LAND DEGRADATION & DEVELOPMENT

Land Degrad. Develop. **10**: 225–239 (1999)

RESILIENCE OF SOUTH AFRICAN COMMUNAL GRAZING LANDS AFTER THE REMOVAL OF HIGH GRAZING PRESSURE

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Received 25 March 1998; Accepted 14 September 1998

ABSTRACT

A paired site study was conducted of communally grazed eutrophic and dystrophic grasslands and adjacent ungrazed areas of varying periods of exclusion from communal grazing. This allowed determination of the rate and extent of change of a number of vegetation and soil variables following the removal of high and continuous grazing pressure characteristic of communal lands. Similarity indices for grass species composition between the grazed and adjacent ungrazed areas showed a significant exponential decrease with increasing time since protection from continuous grazing. Most change in grass species composition occurred within four to nine years of protection from communal grazing in eutrophic grasslands, and in six to nine years in dystrophic grasslands. In both grassland types palatability increased with time since protection. In eutrophic sites the abundance of perennials showed a significant increase with time since protection, while the abundance of annuals showed a concomitant decrease. This relationship was not evident in dystrophic grasslands. Grass species diversity, basal cover and density showed no relationship with time since protection in the eutrophic sites, but a general increase with time since protection was found in dystrophic sites. Soil bulk density, field capacity, pH and soil nutrients showed no evidence of a relationship with time since protection for either grassland type, while soil porosity increased significantly with time since protection at eutrophic sites, but not dystrophic sites. These relatively rapid changes following the removal of the high grazing pressure indicate that these systems are characterized by relatively high resilience. Copyright © 1999 John Wiley & Sons, Ltd.

KEY WORDS: communal; degraded; protected; rapid change; resilience; South Africa

INTRODUCTION

Several researchers have commented on the tendency of past and present state authorities in southern Africa to describe communal grazing lands as unproductive, degraded and beyond recovery (Boonzaier, *et al*., 1990; Dahlberg, 1993; Scoones, 1993; Shackleton, 1993; Sullivan, 1996). Invariably 'overstocking' and hence overgrazing are deemed to be responsible for the apparent degradation. Despite this official perspective, most communal lands have continued to support large numbers of domestic animals for several decades without major fluctuations in numbers except during droughts (Scoones, 1993; Shackleton, 1993; Tapson, 1993). This apparent discrepancy has considerable policy implications in a variety of areas, including land tenure, land usage, conservation ethics, and recommended agricultural stocking rates, all of which have a bearing on the economic welfare and sustainable livelihoods of rural communities. For example, the current land reform process in South Africa (see De Wet, 1997 for an overview) requires communities to commit themselves to adherence to livestock stocking levels recommended by the Department of Agriculture. Failure to do so jeopardizes the award of a government financial seed grant. Yet these recommended stocking levels are conservative, and are set for commercial beef enterprises, not multipurpose systems such as communal lands (Shackleton, 1993, 1998). Moreover, the value of the seed grant is too low, making it necessary for people to club together to raise sufficient capital for the purchase and development of land (De Wet, 1997). With many

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Contract grant sponsor: FRD Grant, Wits Senior Bursary and Wits Rural Facility Research Funds.

CCC 1085–3278/99/030225–15$17·50

households seeking to own livestock, it is inevitable that the clubbing together will lead to high livestock densities, even if that was not the original intention.

There is little empirical evidence concerning the stability and resilience of communal lands in southern Africa to support the notion that these systems are in danger of imminent collapse (Dahlberg, 1996). Previous work indicates that in mesic and high rainfall grasslands no significant, or very little, difference exists between communal lands and adjacent management systems (Du Toit and Aucamp, 1985; Venter, *et al*., 1989). In contrast, results from arid environments have shown changes in species composition; replacement of perennials with annuals; and replacement of palatable species by unpalatable ones (Kelly and Walker, 1976; O'Connor and Pickett, 1992; Parsons, *et al*., 1997). However, these studies have not indicated the permanence, or reversibility, of the measured changes, and the magnitude of grazing effects is usually minor relative to interannual rainfall effects (O'Connor, 1985; O'Connor and Roux, 1995).

Additionally, the interaction of rainfall and grazing effects means that relative differences between land uses are not static, and should therefore be monitored over a period of time, rather than by a snapshot comparison (O'Connor and Roux, 1995; Dahlberg, 1996). Other studies have demonstrated that heavily grazed African grasslands are remarkably resilient (Ellis and Swift, 1988; McNaughton, 1979; Mentis and Tainton, 1981), and that changes induced under continuous and high stocking rates appear to be transitory and readily reversible to the previous, or some other, state (McKenzie, 1982). Despite this, the perception persists that such areas are degraded, prompting several authors (e.g. Behnke and Scoones, 1993; Dahlberg, 1996; Shackleton, 1993) to argue that aspects of the stability and resilience of all grazing systems require greater empirical investigation, especially within the framework of current state-and-transition models and disequilibrium dynamics.

Of concern to the above debates and rangeland managers is the actual rate of change of supposedly degraded communal grasslands to some other state after the removal of the driving pressures (Walker, *et al*., 1997), i.e. a quantitative measure of resilience. The nature of the new state may be difficult to predict in event-driven systems (Westoby, *et al*., 1989), but given that communal lands are viewed as degraded, interventions (usually destocking) assume that there will be a shift to a state with more desirable traits, otherwise why would any intervention be expounded at all? In particular, do changes occur rapidly, within the time span that most managers operate, or do they span several decades, thereby having little immediate practical value, i.e. how resilient are these grazing systems? This has management and policy implications for the notions of degradation and rehabilitation of communally managed areas.

Consequently, the aim of this study was to determine the rate of change of communal grazing lands released from high and continuous stocking by studying the rate and extent of change of a number of vegetation and soil variables, and furthermore, to determine which environmental factors influence the rate of change.

