Resource variations across the landscape mediate the impact of grazing on vegetation in Mongolian rangeland under high climatic variability

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Introduction

Assessment of grazing-induced degradation of arid and semi-arid rangelands with stochastic rainfall regimes is challenging. For the last two decades, rangeland ecologists have been discussing the relative importance of biotic and abiotic factors in controlling vegetation dynamics. According to the non-equilibrium concept, which emerged as a new paradigm to describe ecosystems in highly variable and poorly predictable environments, vegetation dynamics are driven primarily by abiotic factors such as rainfall, rather than by internal biotic regulation (*e.g.* grazing impact). Although a number of studies have emphasized the non-equilibrium nature of most rangelands, they have produced inconsistent results and there is still no consensus on the relative importance of grazing impact. Alternatively, recent studies have suggested that a continuum of systems exists, rather than a stark dichotomy between equilibrium and non-equilibrium rangelands. Moreover, theoretical studies have predicted that, in addition to climatic variability, resource variations occurring in space and time as a result of landscape heterogeneity should be taken into account in assessments of grazing impact. However, there have been few empirical studies of the role of resource variations in either mitigating or enhancing the impacts of grazing on vegetation.

This study explores the impact of grazing strategies on vegetation in Mongolian rangelands under high climatic variability. Specifically, it is focused on key resource areas, defined in terms of the key factor determining livestock population, and thus the ability to forage during drought. Based on the prediction proposed by Illius and O'Connor (1999) that animal numbers are regulated in a density-dependent manner by the limited forage availability in key resource areas, we established and examined the hypothesis that grazing impacts would be greater in key resource areas than in other areas even in Mongolian rangelands.

Methods

Study area

The study area was located in the Saintsagaan *sum* (district), which includes the city of Mandalgobi (45°46′N, 106°16′E) in Mongolia's Dundgobi Province. Mandalgobi is located in the desert-steppe ecological zone. According to the prediction that non-equilibrium dynamics predominate in areas where mean annual precipitation is less than 250 mm and precipitation coefficient of variation exceeds 33%, the study site was considered to be in a highly variable environment. Our survey examined in July to August 2010, and total precipitation in 2010 is 101.8 mm, and total precipitation in the previous year of research was 81.0 mm, therefore we considered 2010 as normal year.

Sampling design

We established study sites in four typical vegetation communities (*Caragana*, *Allium*, *Achnatherum* and *Reaumuria*) according to landscape type (Hill slope, Tableland, Pediment and Depression). First, we interviewed key informants about the four community types to examine how local pastoralists used these communities during normal and drought summers. Second, to determine grazing impacts on vegetation in each community, we set up 20 quadrats (each 1 m × 1 m) each within a grazed and an ungrazed plot in each community. We identified all species present in the quadrats, estimated their percentage cover and calculated the dissimilarity indices between the ungrazed and grazed plot in each community. We then compared the dissimilarity indices among the four communities. Finally, we compared dung pellets numbers among communities to quantify the different grazing impacts on each community.

Results

According to respondents, during normal summers all types of community were used, but during drought the main community used was *Achnatherum* community (Fig. 1).

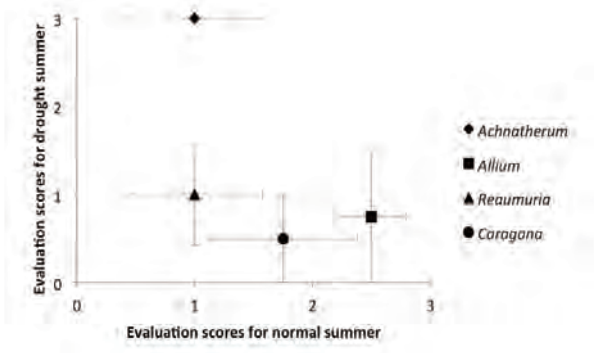

Figure 1. Key informants' evaluation scores for communities during normal and drought summers. Error bars represent means ± SE.

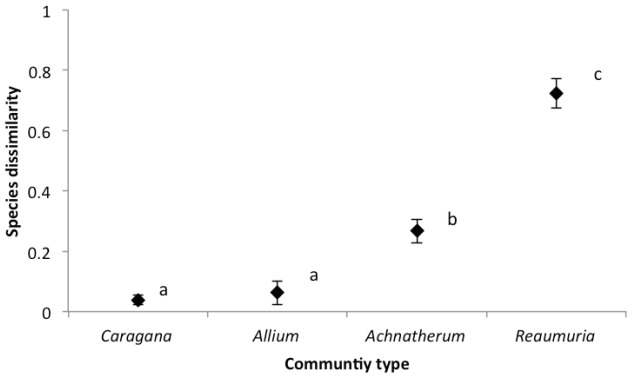

Figure 2. Comparison of species composition dissimilarity (Sørensen's index) among communities. Error bars represent means ± SE. Letters indicate differences among communities at the P< 0.05 level (*t*-tests with Bonferroni's correction).

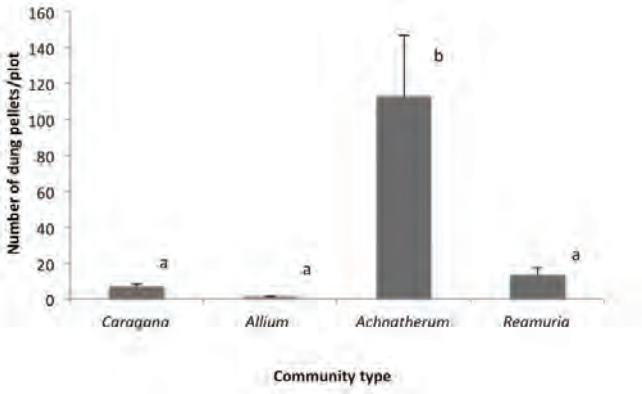

Figure 3. Comparison of numbers of dung pellets among communities. Error bars represent means ± SE. Letters indicate differences among communities at the P<0.05 level (*t*-tests with Bonferroni's correction).

The dissimilarity index of the *Achnatherum* community was the highest, indicating that species composition was significantly more affected by grazing in the *Achnatherum* community than in the other three communities (Fig. 2). The number of dung pellets was also highest in the *Achnatherum* community (Fig. 3), suggesting that this community was subject to the highest grazing intensity.

These results suggested that the distribution of grazing impact was uneven across communities, and that the *Achnatherum* community was affected more by grazing than were the other communities, supporting the predictions of theoretical studies that equilibrial forces exist over a limited part (*i.e.* key resource area) of the non-equilibrium environment.

Conclusion

The key finding of this thesis study is that grazing-induced degradation, that is, the equilibrium nature is detectable over key resource areas even in non-equilibrium environments by taking into account resource variations at a landscape scale in relation to the scale of local rangeland use. Therefore, to develop effective rangeland management systems the debate needs to be shifted from the equilibrium versus non-equilibrium dichotomy toward a greater awareness of resource variation.

References

Illius AW, O'Connor TG (1999) On the relevance of nonequilibrium concepts to arid and semiarid grazing systems. *Ecological Applications* **9**, 798-813.