New Way to Manage Grazing Livestock System in Degraded Grassland Based on System Economics

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Abstract

Grasslands provide about half of the total feed for livestock production and support a large number of social and cultural ecosystem services around the world. Grazing livestock systems mostly depend on grasslands, but the production efficiency of this system is often very low. Improving the efficiency of grazing livestock systems while conserving grasslands is a great challenge. One large size on-farm experiment with traditional whole-year grazing and a lower stocking rate summer animal grazing plus three months of greenhouse feeding was carried out in grassland areas of northern China. Ecological sites were classified and their aboveground biomass was estimated with ground measurements and remote sensing technology. Models of balance of forage supply and animal requirements, and the optimization of grazing livestock system were used to understand the current situation of the grazing livestock system, and to find an improved way to manage grazing livestock system. Finally, we worked with a private company and some herders to upscale adoption of the results in a wider area. The results indicated that a lower stocking rate during summer grazing plus greenhouse feeding in winter is a suitable improved grazing livestock system in pastoral areas in northern China. This management system is innovative in that it both enhances livelihood outcomes and conserves the grazing lands. The key points for this new system are estimation of forage and feed supply and animal requirements, grazing livestock management improvement (such as the low stocking rate plus winter greenhouse feeding) assessed based on maximum net income, integration of Dorper sheep and improved management.

Introduction

Grasslands provide about half of the total feed for livestock production and support a large number of social and cultural ecosystem services around the world (Herrero 2013). Traditionally these grasslands have supported livestock grazing systems as distinct from those that intensively use forage and grain crops. However, as a result of limited forage resources and environmental constraints through much of the year, both inputs and production efficiency are often low. Often livestock herders have focused on maximising the number of animals they have and have learnt the skills needed for survival, but a consequence has been that overgrazing and grassland degradation is not uncommon. This is especially true where other factors lead to large increases in the human population and concurrent increases in reliance and use of grassland resources. The features of degraded grassland include significant shifts to less-desirable plant species, decreases in plant cover, and in some cases to desertification, reduced net primary production and reduced capacity of soils to sequester carbon, and increases in water and wind erosion and in greenhouse gas emissions from soil (Kemp 2013). At the same time an increasing world population is demanding more animal products while also expressing a desire to maintain natural ecosystems in a better state. These conflicting pressures and effects are very evident in northern and western China, where the herders / pastoralists are among the poorest groups in society. The Chinese central and local governments commenced discussions on restoring degraded grasslands in 1985, though large scale implementation of programmes only started in 2002 once the Grassland Law was in place. These programmes included resettlement of herders, forage reseeding, and grazing bans and fencing, all aimed at promoting grassland recovery. However, implementation of these measures has been expensive and with variable results, in part because these measures did not address herders' reliance on growing numbers of animals for livelihood improvement. Overstocking of the grasslands was still an underlying problem. Alternative strategies were needed.

In 2001 discussions started on a new project (Kemp and Michalk 2011) to analyse grazing livestock systems on farms in northern and western China and to use simple models to investigate potential changes in management practices. In addition, data were used from grazing experiments and other sources, where sufficient information could not be derived from farms. From those studies some system changes were initially tested. From 2007to 2015 a larger farm scale study was done aimed at enhancing herder household incomes in a way that also improved grassland conditions. The modelling had shown that reducing animal numbers should increase animal production per head and thus income per head, providing an economic incentive for lower stocking rates. A reduction in animal numbers could then deliver benefits for grassland rehabilitation. An important aim was to help shift the focus among herders and officials towards evaluating net household income from livestock, rather than gross income or maximising animal numbers.

Materials and Methods

Nine sites were selected from Jilin Province in eastern China to Xinjiang and Gansu Provinces in the west and southwest pastoral areas of China (Fig. 1). The grassland types varied from the higher rainfall meadow and meadow steppe, through typical steppe, alpine meadow, and mountain steppe, to the dry desert steppe. This paper mainly presents data from the desert steppe site at Siziwang Banner (250 mm annual precipitation) in Inner Mongolia, while also referring to extension results from other sites in northern China.

