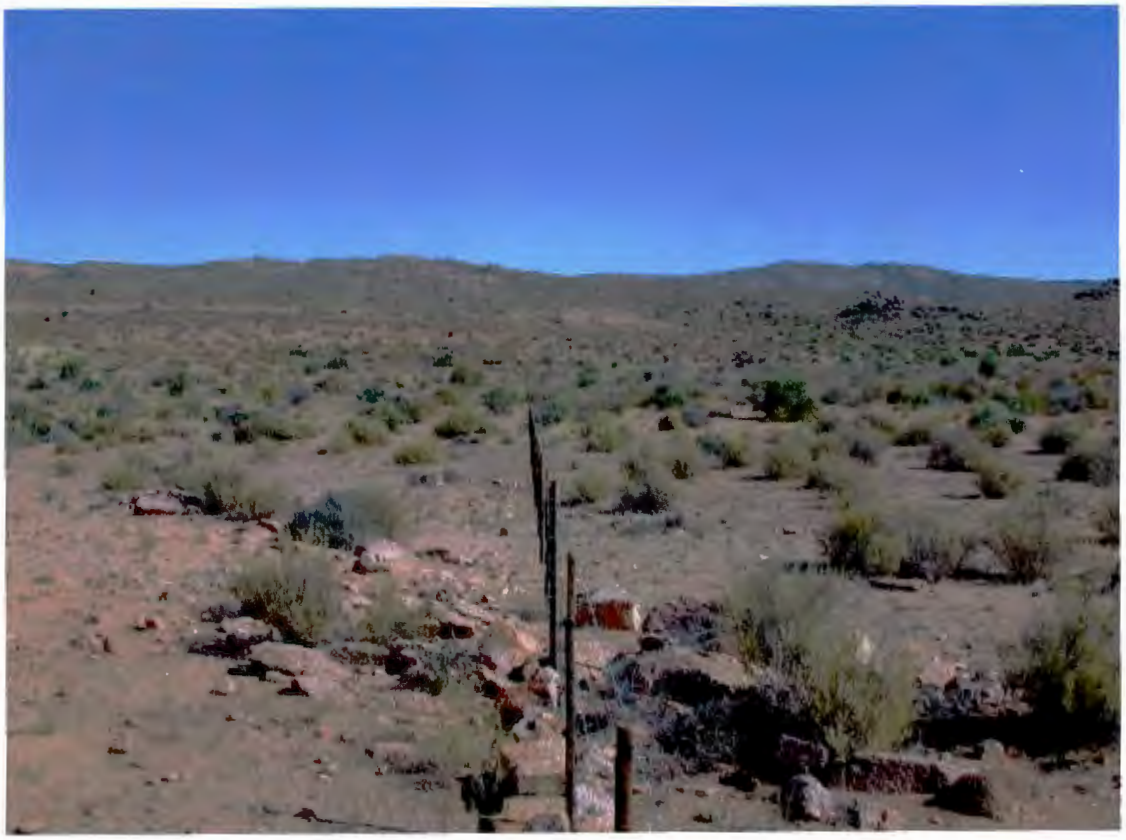
EFFECT OF SHORT TERM REST ON RIVERINE SYSTEMS ASSOCIATED WITH HEAVY GRAZING IN PAULSHOEK, NAMAQUALAND, SOUTH AFRICA

CHARLOTTE MONAKISI

SUPERVISORS:
DR. NICKY ALLSOPP
PROF. TIMM HOFFMAN



Picture taken from one of the study sites, Moedverloor, Paulshoek, Namaqualand.

TABLE OF CONTENTS

ABSTRACT

Arid and semi arid systems comprise one third of the earth's surfaces. The succulent karoo alone comprises approximately 1660 endemic species and is one of the world's hotspots in terms of diversity. Although these areas are of high ecological value less than 10% of arid systems are conserved.

This study was conducted in Paulshoek a remote village in the Leliefontein area of the Namaqualand. Historically Paulshoek has been under continuous selective grazing since the 18 th century. A fence line contrast is investigated in an area that was fenced three years ago and in one that has been exposed to heavy, continuous, selective grazing over the past century (both areas were fenced prior to fencing). The objective of this study was to investigate the effect of short-term rest on key vegetation demographic parameters as well as the physical characteristics of communal river systems.

No significant differences in plant species richness were observed across the fence line. However the numbers of plants of each species within the plots were significantly different, depending on presence or absence of grazing. The grazed sites had more species tolerant of grazing such as geophytes, annuals and toxic species such as *Galenia africana.* Heavy grazing in this ecosystem has resulted in increased proportions of unpalatable species with a slow reduction in the number of palatable species.

Species cover was significantly reduced on the grazed sites, however these reductions were insignificant for Lyceum cinereum species due to large standard deviations. Heavy grazing of palatable sedge species (*Scirpus nodosus)* resulted in significant reductions in the number of flowers of plants, in the grazed sites. Grazing not only reduced the size of the plants, it also reduced flowering, fruit set and recruitment rate.

There was no significant difference in the physical and geomorphologic characteristics of the river across the fence-line.

This study indicates that short-term rest has major implications for plant recovery. Educating communal farmers to use a farming system that insures temporary rest on certain areas of the rangelands at certain times of the year will go a long way in improving species richness in Namaqualand.

INTRODUCTION

Arid and semi arid ecosystems comprise one third of the earth's surfaces (Schlesinger et al 1990). They are some of the richest ecosystems constituting a diversity of plants and animals many of which are endemic to these locations. The succulent karoo alone comprises approximately 1660 endemic species (Cowling & Hilton Taylor 1994) and is one of the world's hotspots in terms of diversity. The flora includes 730 genera of which 67 (9.2%) are endemic (Hilton Taylor 1996).

It makes sense that these biological hotspots should be of high conservational value. This is however not the case. Less then 10% of arid ecosystems as a whole are conserved and only 4% of the succulent karoo biome is conserved (Todd & Hoffman 1999). The rest of the land is highly degraded by overgrazing and continual selective grazing.

In Namaqualand communal grazing refers to animal production on land where the tenure system provides access to 'rangeland' to all members of the community holding the land (Theunis et al 1998). Unlike the private land ownership in commercial farms, communal grazing allows the use of land by all members of the community.

Emphasis on communal grazing is not the sale of animals for profit but rather as a form of investment and insurance. Unlike their white counterparts communal farmers still have relatively poor access to financial services and markets, and there is little incentive for communal farmers to adhere to a market based approach in farming (Todd and Hoffman 1998).

