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Vegetation changes (1995–2004) in semi-arid Karoo shrubland, South Africa: Effects of rainfall, wild herbivores and change in land use

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Abstract

Degradation in semi-arid Karoo rangelands has been ascribed to over-utilization by livestock and variations in rainfall regime. The understanding of vegetation dynamics in confined plant–herbivore systems is hampered by the difficulty in uncoupling biotic and abiotic determinants of vegetation change, and a paucity of long-term studies. Vegetation change in permanent fenced and open plots in Karoo National Park was monitored over 10 years, largely falling within a high rainfall phase. Herbivore pressure more than tripled during this period with notable increases in the larger ungulates and ostrich. No clear correlation could be established between rainfall and vegetation parameters. Rangeland condition improved and species richness increased over time. Annual grass cover decreased and perennial grass cover increased with time following a change in land use from small-stock farming to conservation and reintroduction of wild ungulates. Changes were more rapid in exclosures than in areas exposed to herbivory. Rangeland condition was closely correlated with canopy spread cover. To differentiate rainfall-induced fluctuations from directional changes in vegetation dynamics caused by herbivory, monitoring needs to be conducted for extended periods that include various rainfall cycles. The value of vegetation monitoring

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would be greater if additional data were collected to measure persistence of uncommon species.

Keywords: African wild herbivore; Herbivore exclosure; Plant functional type; Protected area; Vegetation monitoring

1. Introduction

Degradation in the world's arid and semi-arid rangelands is a widespread phenomenon and has often been attributed to over-utilization by livestock (Walker et al., 1981; Sundquist, 2003). Shifts in vegetation composition in arid and semi-arid rangelands have been conceptualized to occur either in predictable directional sequences (succession theory; Clements, 1916), in cycles according to natural oscillations in abiotic factors (cyclic models; Roux, 1966; Novellie and Strydom, 1987; Hoffman and Cowling, 1990; Palmer et al., 1990; Wiegand et al., 1998), or unpredictably in response to stochastic events (non-equilibrium theory and state-and-transition models; Ellis and Swift, 1988; Westoby et al., 1989; Behnke et al., 1993; Milton and Hoffman, 1994; Milton et al., 1994; Sinclair, 1995). Milton et al. (1994) described rangeland degradation as a stepwise process, whereby vegetation composition in pristine rangeland is mostly determined by climatic factors. When degradation, caused by intensive herbivory, sets in, it initially affects plant population demography, upon which diversity and productivity start to decline. Thereafter a reduction in perennial plant cover facilitates the establishment of ephemeral and weedy species. Ultimately vegetation cover is lost and geohydrological processes severely altered.

Rangeland degradation and the declining ability of rangelands to support livestock has been a major concern of land managers in southern Africa for some time, particularly in the Karoo biome (Acocks, 1953; Dean and Macdonald, 1994; Milton and Dean, 1995; Hoffman et al., 1999). The composition of the semi-arid rangelands of the Karoo is presumed to have changed in response to ranching with a narrow suite of domesticated herbivores (Roux and Vorster, 1983; Hoffman, 1991). Shifts to vegetation assemblages dominated by unpalatable (i.e. toxic and spinescent) woody plants have been observed (Milton, 1994; Rohner and Ward, 1997; Riginos and Hoffman, 2003), as well as the replacement of perennials by shorter-lived species (Todd and Hoffman, 1999), making the supply of forage less reliable, particularly during droughts (Milton et al., 1994).

Changes in rangeland composition have further been linked to rainfall amount and seasonality (Milton et al., 1995; O'Connor and Roux, 1995). Differential responses of growth forms to rainfall seasonality have been suggested for the grassy dwarf shrubland vegetation of the Karoo, where spring and summer rainfall promoted the growth of grasses while autumn and winter rainfall promoted the growth of dwarf shrubs (Roux, 1966; Roux and Vorster, 1983). However, subsequent studies yielded inconsistent results, indicating that vegetation structural