CO_2 concentration (Midgley and Thuiller, 2011). The projected direction of change for the Grassland and Nama-karoo biomes in response to future changes in temperature and rainfall is very similar to that proposed by Acocks (1953) in response to overgrazing by domestic livestock. The expansion of the Albany Thicket biome since the Last Glacial Maximum (Potts et al., 2013) and projected future increase in temperature and associated decline in frost events in the region (Duker et al., 2015) suggest that arid, but probably not mesic thicket elements of this biome, will