In each site, three households were selected as experimental farms (testing both stocking rate reduction and summer grazing with greenhouse feeding for three months) and another similar three households were selected as control farms (implementing traditional management, i.e. whole year grazing with some supplementary feed in winter). All households were mapped and classified to assess ecological sites and rangeland health (Fig. 2). Grazing land condition and forage supply from both natural grassland and tame pasture were estimated using field measurements, such as aboveground biomass and plant composition with 1×1 m quadrat and remote sensing. Data on grassland condition and all feed inputs (concentrates and grain) were monitored regularly. Household and livestock income and costs were surveyed each year.

Figure 1. Grazing livestock sites in China.

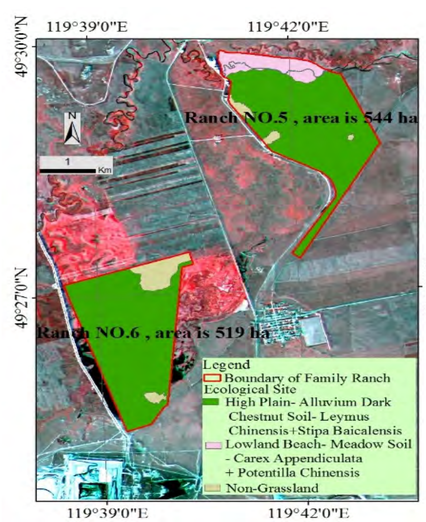

Figure 1. Grazing livestock sites in China. **Figure 2. Remote sensed images of farms.**

Semi-structured interviews were used to obtain data on the grassland and livestock production systems. Two models (Stage I, II) were used to test the balance between forage supply and livestock requirements, and to predict the effect of changing the grazing livestock system (Han *et al*. 2011). The data used in the models were based on household surveys and results from grazing and other experiments. The Stage I model, calibrated with farm data, analysed the metabolizable energy (ME) balance between feed supply and demand for all animal types and classes on the farm on a monthly basis under steady-state conditions, and was used to investigate scenarios for a range of potential grazing livestock options. The Stage II model is a steady-state linear program optimising model used to predict the optimal combination of factors that would enhance household income while changing stocking rate and other factors, including lambing times, livestock infrastructure change (conventional or greenhouse sheds) and livestock feeding strategies.

The farm demonstrations were done in collaboration with local government and a private company, Sainuo Sheep Company. The local government provided support for the herder association to adopt new technology and subsidised cross-breeding of Dorper (meat breed) with local Mongolian fat-tail sheep. The cross bred with Dorper sheep has faster growth characteristics compared to local Mongolian fat-tail sheep after lambing. Usually, Mongolian fat-tail lambs need 6 months before they are ready for sale, but cross-bred lambs need only 4 months to marketing. Therefore, when herders use the cross-bred sheep grazing pressures will be reduced and feed demand is reduced. The private company promoted and marketed sheep products from 2009, paying herders a premium per kg for larger animals and hence more meat per head. Changes in stocking rate and livestock summer grazing with greenhouse feeding in stalls for three months were combined with market changes.