Considering the large number of people with equal access to 20 000 ha of land in Paulshoek, it is not surprising that these communal areas carry twice the number of animals recommended for commercial livestock farming. The mean stocking rate in Paulshoek has been approximately 6 ha per small stock unit for the past 30 years, twice that recommended for the region, by the Department of Agriculture. (Todd and Hoffman 1999). Stocking rates are also twice that of the local commercial farmers with stocking rates of 12 ha per small stock unit.

Extensive livestock farming is the major form of land use in Paulshoek and is considered to be a major threat to the vegetation of the region (Milton 1997). Grazing in the communal areas is continuous and selective. According Milton et al (1994) heavy grazing in this ecosystem should result in increased proportions of unpalatable species. Continuous selective grazing selects against the palatable species, reducing their cover, composition and species diversity. Poisonous, unpalatable species on the other hand are not grazed and start to dominate. The selective grazing of palatable species results in a shift in species, to rangelands dominated by toxic and spinescent woody plants such as *Galenia africana* (Milton and Hoffman 1994).

Dominance of woody unpalatable species (*Galenia africana*) results in a loss of biodiversity (West 1993), this results in selection of weedy generalists such as geophytes and annuals (Milton et al 1994).

Livestock have major effects on the growth, reproduction as well as the recruitment rate of plant species, thus crippling them. Continual feeding reduces the size of the plants significantly. Non-selective feeding by donkeys further reduces flowering, seed set and seed recruitment. Under these grazing regimes palatable species are slowly and gradually eliminated, as they are not given a chance to produce seeds.

Once dominated by unpalatable species even the total removal of stock from the veld will not return it to the former state (Todd and Hoffman1999). This is because Karoo shrubs are long lived and it may take several decades for the vegetation to recover.

There are several publications on the effect of overgrazing on non-riverine vegetation (Todd and Hoffman 1998, Bruyn et al 1998), however only few publications exist on the effect of overgrazing on riverine vegetation. eg ?.

Riverine systems play a vital role in supplying water for basic human needs as well as agricultural purposes. They need to be preserved in order to insure sustainable development, so as to yield the greatest benefits to present day populations without destroying the resource base and to still leave enough for future generations (~~The reserve~~, Vanishing waters, 1998). Riverine systems are not just a water source but also provide grazing food for livestock. They have lots of benefits many of which are secondary (not directly used by people and animals).

Riverine vegetation slows the flow of water, by physically blocking it or absorbing water into their roots (WRC 2001) this reduces flooding impact. The vegetation plays a role in water quality regulation by acting as buffers, filtering sediments, bacteria, contaminants as well as other toxic substances such as pesticides. Riverine vegetation also provides habitats for many plants and animals and serves as a corridor linking two or more habitats (WRC 2001), this only happens during the rainy season because rivers in Paulshoek are ephemeral.

Overgrazed riverine vegetation result in the collapse of riverbanks due to erosion, which causes high silt levels (WRC 2001, Gaika 1999). Increased sedimentation due to overgrazing also poses major problem. Removal of riverine vegetation results in increased run off as well as reduced penetration of water into the soil (Evans et al 1997), Soil moisture usually retained in the upper surfaces is reduced to the lower surfaces in overgrazed lands (Tugela basin regional survey 1952).

In this study a fence line contrast was investigated. The fence was put up in 1999 to eliminate grazing from an area selected by the community based Paulshoek land care project in order to promote veld recovery (subsequently we use this area for monitoring and research). The site has been rested for three years allowing for the recovery of species. The other side of the fence has been exposed to continuous selective grazing to the present day.

The study used the fence-line contrast to address the following questions:

- What is the effect of short-term rest on species diversity?
- What is the effect of short-term rest on plant composition and cover?
- What is the effect of short-term rest on Sedge flower production and plant recruitment rate?
- What is the effect of short-term rest on the volume of *Lycium cinereum* species?
- What is the effect of short-term rest on plant growth forms?
- What is the impact of short-term rest on the physical characteristics of the river?

The result of this investigation will allow us to determine if the river system has been permanently damages by grazing (i.e. degraded) or if it has the capacity to recover from the impact of grazing.

MATERIALS AND METHODS

STUDY AREA

The study was carried out in Paulshoek, a remote village in the Leliefontein communal area, in Namaqualand, Northern Cape province of South Africa .It forms one of the nine villages of the Leliefontein communal area. The village lies 50 km east of Garies (30.24 S : 18.08 E) and 80 km south of Springbok (Solomon 1998).

Climatically this region belongs to the winter rainfall area of the Western Cape. Paulshoek receives an average of 150-200 mm of rainfall annually (Todd and Hoffman 1999). The mean annual temperature is 16.3 °C. Minimum temperatures can reach below zero and maximum temperatures can reach a high of 37 °C (Hoffman et al 1999).

The village constitutes 20 000 ha, which together with the other communal areas in the Namaqualand only make up 25% of the land surface area but constitutes 45% of the population. There were 140 households in 1999 housing 800-1000 inhabitants (Hoffman et al 1999)

For the past 200 years the area served as a refuge for nomadic pastoralists who grazed the lowlands in winter and returned to the plateau in summer (Steinschen et al 1996). Permanent occupation and fencing took place in early 1900s with the provision of borehole water (Steinschen et al 1996).

The dominant rock type is gneiss, a derivative of granite; it reflects a long history of volcanic activity. Soils generally have low clay content.

Lots of rivers run through the area forming species rich habitats, rich in succulents and other palatable plants. The low-lying lands are highly grazed in comparison to the surrounding hilly slopes; these provide shelter against grazing and shade the plants thus protecting them against intense heat.

Succulents, evergreens, deciduous shrubs and sedges (*Scirpus nodosus*) are the dominant growth forms in the region. However, heavy grazing, overstocking as well uncontrolled continuous grazing has resulted in unpalatable species taking over and out-competing the palatable species. Thus unpalatable species such as *Galenia africana* are the key species of these degraded lands.

