Effects of grazing intensity and rainfall on plant population dynamics in the Succulent Karoo, South Africa

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Introduction & study site

One of the major threats to the exceptionally high biodiversity of the Succulent Karoo, a winter rainfall desert in South Africa, is heavy livestock grazing. In addition, recent climate change projections indicate a future decrease in rainfall. The study was conducted on a pair of two BIOTA Biodiversity Observatories near the village Paulshoek. One is grazed with low intensity and in a good condition, the other intensively grazed and strongly degraded (Fig. 1). On the overgrazed site, the diverse succulent dwarf shrub community tends to be replaced by stands dominated by the unpalatable species *Galenia africana*.

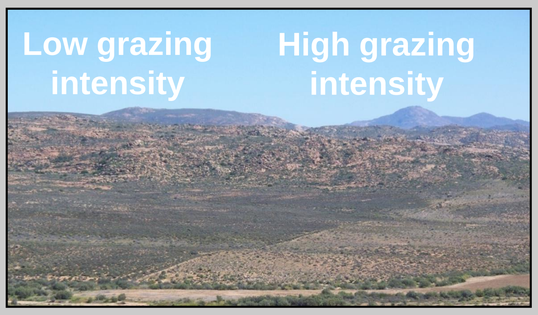

Figure 1. Pair of two BIOTA Biodiversity Observatories near Paulshoek (Succulent Karoo, South Africa) with well pronounced fenceline contrast. (photograph: J. Weber 2008)

Data collection

We monitored abundances (i.e. number of individuals) of the most common 52 perennial plant species over 7 years (2002–2008), on 36 permanent plots (19 grazed with low, 17 with high grazing intensity). The time series were handled with the BIOTAbase software. Rainfall data were obtained from a weather station positioned in the centre of the study site.

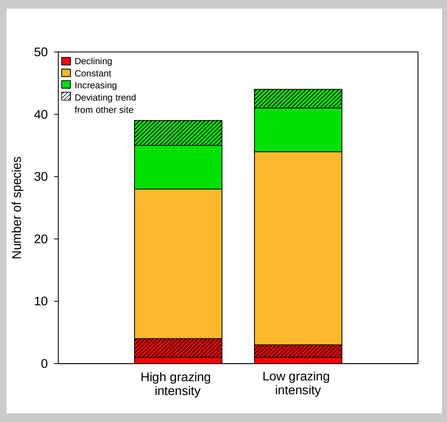

Figure 2. Comparison of numbers of species between the two grazing intensities with respect to population trends. Hatched stacks indicate deviating trends from the other site.

Research questions

1. Has the vegetation changed over the seven years and did grazing intensity impact population trends? →
2. Have population sizes of key palatable or unpalatable species increased or decreased under the differing grazing intensities? →
3. How did three subsequent dry years influence key species and what conclusions can be drawn with respect to climate change predictions? →

Statistical methods

Relative changes in abundance from year to year were analyzed by ANCOVAs (relative abundance ~ grazing intensity x year), first all taxa combined, then species-wise.

Simple linear regressions (relative abundance ~ year) were conducted. In case grazing intensity had no influence, regressions were conducted jointly for the both sites, in case grazing had a significant effect, separately.

The population dynamics were interpreted with respect to annual rainfall patterns.

Results

1. Generally, total perennial plant cover (i.e. relative abundances of all taxa) slightly increased over the 7-year. monitoring period. This trend was unaffected by grazing intensity (Fig. 3a).

2. Populations of most species remained constant, while 14 species significantly increased and 6 species significantly decreased over the years (Fig. 2). On the site with high grazing intensity the percentage of species with significant changes in population size was higher (38%) than on the site with low grazing intensity (29%). For 11 species, the population trends depended on grazing intensity. Among these are highly palatable species increasing only at low grazing intensity and poisonous species increasing only on the intensively grazed site (Fig. 3b–e).

3. Total perennial plant cover showed a clear decline in 2005/06, probably a postponed reaction to the dry years from 2002–2004 (Fig. 3a). The majority of species has recovered, within three years of good rain. By contrast, the population of *Galenia africana*, a toxic degradation indicator, increased in the years 2005/06 and declined in the following years (Fig. 3f). The pioneer species is a weak competitioner and probably benefited from decreased competition (and vice versa).

