

Grazing alters ecosystem functioning and C:N:P stoichiometry of grasslands along a regional precipitation

Yongfei Bai^A, Jianguo Wu^{AB}, Chris M. Clark^B, Qingmin Pan^A, Lixia Zhang^A, Shiping Chen^A, Qibing Wang^A and Xingguo Han^A

^A State Key Laboratory of Vegetation and Environmental Change, Institute of Botany, Chinese Academy of Sciences, Beijing, 100093, People's republic of China, <http://ivec.ibcas.ac.cn/en/>

^B School of Life Sciences and Global Institute of Sustainability, Arizona State University, Tempe, AZ, 85287-4501, USA, <http://sustainability.asu.edu/about/>

Contact email: yfbai@ibcas.ac.cn

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Introduction

Grasslands have experienced dramatic shifts in structure and functioning driven primarily by human disturbances and global climate change. The long-term grazing has resulted in widespread declines in biodiversity and ecosystem functioning and services. This is triggered by the direct and indirect effects of grazing and often mediated by the complex interactions between vegetation and environmental. Thus, it is critical to obtain a better understanding of how grazing, abiotic factors and biotic–abiotic interactions influence key properties of ecosystem functioning and sustainability and thereby provide guideline for improving grassland management practices in the Eurasian steppe. While abundant evidence demonstrates that heavy grazing alters the ecosystem structure and function of grasslands, research on how grazing specifically affects ecosystem functioning and stoichiometry on broad scales is scarce because of a lack of adequate ungrazed reference sites.

We examined the effects of grazing on ecosystem functioning and C:N:P stoichiometry along the 700 km China–Mongolia transect (CMT) using consistent methods. The CMT, which covers a wide range of biotic and abiotic conditions, enables us to observe the total effects of multiple mechanisms that probably operate simultaneously but vary in their relative strengths across regions. The key research questions we are trying to address are: 1) How has grazing affected ecosystem functioning (*i.e.* species richness, above- and below-ground biomass and litter biomass) and C:N:P stoichiometry of grasslands along the regional precipitation gradient during the last 50 years? 2) How do the responses of plant and soil C, N and P pools and stoichiometry to grazing differ among community types? 3) What is the relative importance of plant functional group (PFG) composition and species plasticity in influencing ecosystem functioning and stoichiometry?

Methods

We established 18 paired study sites on a regional transect across a precipitation gradient along the China–Mongolia border, which runs 700 km and covers three

major community types: meadow steppe, typical steppe and desert steppe. The ungrazed (control) sites were located within the fenced buffer zone along the China–Mongolia border, which has not been grazed by large herbivores for more than 50 years. In contrast, the grazed sites were inside the Chinese border, which have been subjected to grazing of different intensities since the 1950s. Leaf samples of 15 dominant and subdominant species, standing dead, litter, above- and below-ground standing biomass of herbaceous plants, and soil samples were sampled in 10 quadrats (1 m × 1 m) located randomly within a 100 m × 100 m area. C, N, P contents for both plant tissue and soil samples were measured in the laboratory after the transect survey.

Results

Long term grazing had marked impacts on the pattern of plant species richness, above-ground biomass and litter biomass along a precipitation gradient, but not on below-ground biomass (Fig. 1).

Grazing increased the foliar N, P contents of the dominant species in meadow and typical steppes, decreased their C:N ratio, and had strong impacts on their N:P ratio. Grazing significantly changed C, N and P pools in the grassland ecosystems, and thus their C:N:P stoichiometry.