METHODS

A fencelike contrast study was conducted between September 1992 and January 1993 at eighteen sites throughout South Africa; nine in eutrophic grasslands (locally termed sweetveld) and nine in dystrophic grasslands (locally termed sourveld), according to the veldtype classification of Acocks (1988). Sweetveld is generally located at low altitudes receiving less than approximately 700 mm rainfall per year, and is usually within the savanna mosaic, so woody elements are present. Sourveld is commonly found at higher altitudes with cooler temperatures and higher rainfall (Tainton, 1984a), although there are exceptions to these general guidelines. In this study, the sweetveld sites were within the range of mean annual rainfall of 580–680 mm, and the sourveld sites in the range of 750–900 mm. Most of the sweetveld sites were situated within the lowveld areas of Northern Province, Mpumalanga and KwaZulu–Natal. The sourveld sites were in KwaZulu–Natal and the Eastern Cape. The protected sites had become so for a range of reasons, but most were associated with the establishment and fencing of infrastructure such as a police station, a graveyard, an agricultural scheme, and the like.

At each site a boundary fence was located that separated a current communal grazing land (CGL) from an area that had previously been a communal grazing land (for at least 15 years) but was now protected from communal management (PGL). In some instances the PGLs supported livestock, but at negligible stocking rates. Sites were selected to provide a range of ages, or elapsed time since protection (0·5–25 years), which allowed for comparisons of changes in biotic and abiotic attributes within PGLs with time since protection.

At each site a pair of 40 m × 50 m plots were sited approximately 25 m from the boundary fence (to avoid edge effects), one in the CGL paired to one in the PGL. Within each plot 100 points were distributed between 10 transects. At each point we recorded the distance to the nearest grass plant, and from this to its nearest neighbour and the basal circumference of both tufts. From these data we calculated grass species composition, percentage grass basal cover and grass density.

The tuft circumference measurements from all sweetveld and sourveld sites were pooled separately to construct grass tuft size distributions for the PGL and CGL respectively. Differences were assessed using a chi-square test.

The similarity in species composition between the paired plots was calculated using a percentage similarity index (P)(Krebs, 1989). This measure of similarity required the abundance of each species to be expressed as a percentage of the total abundance. The higher the value of P the greater the similarity in species composition between the paired PGL and CGL. The similarity indices of sweetveld and sourveld sites were plotted against time since protection, and exponential curves were fitted using SAS (1985) together with the 95 per cent confidence intervals. Exponential curves were fitted to test the null hypothesis that the grass species composition of the PGL remained similar to that of the CGL with time since protection.

Grass species diversity was calculated for each plot using Simpson's index of diversity (Krebs, 1989). Additionally, the grass species in each plot were characterized as palatable or unpalatable using the classifications of Shackleton (1991), Van Oudtshoorn (1992) and Van Rooyen, *et al.* (1990), and perennial or annual (Gibbs Russell, *et al.*, 1990; Van Oudtshoorn, 1992), although it is recognized that there is considerable ecotypic variation for both these traits over the large geographic area of this study. The abundance of species in each of the above categories was then summed for each plot.

Soil bulk density was measured at three points per plot. At each point a small hole was dug and the excavated soil was ovendried (80 °C) and weighed. A sheet of polyurethane (plastic) was moulded into the hole surface and covered with water, the volume of which was measured. Bulk density was then calculated as mass/volume (g ml^{-1}). Five replicate soil samples were collected from the upper 10 cm of each plot, mixed, ovendried (50 °C) and sieved. Soil porosity was calculated by adding water to a known volume of soil until a film of water formed on the soil surface. The volume of water added was recorded and the saturated soil water content calculated as being the equivalent to soil porosity (McIntyre, 1974). Maximum water holding capacity was determined as field capacity (cm^3 water/cm^3) measured by adding a known volume of water to a soil sample of known mass and volume. The cumulative volume of water draining through the soil was recorded every five minutes for two hours. The soil volumetric content (water remaining in the soil after each time interval divided by soil volume) was plotted against time and the inflection point indicated the soil field capacity. The bulked soil samples were analysed in a commercial laboratory for pH (KCL), texture (pipette method), organic carbon (Walkley–Black method); extractable nitrogen (KCl) and the concentrations of potassium, sodium, calcium, magnesium, and zinc (Ambic I method).

To standardize for macroenvironmental differences among sites, each variable was expressed as the percentage difference in that variable from the CGL plots to the paired PGL plots prevailing at the time of sampling. Mean annual rainfall, stocking density (livestock units per hectare), fire frequency, slope position and aspect were obtained for each plot. If cattle were permitted into the PGL during drought conditions when grazing shortages occurred in the CGL, that was also recorded.

A backward stepwise multiple regression was used to identify the most important set of environmental variables which could be used to predict the extent of change in species composition. Variables with high colinearity were removed prior to the regression analysis. The remaining variables used in the regression were for both PGL and CGL plots, except soil variables where only CGL values were included in the regression as these were assumed to be indicative of the conditions occurring in the PGL at the start of the change.

RESULTS

Change in Species Composition

A significant exponential decrease in the species composition similarity index with time since protection was evident in both sweetveld ($r = 0{\cdot}73$; $p < 0{\cdot}001$) and sourveld ($r = 0{\cdot}59$; $p < 0{\cdot}001$) (Figure 1). From this it appears that most change occurred within four and nine years since protection in sweetveld and within six and nine years since protection in sourveld. Thereafter the rate of change was negligible. The pooled relationship for both veldtypes was:

$$\%\text{Similarity} = 92{\cdot}1\ (\text{Time since protection})^{-0{\cdot}401} \quad (\text{r} = 0{\cdot}72;\ \text{p} < 0{\cdot}001).$$

Change in Species Diversity

No relationship was evident in the change of diversity with time since protection in sweetveld ($r = 0{\cdot}3$; $p > 0{\cdot}1$) (Figure 2) or sourveld ($r = 0{\cdot}4$; $p > 0{\cdot}05$). Pooling data from sweetveld and sourveld indicated a significant increase in diversity with time since protection ($r = 0{\cdot}54$; $p < 0{\cdot}05$).