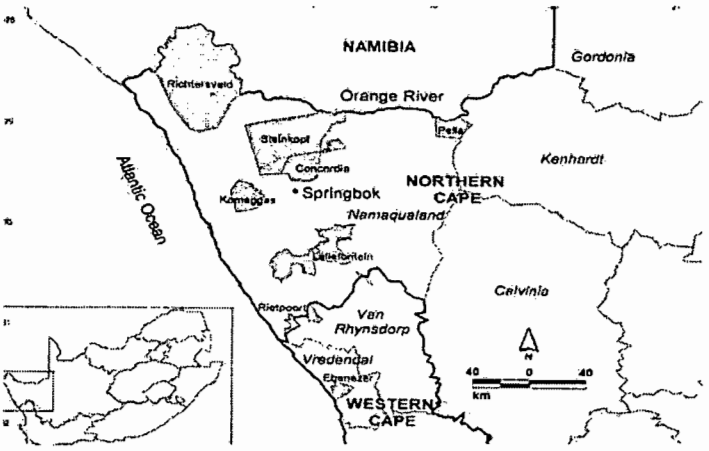


Figure 1: Map of Namaqualand showing the Leliefontein communal area.

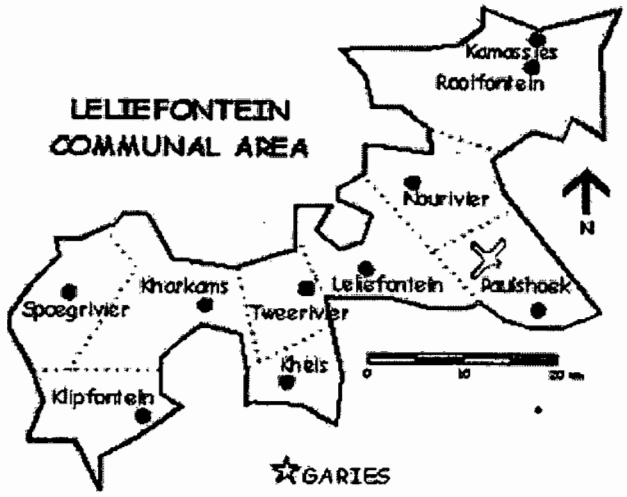


Figure 2: Map of the Leliefontein communal area showing the village of Paulshoek.

METHODS

All studies were conducted in Moedverloor, in an area of about 800 ha in Paulshoek that was fenced three years ago, to allow for species recovery. There were three sites:

Site 1 = First site- southern boundary of Moedverloor

Site 2 = Second site - Northern boundary of Moedverloor

Site 3 =Third site – Eastern boundary of Moedverloor

There were two treatments

Treatment 1 = grazed (i.e. outside of Moedverloor fenced off area)

Treatment 2 = un-grazed (i.e. inside fenced Moedverloor area)

Because dispersal across the fence can affect results obtained from the plots and transects, plots and transect were kept a few meters away from the fence.

Plots (5 * 5 m) were used to estimate plant cover. Plots were visually divided into percentages and the plant cover assigned to these percentages. The numbers of plants were counted for all the groups except annuals. Plant composition was noted for all the plots. Plant species found within plots were then assigned to different growth forms these include annuals, geophytes, sedges, grass, herb, deciduous shrubs, evergreen shrubs, leaf succulent shrubs and stem succulent shrubs.

Line transects were run crossways to river flow, these were placed 50 m intervals moving away from the fence. The edges of the river were determined by sudden steepening in the ground or the lack of signs of water flow. 5 replicate transects were run on each side of the fence wherever possible. However, where the river branched or a change in substrate occurred (e.g. change to rock banks) no further transects were laid.

The number of species were counted along each transect. Intersections of plants with the transect were measured and the identity of the intersecting species noted. From this percentage plant cover could be calculated. Annuals were once again excluded in species counts and plant cover measurements.

We also measured % dead wood, % dead shrubs as well as % litter along transects. River physical characteristics along the transects were also noted, such as river width, number of channels, average channel width, and total channel width. A channel is

Recruitment rate was achieved using a line transect that was run parallel to the direction of river flow. The height of *Scirpus nodosus* species, the basal diameter and two axes were measured. Sedges (*Scirpus nodosus)* of different sizes were selected and, the number of flowers on each sedge plant counted.

Lastly, *Lycium cinereum* species were chosen at random. The heights and two axes (widths) of the species were measured.

DATA ANALYSIS

Data analysis was done using a program called Statistica, ANOVA (analysis of variance) was the statistical test used within the program. ANOVA was used for all plant parameters except flower data in which a t-test was used. A program called Primer for multivariate analysis was used to give a scatter plot of the three sites studied, for the two treatments (grazed and un-grazed).

RESULT

ANALYSIS OF PHYSICAL CHARECTERISTICS OF THE RIVER

River width did not differ significantly between the grazed and un-grazed side of the fence. The mean river width was 21.4 m (± 17.2 m) for the ungrazed side of the fence (n=12) and was insignificantly different (F= 0.5, p= 0.5) to the grazed (n=13), which was 17.1 m (± 13.1). Table1.

There was an insignificant difference in the number of channels in the fenced area compared to the unfenced area. The mean number of channels for the un-grazed plots (n=12) was 3.2(± 2.0) and was insignificantly different F= 3.3, p = 0.1) to the mean number of channels on the grazed side(n=13) which was 2.5 (± 1.4). Table 1.

The mean channel width on the un-grazed side of the fence (n=12) was 7.4 m (± 4.7) and was insignificantly different (F= 0.0, p = 1.0) to mean channel width of the grazed (n=12) which was 7.6 (± 5.2).

Average channel width is the channel width divided by the number of channels. The average channel was insignificantly different ($F = 0.2$, $p = 0.7$) on the two side of the fence, on the grazed side ($n=13$) the mean was 2.9 m (± 2.2). The mean on the un-grazed side was 2.6 (± 1.6).

The un-grazed side of the fence had an overall higher % dead bush to the grazed side. The difference however was insignificant. The mean % dead bush for the un-grazed side of the fence ($n=12$) was 2.9 % (± 5.3) and was insignificantly different ($F = 0.0$, $p = 0.9$) from the % dead bush on the grazed side of the fence ($n=13$), which was 2.8 % (± 7.3).

The mean dead wood for the ungrazed ($n=12$) was 2.9 % (± 6.3) and was insignificantly different ($F = 0.0$, $p = 0.5$) to that of the grazed ($n=13$) which was 7.3 % (± 19.3). Table 1.

Total obstructions, obstacles that block water flow include % dead wood, % plant cover and % dead bushes. There were more obstacles on the ungrazed side of the fence. The mean % obstacles for the ungrazed ($n=12$) was 39.3 % (± 13.6) and insignificantly different ($F = 0.6$, $p = 0.5$) to that of the grazed ($n = 13$) which was 33.2% (± 25.5). Table1.

