Management effects on the vegetation of rangeland in the middle of southern slope of Tianshan Mountains

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Introduction

Rangeland degradation is a widespread problem and its restoration remains a major challenge. In recent years, many scientists have discussed the primary causes of overgrazing and approaches to restoration of China's grasslands (*e.g*. Harris 2010; Wang and Han 2005; Lu *et al.* 2005). The major evidence of grassland degradation is lower plant productivity, reduced biodiversity and increase in poisonous weeds (Zhao *et al.* 2010), increased frequency of rodent and grasshopper infestations, and large scale dust storms (Lu *et al.* 2005). Restoration of these impacted ecosystems is an important and challenging task, especially in Xinjiang Province, China, where the natural grassland is rapidly degrading year by year (Yuan *et al.* 2011). Many strategies have been used to restore condition to these degrading grasslands, but since not all have proved successful, efforts are continuing to find methods that promote vigorous growth low soil disturbance and minimal vegetation destruction. In this study we investigated the response of grassland species and soils to strategic rest and shallow cultivation relative to current overgrazed grassland in the Tianshan Mountains of the Xinjiang Uyghur Autonomous Region, China.

Materials and methods

Study site

The study was carried out in the heavily grazed rangelands of the middle southern slope of the Tianshan mountains, located in Baicheng County (41°79'N; 81°04'E; 1787 m a.s.l.) which lies in the far west of Aksu Prefecture bordering Kyrgyzstan. The climate is extremely dry and the soil poor with a high grit or gravel content. The vegetation is classified as temperate desert steppe. Baichang is a semi-pastoral, arid, mountainous county where 60% of pastoral households depend on wool for more than 50% of income (Waldron *et al.* 2009). Sheep have traditionally been fat tailed meat sheep, but Baicheng has promoted fine wool as a pillar industry it is now one of the only counties in Xinjiang to maintain commitment to fine wool.

Experimental design

This experiment was designed to study the effects of three different management treatments on the response of range vegetation: (1) overgrazed control – current grazing level; (2) enclosed from grazing from 2009; (3) shallow ploughing to a 10 cm depth in 2009 and rest from grazing for 2 years but mown for hay production.

Data collection

Data were collected in mid-July for four years. In each plot species parameters were determined, including height (H), coverage (C), frequency (F), density (D), and aboveground biomass (W). Importance Value (IV) which provides a reasonable measure of the overall significance of a species was assessed as: IV = Relative Frequency + Relative Density + Relative Dominance (Curtis and McIntosh 1950).

Data analysis

To analyse differences in species richness and to investigate the impact of different management regimes on species diversity, we calculated Shannon-Wiener diversity index, Simpson's index, Simpson index, and Peilou index for each plot. The data were analysed with one-way ANOVA and LSD (P<0.05) for tests of significance using the SPSS 10.0 software.

Results

Important value (IV)

Results from the repeated measures showed that IV was significantly affected by management. The dominant species were *Taraxacum officinale*, *Elytrigia repens*, and *Elytrigia repens* in overgrazing, enclosing, and shallow ploughing plots, respectively. This clearly showed that different management can effective change vegetation composition within relative short time-frames with the overgrazed control dominated by the herbaceous perennial common dandelion whereas resting or shallow ploughing combined with resting were largely dominated by a few grass species, in particular *E. repens. E.repens* is a perennial, rhizomatous grass regarded as one of the most valuable forage plant because of its high protein and starch content.

Height

The average canopy height was 8.8 cm, 34.1 cm, and 50.8 cm in overgrazing plots, enclosing plots, and shallow

ploughing respectively. Enclosures is conducive to increasing (P<0.05) species height.

Coverage

The total coverage was 63%, 100%, and 100% in overgrazed plots, rested plots, and shallow ploughing, respectively. Management can increase total and dominant coverage significantly which reduces soil loss through wind erosion and improved infiltration of precipitation.

Density

Average plants density was 190 plants/m^2 in overgrazing plots compared to 717 plants/m^2 (P<0.05) and 979 plants/m^2 (P<0.05) in enclosing plots and shallow ploughing, respectively. Management can increase total and dominant density significantly.

Frequency

Frequency index analysis used Raunkiaer's law of frequency which is often used to summarise seasonal differences between protected and overgrazed grasslands. In Raunkiaer's law, species are categorised in levels based on frequency as: level A 0-20%; B, 20-40%; C, 40-60%; D, 60-80%; and E, 80-100%. E level plants were *T. officinale*, *Plantago major* and *R. japonicas.* Frequency level A>B<C>D<E in overgrazing rangeland. The enclosing range plant frequency E level plants were *E. repens*, *G. verna*, *P. pretensis* and *A. matsumurae.* The level A>B≥C≥D<E was stable community. Plant frequency in shallow ploughing was A<B≥C≥D≤E and E level was *E. repens.* The shallow ploughing and overgrazing can have a significant affect on community succession.

Yield

The proportion of toxic and harmful plant biomass was higher but the proportions of useful legumes and grasses were low in overgrazed grassland (Fig. 1). Enclosing the same grassland from grazing increased the yield of grasses and legumes significantly, and to a leaser extent broadleaf species. The shallow ploughing was superior at promoting the establishment and growth of grasses, especially rhizomatous *E. repens*. The shallow ploughing improved both productivity and plant composition. The total yield of overgrazing, resting and shallow ploughing were: 140 g DM/m^2, 244 g DM/m^2, and 328 g DM/m^2, respectively.

Diversity

The larger Simpson's index value for shallow ploughing indicated that diversity was significantly lower than either overgrazing or resting. This may reflect the adverse effects of soil disturbance on broadleaf species, mostly likely through competition from high density of establishing grasses.

Discussion and Conclusions

Enclosing grassland from grazing and/or shallow ploughing can significantly improve the aboveground biomass. Since the roots of *E. repens* were mainly distributed in the 10-15 cm depth, the shallow ploughing can cut rhizome of *E. repens* as well as loosen the surface soil stimulated *E. repens* growth thereby accelerating the recovery. This explains why shallow ploughing was more conducive to promoting *E. repens* population recovery than enclosing. Overgrazing inhibited strong growth of the species favoured by livestock, especially the dominant species (*E. repens*). The forbs multiplied largely. The Shannon-Wiener index explains the influence of species richness and abundance for each site (Table 1). Under suitable managements, *E. repens* was quickly restored to become the dominant species.

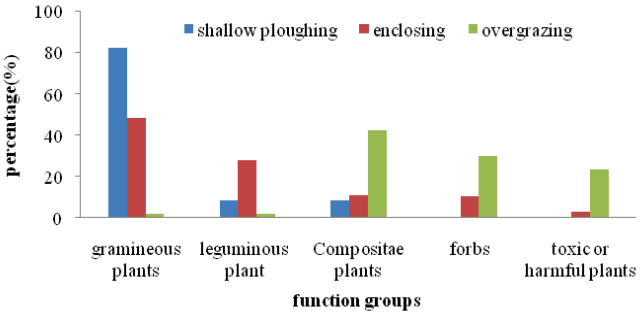

Figure 1. The effect of management on percent aboveground biomass of function groups.

Table 1. The effect of treatments on diversity index

Diversity index	Overgrazing	Enclosing	Shallow ploughing
Shannon-Wiener diversity index	3.11	3.15	1.97*
Simpson's index	0.14	0.14	0.423**
Simpson index	0.86	0.86	0.58*
Peilou index	0.87	0.85	0.62*

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