Change in Palatability

Sward palatability increased with increasing time since protection for both sweetveld and sourveld, although not significantly ($r = 0{\cdot}06$; $p > 0{\cdot}5$ and $r = 0{\cdot}248$; $p > 0{\cdot}1$, respectively) (Figure 3). In the first three years of protection the PGL areas showed no increase in the quality of the grazing resource relative to the CGL areas. However, from the fourth (sourveld) or fifth year (sweetveld) of protection onwards, the proportion of palatable tufts increased within the PGL areas. The only sites not to follow this sequence were the 25-year-old sweetveld site which showed a lower palatability in the PGL and the 17-year-old sourveld site which showed no change in palatability between the PGL and the adjacent CGL, even though the species composition had changed quite substantially.

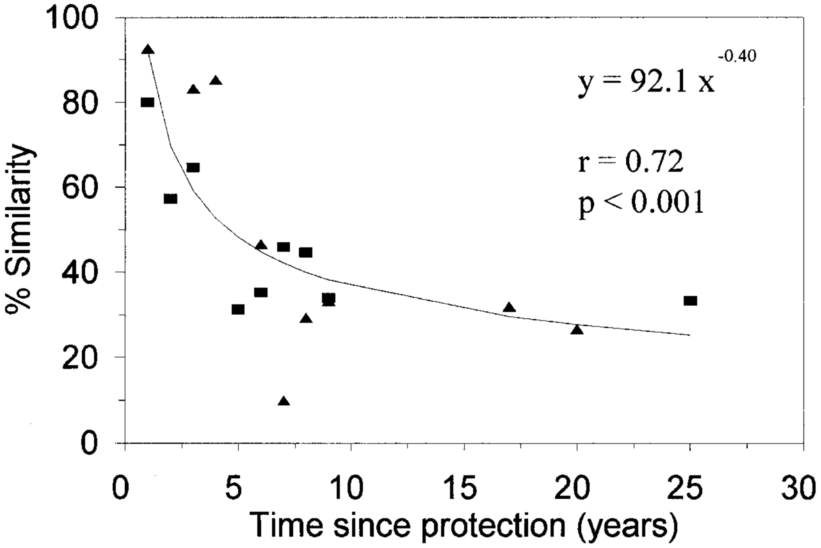

Figure 1. Change in the index of similarity in species composition with time since protection for (▲) sweetveld and (■) sourveld

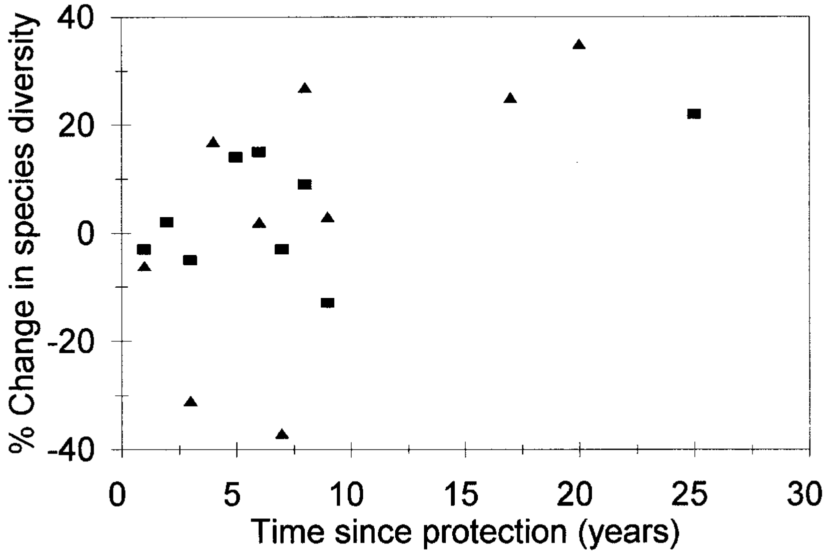

Figure 2. The percentage difference in Simpson's diversity index with time since protection for sweetveld (▲) and sourveld (■). Values above 0 indicate that the diversity index of the PGL was higher than that of the CGL, and, conversely, values below 0 show that the diversity index in the PGL was lower than that of the CGL

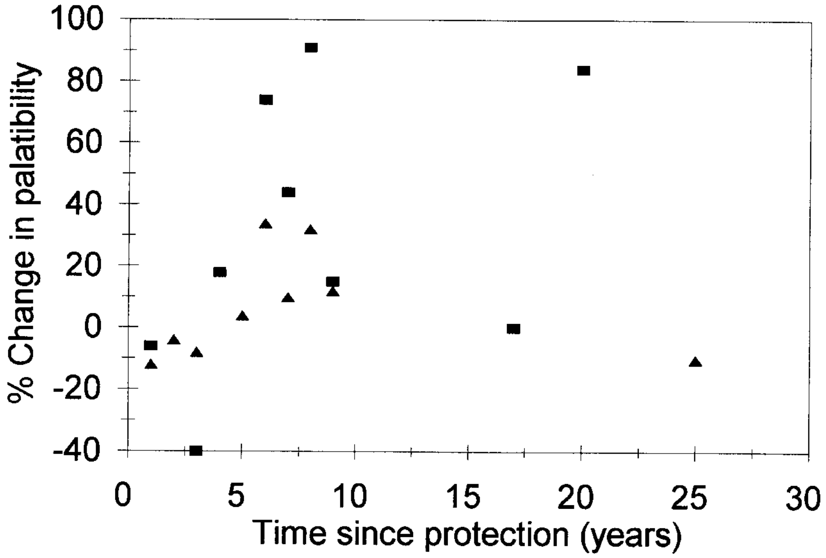

Figure 3. The percentage difference in the proportion of palatable grass tufts with time since protection for sweetveld (▲) and sourveld (■)