ANOVA showed variations among sites for all the river characteristics except plant cover to be insignificant ($p>0.05$).

VEGETATION ANALYSIS

There is a significant difference in plant cover between the grazed and ungrazed plants, with the ungrazed plants having higher cover (transect data, table 1). The mean plant cover for the un-grazed side of the fence (n=12) was 30.4 (± 1.9) and was significantly different (F = 11.17, p = 0.003) to the % plant cover on the grazed side (n=3), which was 16.3 (± 8.9). Plot data showed no significant difference in un-grazed and grazed treatments in terms of plant cover.

Volume studies were only done on *Lycium cinereum* species on one of the three sites, for the two side of the fence, grazed and ungrazed. The *Lycium cinerium* species on the grazed side had much larger volumes compared to the grazed side (figure 2). However this difference in volumes was insignificant (F = 3.3, p = 0.1). The mean volume on the ungrazed side was 469,3 cm^3 (± 88,9) and that of the grazed was 252,7 cm^3 (± 79,5).

Measuring numbers of flowers gives an indication of the potential of sedges to recruit from freshly produced seeds. The mean number of flowers for ungrazed plants (n=53) was 229 (±279) and was significantly different (t=3.19, p=0.0)to the mean number of flowers for grazed plants (n=53), which was 82(± 182). Figure 6 and 7 show the number of flowers produced by sedge plants (*Scirpus nodosus)* in the two treatments grazed and un-grazed.

Figure 4 and 5 show the difference in seedling numbers of palatable and unpalatable species. Note the high numbers of *Galenia africana* seedlings in figure 5, (picture taken from grazed treatments), compared to figure 4 taken (picture taken from an un-grazed treatment).

Appendix 1 shows species cover values for the different sites and treatments. A multi dimensional plot of all the sites (showing similarity on plant cover as a distance measure) showed no overlaps between sites and treatments, (figure 3). Site two grazed treatments are grouped together and closely related to site two un-grazed treatments, also grouped together. This is the case for all the other sites. Un-grazed treatments are not grouped together and separate from the grazed treatments. This shows that the three river systems are distinct. This is also shown in the results of the physical characteristics of the catchments (table 1).

There were variations in total numbers of individuals and total numbers of species, on a plot level depending on the sites. There was no significant difference in the number of species ($p>0.05$), percentage cover ($p>0.05$), and total number of individuals per plot ($p>0.05$), based on the treatments (Table 2). There was also no significant difference in the % growth forms in treatments (table 2), except with stem succulents, which were significantly ($p<0.05$) higher in grazed treatments. Results of species number can are noted in appendix 1 and those of % cover and % growth forms in appendix 2.

Table 1: Physical characteristics of the river & vegetation characteristics

Treatment	RIVER CHARACTERISTIC							
	% Plant cover (%)	River width (m)	Channel width (m)	# Channels	Average channel (m)	% dead bush (%)	%dead wood (%)	Total obstruction (%)
Grazed 33.2±25.5	16.3±8.9	17.1±13.1	7.6±5.2	2.5±1.4	2.9 ± 2.2	2.8±7.3	7.3±19.3	
Un-grazed 39.3±13.6	30.4±1.94	21.4±17.2	7.4±4.7	3.2±2.0	2.6±1.6	2.9±5.3	2.9±6.32	

Table 2: Numbers of species, % cover and % growth forms

	Treatment	
	Un-razed	Grazed
Mean no of species	12.5±3.5	13.8±3.1
Mean % Cover	31.6±6.9	22.5±9.9
Mean total individuals	91±46.3	155±107.8
%Growth Form		
Deciduous shrub	4.2±4.1	2.0±2.3
Evergreen shrub	7.3±5.6	6.2±6.3
Geophytes	1.6±1.3	2.0±2.2
Grass	1.4±1.8	0.3±0.5
Herb	1.2±1.8	0.7±1.7
Leaf succulent shrub	2.8±1.7	2.4±2.0
Sedge	14.0±14.1	11.0±11.3
Stem succulent	0	0.51±0.5

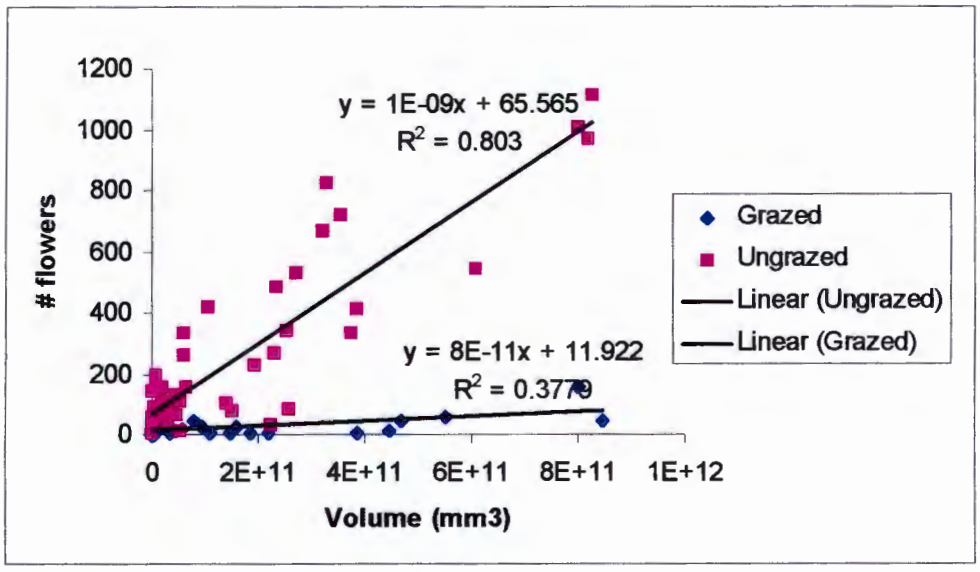


Figure 1: The number of flowers against for the two treatments, grazed and un-grazed for the sedges species.