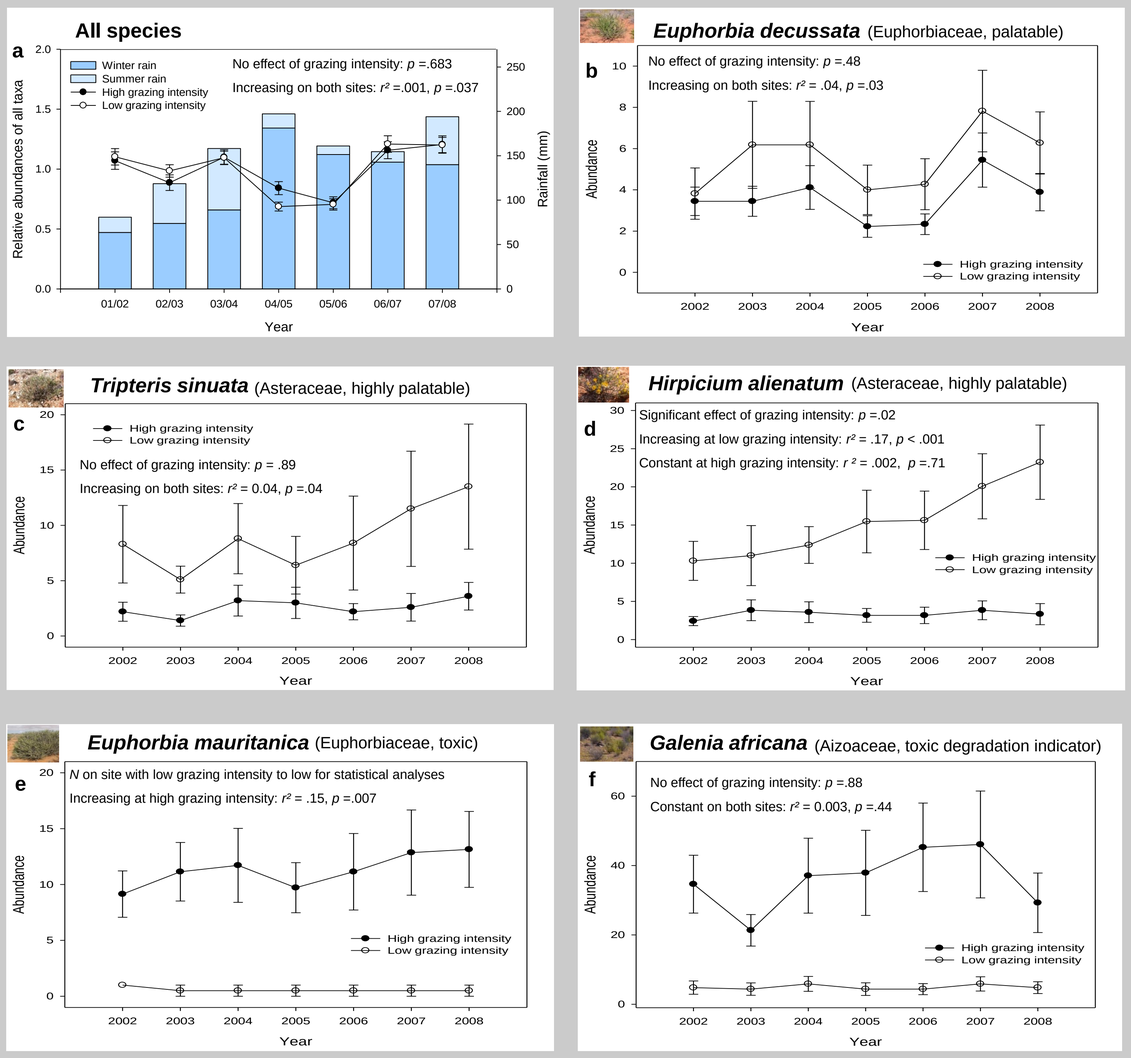

Figure 3. (a) means (±SE) of relative abundances of all species and annual precipitation, with summer rain including precipitation of the summer months of the previous year, respectively. (b-f) Means (±SE) of species abundances. (a-f) *p* values for differences between grazing intensities result from ANCOVAs (relative abundance ~ grazing regime x year), r^2 and *p* values for population trends result from simple linear regression analyses (relative abundance ~ year).

Conclusions

1. During the seven years, total perennial plant cover increased on the two BIOTA Observatories. This trend was independent of grazing intensity. One explanation could be that the vegetation is still recovering from a severe drought in 1999. Another could be fertilization through increasing CO_2 concentrations.
2. Differences in population growth of key species among the two sites show that the vegetation is still diverging as a result of the different grazing intensities, with the tendency to favor unpalatable species on the degraded site.
3. Future decrease in rainfall due to climate change may affect populations of some species negatively. At the same time, pioneer species, which are often weak competitioners, may be influenced positively.