Change in Abundance of Annual and Perennial Species

The apparent decrease in the abundance of annual species in sweetveld with time since protection (Figure 4) was not significant ($r = 0{\cdot}4$; $p > 0{\cdot}2$). Excluding the oldest site (25 years) resulted in a significant decrease across the small range of time since protection covered by the younger sites. A significant positive correlation was found between the percentage difference in sweetveld perennial species abundance and time since protection ($r = 0{\cdot}74$; $p < 0{\cdot}05$) (Figure 4). Annuals were largely absent from the sourveld sites, and perennial species abundance in the sourveld sites showed little change with time since protection ($r = 0{\cdot}12$; $p > 0{\cdot}7$)

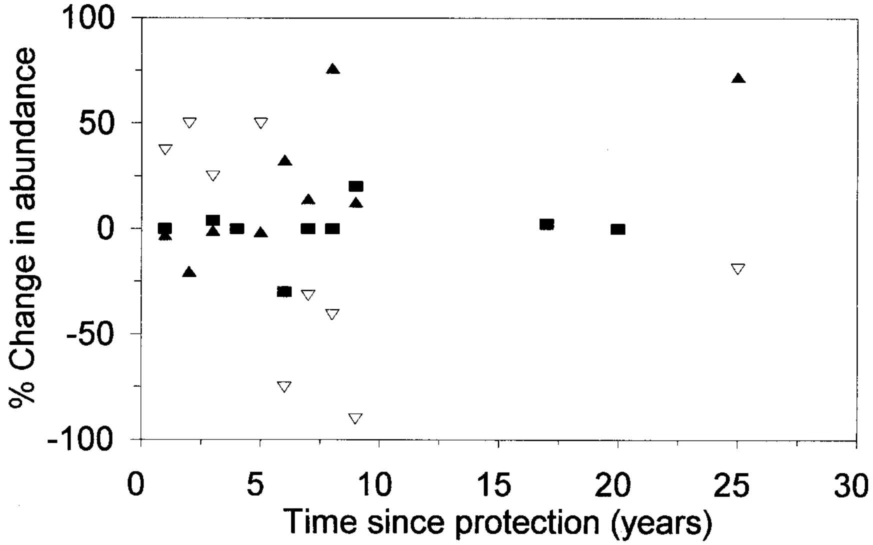

Figure 4. The percentage difference with time since protection in the proportion of annual grasses in the sweetveld (▽), the proportion of perennial grasses in the sweetveld (▲) and sourveld (■)

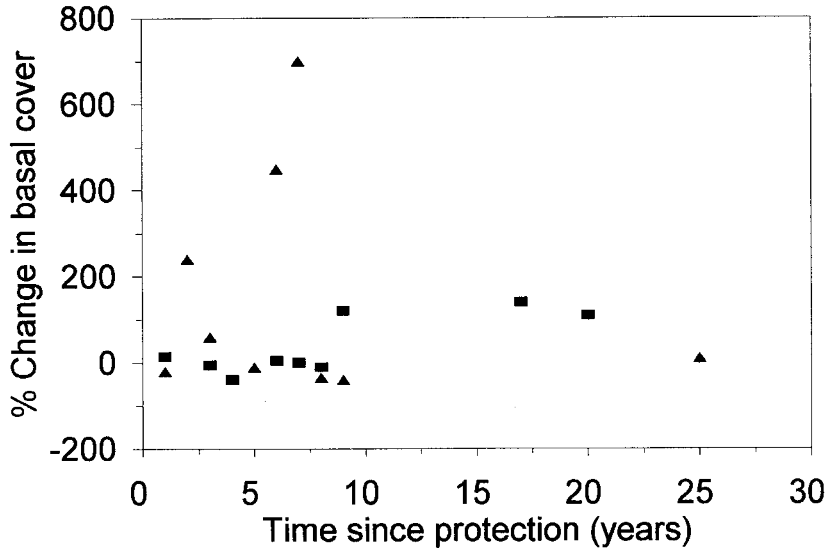

Figure 5. The percentage difference in grass basal cover with time since protection for sweetveld (▲) and sourveld (■)

(Figure 4). Pooling data from all sites, the increase in perennial species abundance was significant ($r = 0{\cdot}47$; $p < 0{\cdot}05$), but annuals not so ($r = 0{\cdot}25$; $p > 0{\cdot}4$).

Change in Basal Cover

No relationship was evident between the percentage difference in grass basal cover and time since protection at the sweetveld sites ($r = 0{\cdot}023$; $p > 0{\cdot}7$) (Figure 5). In contrast, a significant positive relationship ($r = 0{\cdot}57$; $p < 0{\cdot}05$) was found in the sourveld sites.

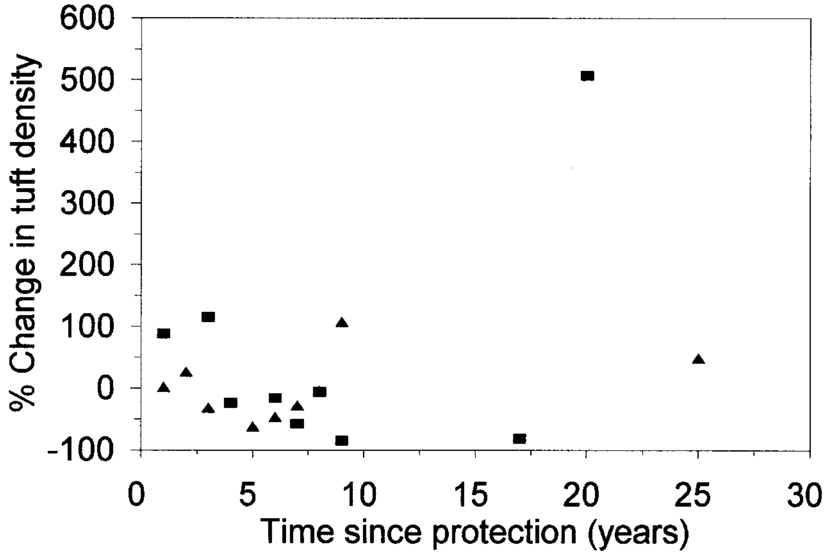

Figure 6. The percentage difference in the grass tuft density with time since protection for sweetveld (▲) and sourveld (■)

Change in Tuft Density

No relationship existed in the percentage difference in tuft density and time since protection for sweetveld ($r = 0{\cdot}026$; $p > 0{\cdot}6$) (Figure 6). A negative relationship was evident for the sourveld sites, although not significant ($r = 0{\cdot}4$; $p > 0{\cdot}1$), because of the significant outlier for the 20-year-old site. This trend indicates a change in sward structure to one dominated by larger individuals.