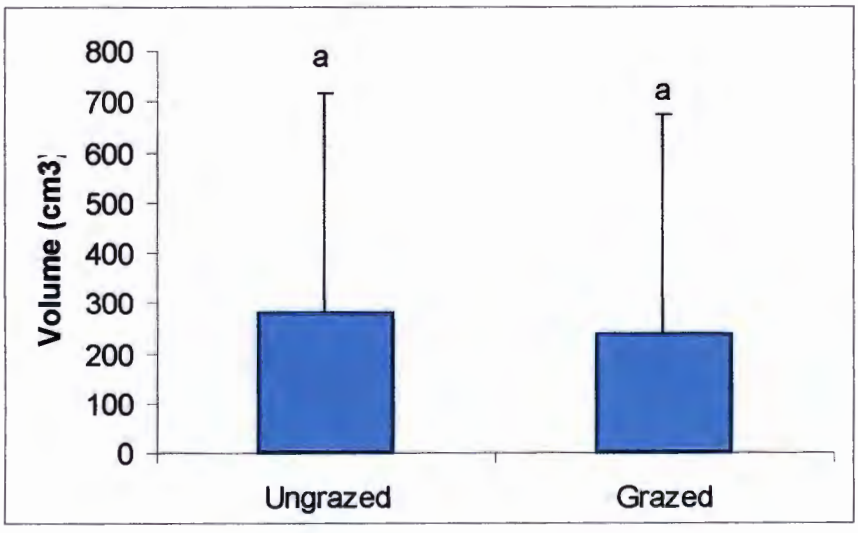


Figure 2: Volume measurements for the two treatments. For *Lycium cinereum* Species. There were high standard deviations obtained in both treatments.

Figure 3: A multiple dimensional plot representing different sites and treatments

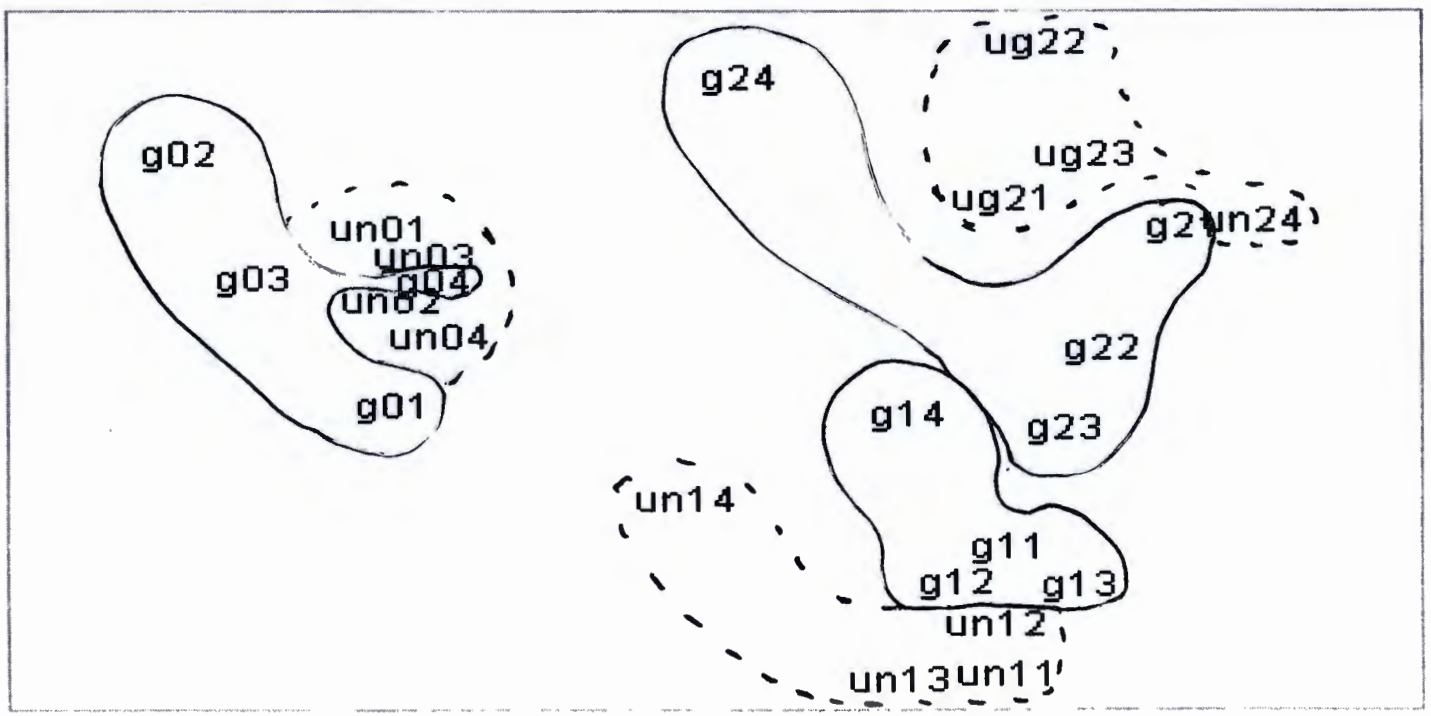


Figure 4: A picture taken from the area of study, showing young developing *Hypertilis salsaloides* seedlings. Picture taken from the un-grazed treatments. Note the vast number of flowers produced and all the seedlings around the parent plant.

Figure 5: Picture showing mainly *Galenia africana* seedlings. Taken from an un-grazed treatment at one of the sites. Palatable species seedlings are few in these sites.

Figure 6: Picture of a sedge plant taken from one of the grazed site outside the fenced area of Moedverloor. Note there are only few flowers on the plants.

Figure 7: Picture of sedge plants taken from one of the un-grazed sites inside the fenced area of Moedverloor. Note the large numbers of flowers on the plants.

DISCUSSION

The rivers were generally dominated by sedges (*Scirpus nodosus)*, *Elytropappus rhinocerots* and grasses. Away from the river more annual and geophytes as well as the poisonous unpalatable species were evident.

EFFECT OF SHORT TERM REST ON SPECIES DIVERSITY

The species diversity in both treatments, grazed and un-grazed was the same, despite the heavy, continuous selective grazing in the unfenced area of Moedverloor. This could be due to the fact that changes in species diversity take a long time to become evident (Wiegand and Milton 1996), as a result of the longevity of Karoo shrubs, which exceeds 50 years for some species. Thus a complete shift in species diversity may take centuries to emerge.

The heterogeneity and exceptional diversity of the region may have played a vital role in limiting the impact of heavy grazing on species richness (Todd and Hoffman 1999). These results compare favorably with those achieves by Todd and Hoffman (1999), on species diversity between communal rangelands and commercial rangelands in the same area of Leliefontein, Paulshoek.