Conclusion

Long-term grazing under high intensities not only alters ecosystem productivity and biodiversity (Bai *et al.* 2007), but also C, N and P pools and stoichiometry across the Inner Mongolian grassland, implicating that grazing altered N cycling in grassland ecosystems. The effects of grazing on C:N:P stoichiometry and ecosystem functioning are strongly mediated by precipitation and vegetation types. Grazing accelerates N cycling in meadow steppe, restrains N cycling in desert steppe, and it has both positive and negative effects on N cycling in typical steppe. Grazing-induced ecological C:N:P stoichiometry changes are mainly attributed to the functional responses of dominant species and plant functional group composition. Grazing significantly increased the foliar N, P contents of dominant species in

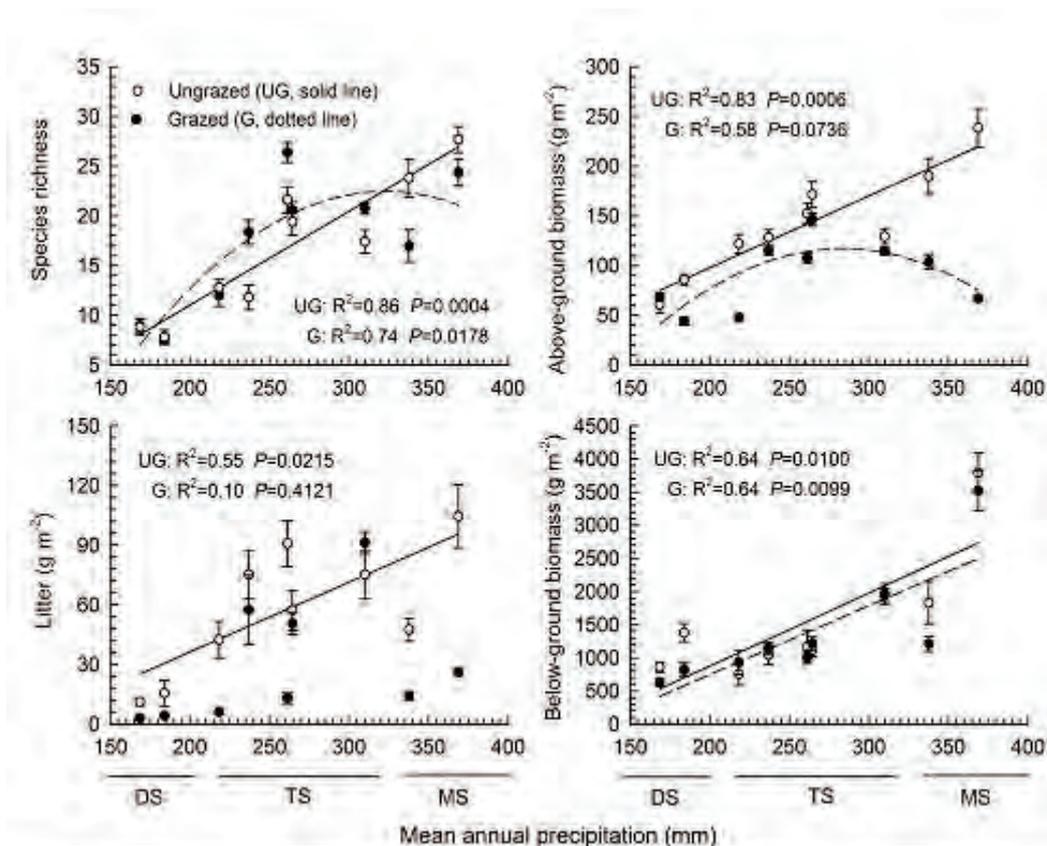


Figure 1. Relationships of species richness, above- and below-ground biomass, and litter biomass with mean annual precipitation across the ungrazed (UG) and grazed (G) sites along the China–Mongolia transect. MS, meadow steppe; TS, typical steppe; and DS, desert steppe.

meadow and typical steppes, decreased their C:N ratio, and had strong impacts on their N:P ratio.

As plant stoichiometric responses to grazing ranged from large in the meadow steppe to small in the typical steppe to generally insignificant in the desert steppe, this implies that different underlying mechanisms operated along the

regional precipitation gradient. Our findings suggest that reducing the stocking rate and restoring the vastly degraded steppes are essential to sustain native steppe biodiversity, ecosystem functioning and biological capacity for mitigating the impact of climate change in the Inner Mongolia grassland.