Change in Tuft Size

The number and proportion of individuals belonging to each size class differed significantly between the PGLs and the CGLs for both sweetveld ($X^2 = 581{\cdot}8$; $df = 8$; $p < 0{\cdot}001$) and sourveld ($X^2 = 134{\cdot}7$; $df = 8$; $p < 0{\cdot}001$). The sweetveld CGLs showed a higher frequency of tufts in the smallest size class (<51 mm) while the PGLs showed a higher frequency in the larger size classes (Figure 7). The sourveld CGLs had more tufts in the first three size classes (<151 mm), with the PGLs showing higher frequencies in the next five size classes. The tuft size distribution profile for the CGLs and PGLs in both veldtypes were typical of those for stable populations.

Change in Soil Variables

A significant increase in the percentage change in soil porosity with time since protection was found in the sourveld ($r = 0{\cdot}86$; $p < 0{\cdot}001$), but not in sweetveld (Figure 8). The percentage change in soil bulk density, field capacity, pH and all soil nutrients showed high variability between sites, with no discernable patterns.

Factors Affecting Change

Of the initial 20 variables available for the analysis, eight were excluded because of high intercorrelation. Of the remaining variables ten indicated a significant relationship with the index of similarity in species composition (Table I). The two non-significant variables were field capacity and use of the PGL for emergency grazing. While each of the ten variables were significant, individually they did not explain much of the pattern. Overall there is a suggestion that soil factors were more important than time since protection.

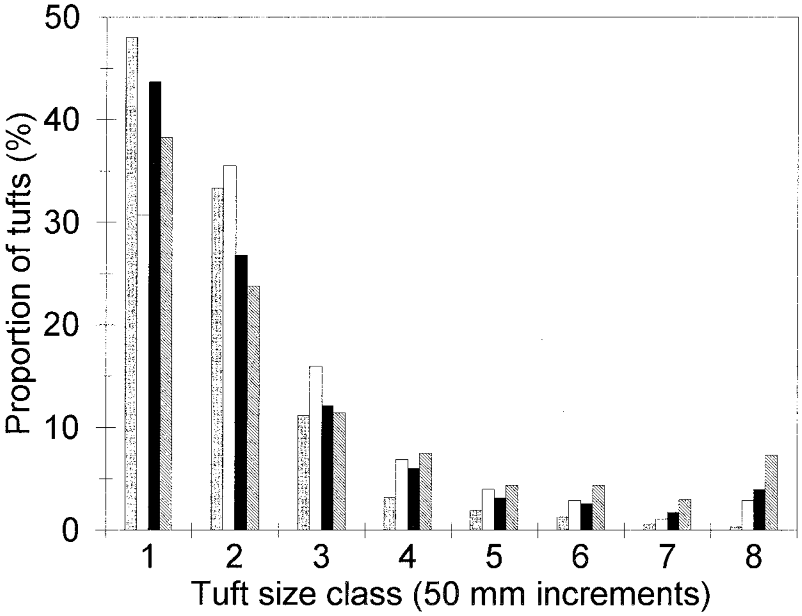

Figure 7. Tuft size class distribution for pooled sweetveld and sourveld sites. (Classes are in 50 mm increments in basal circumference; ■ Sweetveld CGL, ☐ Sweetveld PGL, ■ Sourveld CGL; ▨ Sourveld PGL)

Table I. The environmental variables remaining after backward stepwise multiple regression and the amount of variation (r^2) in species composition explained by these variables

Dependent variable	Independent variable	p for each variable	Final p	r^2
			<0·001	0·987
Similarity index (%)	Constant	<0·001		
	Time since protection	0·021		
	Mean annual rainfall	0·002		
	Regular fire	0·001		
	% Sand	0·001		
	pH	<0·001		
	Bulk density	<0·001		
	Magnesium	<0·001		
	Potassium	<0·001		
	Nitrogen	<0·001		
	PGL stocking rate	<0·001		

DISCUSSION

The equilibrium or non-equilibrium behaviour of communal grazing systems needs to be clearly understood to assist in the development of appropriate policies and management strategies, where required. In other words, it is necessary to know how much the herbaceous layer can be changed through management (including grazing), but retain the capacity to respond to a decrease in the driving management pressure, i.e. the stability and resilience of the system (Walker and Noy-Meir, 1986). Such a change may be to revert to some previous condition or to enter an alternative state, perhaps with more desirable attributes (depending upon the management objectives). The issue of concern in this study was whether the changes induced under high and continuous grazing pressure are permanent or whether these changed grasslands are able to improve in condition once the grazing pressure is removed, and at what rate. The data demonstrated that