EFFECT OF SHORT-TERM REST ON PLANT COVER AND GROWTH FORMS

Heavy grazing resulted in a significant decrease in plant cover (transect data). Cover is reduced as a result of continuous grazing, which alters the dominance of perennials in favour of annuals and other toxic species. An analysis of cover shows the three river systems as distinct, one should bare this in mind when making necessary changes to the systems.

Palatable species such as stem succulents, leaf succulents, Sedge species and perennials had a slightly higher cover on the un-grazed, fenced side of moedverloor, compared to the continuously grazed side, however the differences were insignificant except in stem succulents which were none existent in the grazed treatments. The grazed treatments showed an increase in cover of geophytes and toxic species such as *Galenia africana,* differences are however insignificant.

These studies reveal short-term is important in the recovery of palatable species cover. Todd and Hoffman (1999) noted similar results.

EFFECT OF SHORT-TERM REST ON FLOWER PRODUCTION OF *SCIRPUS NODOSUS*

The un-grazed, fenced area of Moedverloor had significantly higher numbers of flowers than the grazed, unfenced side. There were large reductions in flowering and seed set due to grazing. Livestock continuously feed on the flowers of the *Scirpus nodosus,* not giving them a chance to set seed. Similar results were observed in studies by Milton (1992) on *Osteospermum sinuatum,* results showed a 90% reduction in potential seed set. Todd and Hoffman (1999) also found similar results on the same species.

The reduction in seed set has huge implications on the recruitment rate of the palatable species (Todd and Hoffman 1999). Although no studies were done on the number of seedlings in the un-grazed and grazed treatments, there were pictures taken to show the proportions of palatable seedlings to those of the unpalatable. It is evident from these studies that seed set is the limiting factor limiting the recruitment rate on the exposed grazed rangelands. High densities of *Galenia africana* on the unfenced, grazed rangelands shows the recruitment of these species is improved, with no competition from other species they quickly take over producing even more seeds and seedlings. High densities limit the carrying capacity and prevent the establishment of forage species (Milton and Hoffman 1994) as cited by Todd and Hoffman (1999).

This highlights the need for a proper grazing strategy, which will allow some areas to be rested and given the opportunity to produce seed.

Although short-term rest might improve the recruitment of the palatable species there is no guaranty that it will reduce the numbers of *Galenia africana*. These shrubs are long

lived and prevention from grazing alone may not reduce their numbers, prevention of grazing shows ans an increase in palatable species.

Although the land may never get back to its original state (Todd and Hoffman 1999) short tem rest will improve the number of palatable species and possibly reduce those of unpalatable species.

EFFECT OF SHORT-TERM REST ON THE VOLUME *OF LYCIUM CINEREUM* SPECIES

Short-term rest increased the volume of the *Lycium cinereum* species however the decrease was not significantly. The insignificant reduction of the *Lycium cinereum* species exposed to overgrazing could be correlated to the high standard deviations observed in the volume study of these species. Livestock continuously feed on this palatable species thus reducing its volume. This is the case for most palatable species exposed to continuous grazing regimes. It is not just the reduced volume of the species that is a problem but more importantly the ability to produce seeds.

Short-term rest allows palatable shrubs to grow to their full potential, thus eliminating the crippling effect and allowing for reproduction and seed set.

EFFECT OF SHORT TERM REST ON THE PHYSICAL CHARACTERISTICS OF THE RIVER

Overgrazing results in the removal of vegetation on the riverbanks (Haslam 1990), resulting in bank erosion. Contrary to studies by Lindiwe Gaika (1999) on the physical characteristics of rivers on communal and commercial rangelands, the rivers in the un-grazed treatments were wider and had more channels. This could due to the history of the catchments before the area was fenced. The river systems were probably overgrazed before the elimination of grazing and have not yet recovered.

There were more dead shrubs in the un-grazed treatments, this was also contrary to our expectations, however there was less dead wood in the un-grazed sites compared to the grazed. Overgrazing results in the death of most palatable species, thus the grazed treatments are expected to have more dead wood and shrubs. This was however not the case with dead shrubs, this is probably due once again to the history of the area.

It can be concluded in this study that more time is required, in order for significant differences in river physical characteristics to occur, between grazed and un-grazed treatments.

CONCLUSION

Short-term rest did not have major implications on species diversity due to the high longevity of the shrub species within the region of Paulshoek and Namaqualand, also due to the large number of species in the area that are able to take advantage of the disturbance caused by grazing in the area.

Short-term rest is however, vital for seed set and the recruitment of species allowing for growth recovery of the palatable species.

No significant results were obtained for the physical characteristics of the river, as the history of the grazing regime in the area of study outweighed grazing elimination time. More time is required to be able to make reasonable conclusions in this area of study.

Short-term rest might not lead to the full recovery of species composition and cover but it does have major implications for the survival of the palatable species in the short term and eventually in the long term.

The implementation of proper grazing strategies in communal areas, education and a proper knowledge and access to local and international markets, will go a long way to improving the degraded nature of the communal rangelands in Namaqualand.

ACKNOWLEDGEMENTS

I would like to that my two supervisors who helped in the fieldwork and gave all the support I needed. Thanks to the two French students who also helped in field work. A special thanks to Sors Cloete one of the inhabitants of Paulshoek who also helped in field work and in giving me a general understanding of the history and current conservation issues in Paulshoek. A final thanks to the inhabitants of Paulshoek for their hospitality and good nature. Thanks to the Mazda Wildlife fund for the use of a courtesy vehicle. The financial support of the European Union funded project, Maposda is also acknowledged.