Results and Discussion

There are plain-light chernozem soil-*Leymus chinensis* and plain-light chernozem soil- *Phragmites australis* ecological sites in the meadow households in Jilin, where cattle grazing is common; high plain-alluvium dark chestnut soil-*Leymus chinensis*+*Stipa baicalensis* and lowland beach-meadow soil-*Carex appendiculata*+*Potentilla chinensis* sites in meadow steppe households in Inner Mongolia with cattle and sheep grazing; high plain-sandy chestnut soil-*Stipa krylovii*+*Cleistogenes squarrosa* and high plain-meadow soil-lowland saline meadow sites in typical steppe households in Inner Mongolia and Hebei Province with sheep and cattle grazing; brown and light chestnut soil-*Stipa breviflora*+*Cleistogenes songorica* sites in desert steppe households with sheep grazing; mountain-chernozem soil-*Poa pretense*+*Achnatherum inebrians*, mountain-brown calcic soil-*Stipa caucasica*+*Seriphidium borotalalense*, mountain-chestnut soil-*Festuca ovina*+*Seriphidium borotalalense* and mountain-grey desert soil-*Petrosimonia sibirica*+*Ceratocarpus arenarius*+*Seriphidium transillense* sites in Xinjiang households with sheep and goat grazing; plateau-meadow soil-*Kobresia humilis*+*Potentilla anserinal* and plateau-meadow marsh soil-*Kobresia humilis*+*Potentilla anserinal* sites in alpine meadow in Gansu Province with Tibetan sheep grazing; and alpine meadow soil-*Festuca ovina*+*Carex* sp., subalpine swamp soil-*Carex* sp., subalpine alluvium dark chestnut soil –*Carex muliensis* sites in Sichuan Province with yak grazing. All households apply a traditional whole-year grazing system with some supplementary feed in the cool season for female livestock.

The new management systems tested resulted in an average 46% reduction of stocking rate during summer grazing with winter greenhouse feeding for three months, while net household income increased substantially in the desert steppe site during 2010-2013 (Table 1). Net income per sheep and per ha in experimental farms was 2 and 1.5 times, respectively, that of the control farms. Experiment farms were larger, but often that leads to a lower net income per head or per ha (Kemp, unpublished data) rather than more as in this case. This effect may be due to the total number of sheep being only about one-third more in the experimental farms and thus more readily managed by a household.

Table 1. Sheep numbers and net income in experimental and control farms in the desert steppe site after four years of implementing a new management system (Han *et al*. 2013)

Farms	Area (ha)	Adult sheep number	Stocking rate (sheep unit/ha)	Cost of supplement (Yuan/household)	Net income (Yuan/household)
Control	406.4±54.2[b]	285±28[b]	0.61±0.05[a]	51,181±14,576[a]	94,715±15,543[b]
Experiment	785.1±145.0[a]	393±58[a]	0.47±0.06[b]	56,007±14,949[a]	278,442±57,348[a]

When the new way of grazing livestock was applied in Jilin, Hebei, Sichuan, Gansu and Xinjiang in northern China from 2013 to 2015, the results were similar to those shown in Table 2. There was no difference in stocking rate between experimental and control farms, but the net income of experiment farms increased by 48.6% in three years. This is due to changing the whole-year grazing with some supplementary feed in the cool season to a slightly lower stocking rate during summer grazing, and greenhouse feeding in the cool season (three months). However, the results showed that after three years there was no significant change in stocking rate, suggesting that although herders could achieve a higher net income with the new management practices, they still do not want to reduce animal numbers due to other considerations, possibly including complex social and cultural barriers. Therefore, although the new grazing livestock system appears to be an innovation with a bright future in pastoral areas in the world, it will take a long time to achieve wider adoption.

Table 2. The results of extension of the new grazing livestock management system in northern China.

Farms	Stocking rate (sheep unit/ha)	Cost of supplement (Yuan/household)	Gross income (Yuan/household)	Net income (Yuan/household)
Control	1.20±0.32[a]	12700±11610[a]	64880±18380b	56420±10470[b]
Experiment	0.84±0.09[a]	13180±10190[a]	97030±11820a	83850±6810[a]

Conclusion

The shift in emphasis to reducing stocking rates to a level where net income can be maximised proved highly valuable to households in northern China. The focus on improving profitability per head of sheep achieved the desired goals when it was accompanied by market changes that gave herders an incentive. Some government support is necessary to foster these changes as herders are understandably reluctant to reduce animal numbers.

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