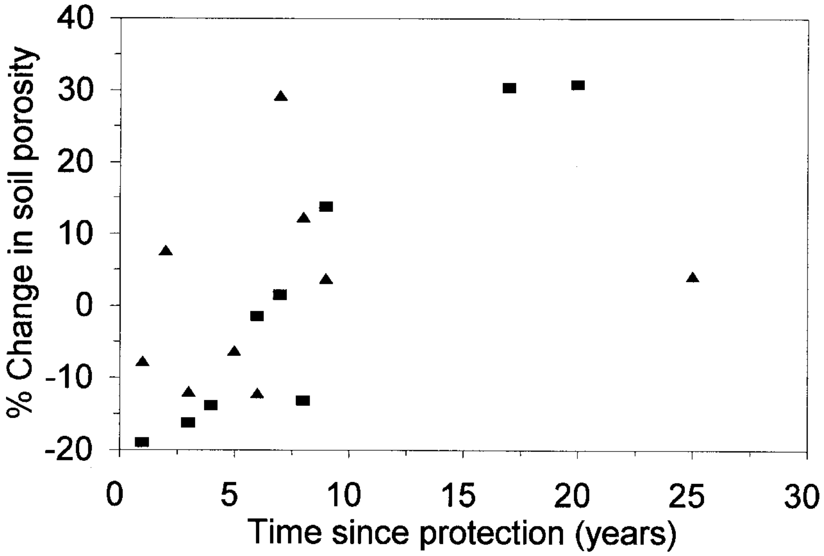

Figure 8. Percentage difference in soil porosity with time since protection for sweetveld (▲) and sourveld (■)

important indicators of the functioning of grasslands, namely grass species composition and grass basal cover, can undergo rapid change after removal of high and continuous grazing pressure. While this study examined sites with reduced grazing pressure because of human management intervention, dramatic reductions in livestock numbers can also occur as a result of drought (Scoones, 1993; Shackleton, 1998) or disease. Recovery of stock numbers following a drought may take several years (Scoones, 1993) depending upon the severity of the drought. This study has shown that the rate of change in species composition is relatively rapid after a reduction in livestock numbers. It is quite probable that the same will apply after a drought. Thus, the species composition will be in a constant state of flux, of 'recovery' immediately after a drought, but at a decreasing rate as livestock numbers reestablish over several years. It appears that the frequency of droughts must be sufficient to ensure that the overall resilience of the system is maintained (Shackleton, 1998). A key component is the differential mortality of particular herbaceous species groups during the drought, as well as post-drought recruitment opportunities (Milton, *et al.*, 1995; Walker, *et al.*, 1997).

Changes in the Grass Sward

Previous studies concentrating on areas removed from heavy grazing pressure indicate changes in species composition after protection. Strang (1974), in Zimbabwe, found that changes in grass species composition resulting from heavy grazing were reduced or eliminated over varying periods of rest (between 3 and 12 years), while McKenzie (1984) considered species compositional changes to be reversible in the moist sourveld of Transkei (South Africa). Compositional changes were also displayed in the Serengeti grasslands after protection from intense grazing (McNaughton, 1979). The results from this study add further support to these earlier findings. The rapid rate of change in the sweetveld conforms to Tainton's (1984b) assumption that this veldtype has the capacity to change its composition and density rapidly after removal of persistent grazing, and possibly also in relation to other driving stimuli such droughts, or localized nutrient addition. Although the change in the sourveld was slightly slower than in the sweetveld, the rate of change was more rapid than was previously thought (McKenzie, 1982; Edwards, 1984; Tainton, 1984b). Artificially disturbed sites in Serengeti recovered their previous species composition within one to three years (Belsky, 1986a, 1986b), and Dahlberg (1996) reported significant increases in herbaceous layer diversity, the proportion of perennial species and less bare ground in a semiarid grazed area in Botswana rested for only four years. A similar 'recovery' period was reported by Walker, *et al.* (1997) after experimental perturbation to mesic savanna grasslands in Australia

Although this study revealed rapid changes in species composition with time since protection, these changes do not necessarily indicate a return to some previous condition (unknown) and composition. The changes that result from protection may merely represent replacement by functional species groups similar to those already present (Walker, *et al.*, 1997). An improvement in species composition will depend on a change in the proportion of species deemed desirable to meet stipulated management objectives. In commercial enterprises, palatable species and perennials are favoured over annuals or unpalatable species. An increase in the abundance of palatable species after four or five years in both veld types was revealed in this study. This suggests that the change in species composition is an indication of the improvement in sward condition after only a few years of protection from livestock. In the absence of defoliation by grazing, unpalatable species eventually become moribund and decline (Frost, *et al.*, 1986). This would create gaps which could then be colonized by more palatable grass species resulting in a change in dominance ratios of palatable and unpalatable species. This implies either (1) relatively long-lived seed banks of the larger palatable species, or (2) a low density of palatable tufts surviving in refuges from grazing (e.g. under thorn bushes) to facilitate recolonization after protection from grazing. The first hypothesis has been refuted by O'Connor (1991a) in a study in the Mpumalanga lowveld (sweetveld), South Africa.

The change in species composition in the sweetveld sites was not confined to a change in palatability, but also to an increase in abundance of perennials in protected areas. In contrast, the proportion of annuals and perennials in sourveld seems relatively stable and independent of time since protection. Walker, *et al.* (1981) suggested that many perennial grasses, including many early successional species, can withstand intense grazing due to a significant proportion of their biomass being underground, as substantiated by empirical root studies (e.g. Strugnell and Pigott, 1978). Other species develop prostrate habits when grazed or are unpalatable. Furthermore, with protection, these perennial grasses may be replaced by other perennial species which are more productive and palatable. This would explain the insignificant difference in perennial abundance between the protected and adjacent communal areas. For example, the site with seven years protection showed a dominance of the perennial but unpalatable *Aristida junciformis* and the palatable but rhizomatous *Setaria nigrirostris* in the communal grazing areas, while protection from grazing resulted in a shift in the dominance to *Themeda triandra*, also perennial but tufted and palatable. A shift in *Aristida junciformis* (dominant in the communal land) to the tufted, more palatable *Hyperthelia dissoluta* (dominant in the protected area) at the site of eight years protection is a similar example (Table IIa and IIb). This sequence was also evident in the other sites (although the change may have involved different species), except where insufficient time had elapsed for changes to become significant (i.e. sites of one, three and four years since protection). The annual species were generally sparse and therefore were not considered to have any significant effect on sward condition.