APPENDIX 1

		% COVER																							
	Growth	Ungrazed 0			Grazed 0				Ungrazed 1			Grazed 1					Ungrazed 2			Grazed 2				
	form	un01	uno2	un03	un0	g01	g02	g03	g04	un1	un12	un1	un1	g11	g12	g13	g14	ug21	ug2	ug23	un24	g21	g22	g23	g24
Aizoon sp	A	1	0.01	2	1	1	0.2	0.1	1	1	0.05	3	1	0	0.01	0	0	0.01	0	0	0	0	3	0.1	0
Annual grass	A	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aptosimum indivism	A	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aptosimum soft	Ds	0.01	0	0.2	0.1	0	0	0	0	0.01	0.01	0	0	0.1	1	1	0.05	1	0.5	0.1	1.5	0	1	0.1	0.02
Artemesia sp	Ev	0.01	0.01	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atriplex perennial	Ev	0	0	0.01	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atriplex semibaccata	A	2	2	1	1	2	0.2	0.5	1	0.01	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0
Berkheya	He	0	0	0	0	0	0	0	0	2	0.01	0	0	0	0	0	0.05	0.01	0	0	0	1	1	0	0
Bulbine sp	De	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	Ev	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
Chrysocoma ciliata	De	0.5	0	3	0	0	0.01	0	0.01	0.1	1	0.01	1	0.1	1	0	0.5	0	2	1	1	0	1	0.1	0.1
Conocosia(farkisknol)	Ge	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drosanthamum hispidu	LS	2.5	1	0.5	2	0	1	1	0	0	0	0	0	1	0.01	0	0.01	0.5	1	0	0	1	0	0	0.1
Drosanthamum sp2	LS	0	0	0	0	0	0	0	0	0.1	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Elytropappus rhinoceroti	Ev	0	0	0	0	0	0	0	0	12	7	5	6	4	12	8	3	0	0	0	0	0	0	0	0
Eriocephalus ericoides	De	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	2	0	1	0	0
Eriospermum sp	Ge	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphorbia decussata	Ss	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0.1	0	0.01	0
Felicia sp	De	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5	0	2	0.01	0	0	0	0
Galenia africana	Ev	0.1	1	0.2	0.2	1	0.1	0.5	1	6	4	4	2	7	4	7	6	9	8	15	12	5	4	14	1
Gazania	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0.01
Geophyte	G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
Gerenium Molle	He	0	0	0.01	0.01	0	0.01	0.01	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grass	Gr	0	0	0	0	0	0	0	0	0	1	2	5	1	0.05	0	0	0.1	0	0	0.01	1	0	0.1	0
Hermannia amoena	Ev	0	0	0	0	0	0	0	0	0	0	0.01	0	0.1	0	0	0.01	0	0	0	0	0	0	0	0
Hirpicium alienatum	Ev	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypertilis salsaloides	LS	0.1	1	1	0.2	0.1	0.1	0.1	0.1	0	0.5	0.01	0.5	0	0	0	0.1	0.1	0.3	2	1	1	1	0.5	0.2
Leipoldtia schulzii	Ls	0	0	0	0	0	0	0	0	1	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidium sp	A	0	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotononis sp	He	0	0	0	0	0.01	0	0	0.5	0	0	0.01	0	0	0	0	0	0	0	0	0	5	0	0	0
Lycium cinereum	De	5	2	2	6	0.1	1	0	1	0	0	0	3	0	0	0	0.5	3	7	3	0.3	0	0	0	2.5
Lycium ferocissimum	De	0	5	0	0	0	0	0	0	3	0	0.01	0	4	0	0	3	6	0	0	0	0	3	3	0
Mesembryanthemum capobrotis	EG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	1	3	2	3	4	0	0	0
Mesembryanthemum chrystalium	A	0.01	0	0.1	0.1	0	0.2	0.1	0.1	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01
Mesembryanthemum psilocodon	SS	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mesembryanthemum sp	LS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

		% COVER																								
	Growth	Ungrazed 0			Grazed 0				Ungrazed 1			Grazed 1					Ungrazed 2			Grazed 2					
	form	un01	uno2	un03	un0	g01	g02	g03	g04	un1	un12	un1	un1	g11	g12	g13	g14	ug21	ug2	ug23	un24	g21	g22	g23	g24	
Oxalis	Ge	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Pentzia incana	De	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Pteronia divoricata	Ev	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Pteronia incana	Ev	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0.01	1	0.4	0.5	0	2	0	0	
Raap	Ge	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	
Ruschia robusta	LS	0	0	0.5	0	5	0	0	0	0	0	0	3	2	6	0	5	4	0	0.01	0	0	0	0.5	1	
Salsola	Ev	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	
Sand grass	Gr	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Scirpus nodosus	Se	5	5	7	7	8	2	6	3	0	0	0	4	0	0	0	3	0	0	0	0	0	0	0	0	
Senecio burchellii	He	0	0	0	0	0	0	0	0	0	2	2	5	0.1	0	0	0	1	0	0	0.5	0	0	0	0	
Spiky geophyte	Ge	2	2	3	0	6	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Teeblom	De	0	0	0	0	0	0	0	0	0.01	0	0.01	0	0.1	0	0	0	0.2	0	3	0	0.5	0	0	0	
Thubee geelblom	Ev	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1.5	1	0	0	0	
Tretragonia fruticosa	De	0	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Tripteris sinuatum	De	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	
Weedy composit	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	2	0	0	0	0	
Zygophyllum microphyllu	Ev	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown 1	LS	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown 2	He	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	
Unknown sp 3	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0.1	0	0	0	0	
Unknown sp 4	LS	0.1	2	2	0.2	0.1	0.2	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 5	He	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 6	He	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	
Unknown sp 7	De	0.1	1	0.1	0.1	1	0.01	0.1	1	0	0	0	0	1	0.01	0	0.01	1	0	0	0.05	1	1	0.2	0.2	
Unknown sp 8	Ev	0	0	0.01	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 9	Ev	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 10	Ge	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 11	De	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 12	De	0	0	0	0	0	0	0	0	0	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 13	De	0	0	1	0	0.01	0	0.01	0.1	3	0	0	0	0	0.5	0	0.5	0.1	0	1	0	0	1	0.02	0.1	
Unknown sp14	Ev	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 15	He	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unknown sp 16	De	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dead Litter		0.5	0.5	0.5	4	1	0.28	0.2	1	2	2	3	2	5	3	2	0.5	1	1	1	2	1	1	2	0.5	
Dead Shrub		3	6	6	6	10	0	2	2	15	8	6	5	7	5	3	0.5	1	0	3	2	3	2	3	0.5	
Total % cover		18.4	26	25.7	18.1	26.9	8.16	12.5	11.9	30.3	18.6	16.6	32	20	25.6	16	26.3	31.5	25	30.5	29.47	22	20	20.1	5.26	
Annual	A																									