Fourie, *et al.* (1984) suggested that basal cover was a more sensitive indicator of patterns in herbaceous layer condition than species composition. The changes in grass basal cover measured in the sweetveld sites of this study do not support this assertion; possibly because of the high spatial variability inherent in the basal cover distribution in sweetveld. These results are in contrast to those of Gardner (1950) who found 110 per cent higher grass cover in a protected area in the desert grassland of New Mexico, compared to an adjacent heavily grazed area. Basal cover varies greatly with rainfall, and in semiarid regions rainfall appears to have a greater effect on basal cover than does grazing (O'Connor, 1991b; O'Connor and Roux, 1995). However, the effects of grazing become relatively more important as mean annual rainfall increases and its variability decreases (Frost, *et al.*, 1986). Although the sourveld sites had a significant increase in grass basal cover, only the 9-, 17- and 20-year-old sites showed any major changes within the protected plots. The communal lands of the remaining sites were dominated by *Aristida junciformis* which is known to have a very high basal cover (McKenzie, 1982). This contributed to a higher basal cover than was expected in heavily grazed CGLs, and therefore affected the overall percentage change in grass basal cover.

Table IIa. Species composition (%) of the nine sweetveld sites of differing time since protection

Species	Life form	Palatability	1 year		2 years		3 years		5 years		6 years		7 years		8 years		9 years		25 years	
			PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL
Aristida congesta var *barbicollis*	Ann	Unpal			10·5	7·0			5·0	5·0			12·5	7·0	11·0	35·0	6·0	19·0	7·0	15·5
Aristida congesta var *congesta*	Per	Unpal									4·5	10·0								
Aristida stipitata var *graciliflora*	Per	Unpal	28·5	18·0	14·0	11·0	10·5	15·0			4·0	2·0	11·0	11·0						
Brachiaria brizantha	Per	Pal			0·5	1·5							0·5	1·5						
Cynodon dactylon	Per	Pal	12·0	17·0			2·0	8·5	0	1·0					29·0	3·5	6·0	22·0		
Digitaria eriantha	Per	Pal			0·5	0					11·0	7·5	4·0	0					9·0	0
Digitaria sp.	Per	Pal																	15·5	1·5
Enneapogon scoparius	Per	Unpal					1·0	0												
Eragrostis chloromelas	Per	Pal															0	1·5		
Eragrostis gummiflua	Per	Unpal																	0·5	0
Eragrostis lehmanniana	Per	Pal					4·0	6·5												
Eragrostis rigidior	Per	Unpal	10·5	13·0	6·5	11·5	1·0	1·5	5·0	3·5	5·5	0·5	7·0	11·5	2·5	0	33·5	5·0	4·5	1·5
Eragrostis superba	Per	Pal	7·0	14·5	8·0	21·0					5·0	3·0	3·5	21·0	0·5	9·0	0	23·5	0	5·5
Eustachys paspaloides	Per	Pal			5·5	1·0					12·5	1·0	0	1·0					5·0	0·5
Heteropogon contortus	Per	Pal	0·5	1·5	11·5	8·0	10·5	23·5	9·0	72·5	11·5	45·5	8·0	8·0	0	14·0	0	4·0		
Hyperthelia dissoluta	Per	Pal	16·5	10·5			30·0	7·0	68·0	9·5	4·0		6·0	0	0·5	0	39·5	4·0	4·5	0
Melinus repens var *repens*	Ann	Unpal					1·5	1·5	2·5	0	1·0	7·0			4·5	0·5	3·0	0		
Microchloa caffra	Per	Unpal																	0	28·0
Panicum deustem	Per	Pal			4·0								1·5		0·5					
Panicum maximum	Per	Pal	2·0	3·5	4·0	2·0			4·5	1·5	3·0		29·0	2·0	1·5		3·5	4·0	1·5	
Paspalum scorbiculatum	Per	Pal							4·0	0										
Perotis patens	Ann	Unpal		3·0										7·5	1·0					
Pogonathria squarrosa	Per	Unpal					9·0	12·5					0·5	0	13·5	0				
Schmidtia pappophoroides	Per	Pal									1·0	0								
Setaria pallide-fucsa	Ann	Unpal									1·5	0·5								
Sporobolus africanus	Per	Unpal	12·0	14·0					2·0	2·5									0	0·5
Sporobulus nitens	Per	Unpal			0	6·5			0	0·5			0	6·5			4·5	10·0		
Sprobolus pyramidalis	Per	Unpal					6·5	12·0									4·5	7·0		
Themeda triandra	Per	Pal			1·5	0					32·5	0	10·0	0						
Tragus berteronianus	Ann	Unpal			0	9·0	1·0	0			3·5	21·0	10·5	9·0	6·5	7·0			34·5	4·0
Trichoneura grandiglumis	Per	Unpal					23·5	12·0	0	4·0					1·5	1·5				
Urochloa mosambicensis	Per	Pal			20·0	13·0							1·0	13·0	19·5	28·5			17·5	54·0
Urochloa oligotricha	Per	Pal	11·0	8·0											1·5	0			1·0	3·0
Unidentified					0	8·5					0	2·0	0	8·5						

Life form: Ann = annual; Per = perennial. Palatability: Pal = palatable; Unpal = unpalatable. PGL = Protected grazing land; CGL = Current communal grazing land.

Table IIb. Species composition (%) of the nine sourveld sites of differing time since protection

Species	Life form	Palatability	1 year		3 years		4 years		6 years		7 years		8 years		9 years		17 years		20 years	
			PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL	PGL	CGL
Aristida junciformis	Per	Unpal	60·0	57·0	74·5	57·0	58·0	64·5	0·5	42·5	1·5	31·5	11·0	53·5	4·5	8·0	0	3·5	2·0	46·0
Chloris virgata	Ann	Unpal															2·0	0		
Cynodon dactylon	Per	Pal			2·5	8·5			10·0	8·5	0	8·0	1·0	1·5	2·5	18·0	4·5	0·5	4·5	6·5
Digitaria eriantha	Per	Pal											19·0	0						
Diheteropogon amplectens	Per	Pal													6·0	0				
Elionurus muticus	Per	Unpal													5·0	0	10·5	2·5		
Eragrostis capensis	Per	Pal	10·5	13·5	0	1·0	5·5	2·0					4·0	23·5	7·5	22·5	13·0	4·0	19·0	45·0
Eragrostis curvula	Per	Pal	6·0	10·5	11·0	12·5	0	4·0	29·0	6·5			19·5	0·5	11·0	26·5	17·0	7·0	15·0	0
Eustachys paspaloides	Per	Pal															1·5	12·0		
Harpochloa falx	Per	Pal															2·0	0		
Heteropogon contortus	Per	Pal			4·0	0									8·0	8·5	15·0	11·0		
Hyperthelia dissoluta	Per	Pal					11·5	0·5					33·0	0	22·5	0	4·0	52·5	11·0	
Melinus nerviglumis	Per	Pal									3·5	0								
Melinus repens var *repens*	Ann	Unpal			0·5	2·0			34·5	7·0							1·0	0		
Microchloa kunthii	Per	Unpal													0	12·5	0	4·5		
Panicum maximum	Per	Pal							1·5	2·0										
Paspalum scorbiculatum	Per	Pal							3·0	6·5										
Pennisetum clandestinum	Per	Pal							1·5	0										
Setaria nigrirostris	Per	Pal									7·0	31·5								
Setaria sphacelata var sericea	Per	Pal			0	2·5														
Sporobolus africanus	Per	Unpal	23·5	19·0	7·5	16·5	25·0	29·0					12·5	21·0					16·5	2·5
Sporobolus fimbriatis	Per	Pal							20·0	27·0	2·0	29·0								
Themeda triandra	Per	Pal									73·5	0			33·0	0	9·0	0		
Tristachya leucothrix	Per	Pal									10·0	0					19·0	0	33·0	0
Urochloa mosambicensis	Per	Pal													0	4·5	1·5	2·5		
Unidentified											2·5	0								

Life form: Ann = annual; Per = perennial. Palatability: Pal = palatable; Unpal = unpalatable. PGL = Protected grazing land; CGL = Current communal grazing land.

There was a general decrease in sourveld grass tuft density in the protected areas compared to the communal areas, despite the increase in basal cover. Heavy utilization has generally been found to lead to a reduction in sward density, through fragmentation of grass tufts (O'Connor, 1991a; Parsons, *et al.*, 1997; Tainton, 1984b). The findings of this study could be attributed to the reverse process, with decreased fragmentation of tufts after removal of grazers resulting in fewer, larger tufts in the protected areas. Fragmentation of grass tufts was also considered by O'Connor (1991a) to be a key process (together with recruitment) in tuft size distributions in grazed grasslands. In both PCLs and CGLs small tufts dominated the size distribution profile, which is typical of a stable population with adequate recruitment.

Change in Soil Conditions

Livestock trampling can have measurable effects on the soil (Mentis, 1984), which, in turn, affects plant growth. Increasing cattle numbers lead to reduced infiltration capacity, water storage capacity, porosity and increased bulk density (Frost, *et al.*, 1986; Hatch and Tainton, 1990). Furthermore, cattle also affect soil nutrients through inputs from dung and urine (Frost, *et al.*, 1986; Mentis, 1984; Tolsma, *et al.*, 1987). In arid savannas, reduced plant cover can apparently lead to irreversible changes in the soil (Cumming, 1982; Frost, *et al.*, 1986), although more studies are required regarding the imputed irreversibility, and the conditions under which it may or may not apply. In contrast, protection from grazing leads to an increase in grass biomass and cover, as well as to an increase in soil infiltration, organic matter and some nutrients (Hatton and Smart, 1984; Pluhar, *et al.*, 1987).

In this study the changes in soil conditions showed no relationship with time since protection, except an increase in porosity at the sourveld sites. However, resting did result in a change in these variables at the different sites. Scoones (1992) found that the long-term impact of herbivores on the soil dynamics is dependent on soil type. For example, clayey soils are more easily compacted than sandy soils, particularly when moist (Frost, *et al.*, 1986). The lack of any patterns in this study could be attributed to the large variation in initial soil composition. Thus, any changes occurring in soil conditions under high and continuous grazing are dependent on initial soil type and on climate.

Factors Affecting Change

With the removal of high and continuous grazing pressure the species composition of the protected areas changed. While it was hypothesized that the rate of change would be influenced by external factors such as rainfall and soil type, it was difficult to isolate individual factors in this study, suggesting that rainfall, soil attributes and time since protection are all significant. The different responses between sourveld and sweetveld also suggest that abiotic conditions do influence the rate of change after protection.

CONCLUSIONS

This study has shown that the removal of high and continuous grazing pressure from CGLs resulted in relatively rapid changes in herbaceous layer species composition and species diversity. The changes in composition are associated with increases in the proportion of perennial and more palatable species, as well as change in the size class distribution to larger tufts. Basal area increased with time since protection for sourveld sites only. Most of the changes were rapid (< 10 years) despite the decades of supposed degradation of these systems by overgrazing, interspersed with periodic drought-induced livestock die-offs. Thus, it is concluded that the communal grazing areas are extremely resilient.

The results of this study may indicate that the anxiety expressed over the apparent degraded condition of these communal grasslands is unjustified. Indeed, managers and policy makers need to accept the dynamic nature of communal systems and build upon this within the framework of the immediate management objectives of the communal pastoralists themselves, rather than advocating reductions in stock densities or rotational grazing schemes.

ACKNOWLEDGEMENTS

We would like to thank M. Stalmans, D. Heinsohn, J. Harrison, Mr Zondi and J. Feely for their advice and help in locating study sites; KaNgwane Parks, Transkei Department of Agriculture and Forestry, and I. Sharp (Manyeleti Game Reserve) for allowing access to their reserves, and M. Peel, J. Venter and J. Ellis for constructive criticism on preliminary drafts of this paper. Project and analytical guidance offered by D. Meyer and N. Owen-Smith was much appreciated. YH was supported by a FRD grant and a Wits Senior Bursary. CS was supported by Wits Rural Facility Research Funds.

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