APPENDIX 2

	No of Individuals																							
Gro	Ungrazed 0				Grazed 0				Ungrazed 1				Grazed 1				Ungrazed 2				Grazed 2			
	un01	uno	un03	un04	g01	g02	g03	g04	un11	un12	un13	un14	g11	g12	g13	g14	ug2	ug22	ug23	un24	g21	g22	g23	g24
Aizoon sp	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annual grass	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aptosimum indivism	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aptosimum soft	0	0	8	2	0	0	0	0	1	1	0	0	1	150	77	9	22	8	17	8	17	5	13	47
Artemesia sp	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atriplex perennial	0	0	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atriplex semibaccata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Berkheya	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	5	1	0	1	0	97	260	0	0
Bulbine sp	0	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Chenopodiaceae	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Chrysocoma ciliata	1	0	8	0	0	1	0	1	2	7	5	6	2	9	4	13	0	13	9	5	0	9	4	3
Conocosia(farkisknol)	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drosanthamum hispidu	3	4	17	3	0	2	6	0	0	0	3	0	4	1	0	3	2	0	2	0	18	0	0	3
Drosanthamum sp2	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	9	0
Elytropappus rhinoceroti	0	0	0	0	0	0	0	0	2	2	1	1	1	2	1	2	0	0	0	0	0	0	0	0
Eriocephalus ericoides	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	1	1	1	1	2	4	0	0
Eriospermum sp	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Euphorbia decussata	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	1	0
Felicia sp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0	6	2	1	0	0
Galenia africana	6	43	71	9	120	130	48	49	8	9	31	26	22	28	22	24	18	7	25	55	29	10	22	19
Gazania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	2
Geophyte	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	3
Gerenium Molle	0	0	1	1	0	1	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hermannia amoena	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	1	0	0	0	0	0
Hirpicium alienoctum	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypertilis salsaloides	5	18	7	6	4	2	13	9	0	6	1	4	0	0	0	8	3	19	9	12	84	15	17	11
Leipoldtia schulzii	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Lepidium sp	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lotononis sp	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Lysium cinereum	5	2	2	2	1	2	0	2	0	0	0	2	0	0	0	1	1	2	4	3	0	0	0	3
Lysium Fero	0	3	0	0	0	0	0	0	1	0	1	0	2	0	0	1	4	0	0	0	1	2	2	0
Mesembryanthemum capobrotis	0	0	0	0	0	0	0	0	0	0	1	0	11	0	0	0	2	0	0	0	1	2	0	0
Mesembryanthemum chrystalium	1	0	12	0	0	1	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Mesembryanthemum psilocodon	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mesembryanthemum sp	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

	No of Individuals																							
Gro	Ungrazed 0				Grazed 0				Ungrazed 1				Grazed 1				Ungrazed 2				Grazed 2			
	un01	uno	un03	un04	g01	g02	g03	g04	un11	un12	un13	un14	g11	g12	g13	g14	ug2	ug22	ug23	un24	g21	g22	g23	g24
Oxalis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pentzia incana	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteronia divaricata	5	3	11	0	2	2	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pteronia incana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Raap	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Ruschia robusta	0	0	1	0	8	8	0	0	0	0	0	2	1	5	0	6	1	0	0	1	1	0	8	3
Salsola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Sand grass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scirpus nodosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Senecio burchellii	0	0	0	0	0	0	0	0	0	9	6	17	6	0	1	0	5	5	0	0	0	0	0	0
Spiky geophyte	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Teeblom	0	0	0	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0
Thubee geelblom	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0
Tretragonia fruticosa	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tripteris sinuatum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	2	0	2	135	0	1
Weedy composit	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zygophyllum microphyllu	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown sp1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Unknown sp2	0	0	12	0	1	0	2	2	131	0	0	0	0	9	0	3	45	0	1	7	0	8	2	2
Unknown sp3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	3	2	0	0	0	0	0
Unknown sp4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown sp5	13	11	7	4	1	5	5	7	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Unknown sp6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Unknown sp7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	9
Unknown sp8	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Unknown sp9	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	8	0	29	13	0	1	0	0
Unknown sp10	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown sp 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Unknown sp12	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Unknown sp13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Unknown sp14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	0	0	0	0
Unknown sp 15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	62	0	0	0	0	0	0	0	0	0
Unknown sp 16	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Dead Litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dead Shrub	0	0	7	7	4	10	4	7	7	2	10	7	8	7	1	3	7	3	1	4	5	9	7	3
Total No of indiniduals	40	87	169	27	142	165	92	79	150	37	59	67	93	209	179	100	133	112	103	111	257	453	86	107
Total No of Species	8	9	17	8	13	20	12	10	12	10	17	14	17	11	11	17	18	13	13	11	16	15	11	13

REFERENCES

Cowling R.M and Hilton-Taylor C. 1994.Patterns of plant diversity and endemism in South Africa: an overview. Pages 31-52.

de Bruyn T.D, Goqwana M and van Averbeke W. 1998. Is communal grazing in the eastern Cape Sustainable? Veld and Flora.

Evans N.V, Avis A.M and Palmer A.R. 1997. Changes to vegetation of the mid Fish River Valley, Eastern, Cape South Africa, in response to land use, as revealed by a direct gradient analysis. African Journal of Range and Forage Science 15(2): 68-74.

Hilton-Taylor C.1996. Patterns and characteristics of the flora of the succulent karoo Biome, Southern Africa: 58-72.

Gaika L.1999. Changes in riverine associated with heavy grazing in winter rainfall succulent karoo. MSc Thesis. Department of Botany. University of the Western Cape.

Milton S.J.1992. Effects of rainfall, competition and grazing on flowering of *Osteospermum sinuatum (*Asteraceae) in arid karoo rangelands. South African Journal of grassland society 9:158-164.

Milton S.J, Dean W.R, du Plessis M.A and Siegfried W.R.1994. A conceptual model of arid degradation. The escalating cost of declining productivity. Bioscience 44:70-76.

Milton S.J and Hoffman M.T.1994. The application of state and transition models to rangeland research and management in arid succulent and semi-arid grassy karoo, South Africa. African Journal of Range and Forage Science 11:18-26.

Todd S.W and Hoffman M.T. 1998.Communal rangelands in semi arid South Africa. Veld and Flora 84:3.

Todd S.W and Hoffman M.T. 1999. A fence line contrast reveals effects of heavy grazing on plant diversity and community composition in Namaqualand, South Africa. Plant Ecology.

Water Research Commission. 2001. State of the Rivers Report. Printed in South Africa.

West N.E. 1993. Biodiversity of rangelands. Range management 46:2-13.

Wiegand T and Milton S.J.1996. Vegetation change in semi-arid communities. Vegetation 125: 169-183.

Thorrrington-Smith E, Middleton E.A, Fair T.J, Pistorius R.A and Davies G.A. 1952.Tugela Basin Regional Survey. A regional survey of the catchment area of the Tugela river and its tributaries. The Natal Witness, Pietermarisburg.