Journal of Arid Land

Volume 2 | Issue 1 Article 9

3-7-2010

On sustaining the ecology and livestock industryof the Bayanbuluk Grasslands

Adrian R. WILLIAMS
Pendragon Dryland Management Services, PO Box 841, Bridgetown WA 6255, Australia, adrianrw1@yahoo.com.au

On sustaining the ecology and livestock industryof the Bayanbuluk Grasslands

Cover Page Footnote

I wish to acknowledge the support of the Xinjiang Institute of Ecology and Geography which made possible my visit to the Bayanbuluk Grasslands. I should also like to thank Professors Qian YiBing and Hu YuKun who accompanied me, and Mr. Wu Mer and Professor Bao AnMing, who provided additional in-sights.

On sustaining the ecology and livestock industry of the Bayanbuluk Grasslands

Adrian R WILLIAMS*

Pendragon Dryland Management Services, PO Box 841, Bridgetown WA 6255, Australia

Abstract: A short visit to the Bayanbuluk Grassland in the Tianshan Mountains, Xinjiang, PRC, revealed a number of environmental and livestock production problems, including grassland degradation, loss of grassland biodiversity, soil erosion and flash flooding downstream, decreased pasture productivity, and poor livestock nutrition (especially in winter) leading to stock losses and flocks and herds of low productivity. This paper describes those problems and then suggests some solutions. Short duration, high intensity grazing could be one of the solutions to both improving grassland condition and improving livestock nutrition. Local production of fodder crops for feeding in winter and spring deserves testing, using adapted strains of Alfalfa (*Medicago sativa*) and trialling fodder root crop production. It is important to realise that the land management objectives of scientists, administrators, herders and farmers may be similar, and that there are opportunities for land improvement through working together.

Keywords: Bayanbuluk Grasslands; Tianshan Mountains; reversing grassland degradation; improving livestock productivity

1 Introduction

The Bayanbuluk Grasslands are the second most extensive grasslands in China (42°18′—43°34′N; 82°27′—86°17′E), and nestle in the scenically beautiful Tianshan Mountain range at a mean altitude of 2500 m. These alpine steppe grasslands are an ecologically and economically important part of Xinjiang. A number of important rivers rise here, including the Tarim River, and the grasslands contain areas of alpine wetlands, including the Swan Lake Nature Reserve in the Large Yultuz Basin. The condition of the grasslands and the rivers they feed affect the environmental and financial well-being of all who live down stream. Catchment degradation can lead to conditions such as flash flooding, which we witnessed on our journey to the grasslands.

Despite its beauty, this is a hard, harsh environment for livestock production, one of the main industries on the grasslands. The area receives a mean annual rainfall of 270 mm, more than 100 days of winds stronger than 17 m/s, and has an average annual temperature of –4.8℃. While the grasslands have high plant species diversity, low temperatures result in short growing seasons and lower pasture productivity compared to grasslands at lower elevations (See Hu et al., 2009 for a more detailed description of this area). Occasional severe winters and deep snowfall interrupt winter grazing, and lead to livestock deaths if herders do not have sufficient conserved fodder reserves to feed their livestock through such conditions. Long and difficult supply routes to this isolated area result in high transport costs for fodder brought in to the area and for livestock trucked to lowland markets.

Grassland degradation has become a serious problem, with an estimated 47% of these alpine pastures overgrazed and 49% degraded, leading to a grassland productivity decline of between 30% and 60%. This is a problem for environmental stability, sustainable livestock production and for the growing tourism industry based on the area's natural beauty. In order to improve the environment, I believe it is necessary to understand, and improve, the livestock grazing industry, which appears to be responsible for much of the grassland degradation.

The Xinjiang Institute of Ecology and Geography kindly invited me to visit its Bayanbuluk Station for

Received 8 January 2010, accepted 15 January 2010
doi: 10.3724/SP.J.1227.2010.00057
*Corresponding author: Adrian R WILLIAMS (Email: adrianrw1@yahoo.com.au)

Steppe Ecology Research, Chinese Academy of Sciences, in June 2006. Subsequent to an earlier, unpublished report, this brief communication records my field observations and suggestions for improving grassland and livestock management. I stress that this communication contains more ideas than data. The objective of this communication is to foster discussion and the development of research proposals for grassland and livestock management on the Bayanbuluk Grasslands.

2 Observations

The Steppe Ecology Research Station is located 500 km east south east from Urumqi, the capital of Xinjiang Province. With a biodiversity of 262 plant species (Hu et al., 2009), the area contains most of the alpine species found in Xinjiang. Of these, 150—200 species are palatable and important in livestock nutrition. Grassland research has revealed a positive correlation between plant diversity and pasture productivity on these alpine steppe grasslands (Hu et al., 2009). Hence, arresting grassland degradation and maintaining biodiversity is essential for a sustainable livestock industry as well as for maintaining the grassland environment. The same study revealed that the location and composition of grassland plant communities were affected by temperature (which, in turn, relates to changes in altitude), soil moisture content, soil pH, and soil nitrogen levels. Only temperature and soil organic matter stood out statistically as influences on the locations of forb plant communities. A common factor seems to be the amount of organic matter on and in the soil, since this can affect soil temperature and soil moisture content, and to a lesser extent soil pH and nitrogen content. Organic matter will stimulate populations of beneficial soil microflora and microfauna. Hence, a grazing system that encourages the build up of soil organic matter is likely to improve grassland production. I shall return to this point later.

One process of grassland degradation and loss of biodiversity seemed evident during the visit, both on the valley floors and on grazed hillsides. Palatable species (that decrease under grazing and which are referred to as 'decreaser species') are being replaced by unpalatable species (that increase under grazing and which are referred to as 'increaser species'). As an example (Fig. 3), *Leymus tianschanicus* (Drob.) Tzvel, an apparently unpalatable endemic grass, was seen colonising areas previously occupied by a mix of 'decreaser species'. The steps in the process by which this was occurring appeared to be:

(1) *Leymus* is normally 'non-aggressive' when grasslands are in good condition;

(2) Overgrazing and loss of palatable plants provides niches into which *Leymus* plants spread;

(3) *Leymus* plants increase and out-compete palatable plants for resources (nutrients and soil moisture);

(4) The palatable plants die, creating more niches for *Leymus* plants to establish, until eventually there is a mono-species stand of *Leymus*;

(5) *Leymus* plants compete with one another for nutrients and water, causing the stand of *Leymus* plants to thin out, resulting in poor soil cover;

(a)– Blue green coloration in centre of photograph shows an area of the invading *Leymus* species
(b)– Close up of an area of invasion that still has a number of plant species
(c)– Area of pure stand of the invading *Leymus* species with increased area of bare soil

Fig. 1 Apparent grassland degradation process through invasion by an aggressive increaser species – *Leymus tianschanicus* (Drob.) Tzvel.

(6) Erosion can then remove soil and soil nutrients, further advancing the degradation process.

This apparent process needs confirmation by closer observation over a period of time.

Change to the system of grazing management that allows the palatable species to better compete with unpalatable species will be required in order to limit and control further degradation.

Over a period of 30 years, staff and research students at the Steppe Ecology Research Station have sought to understand the ecology of the grasslands and how to maintain and improve them. Opportunities to restore the productivity of the grasslands through introducing new species appear limited. Few of the introductions tested have shown promise in this environment. The successes have been with fodder species, especially varieties of Alfalfa (*Medicago sativa*). Since research to date has failed to find a pasture 'wonder plant' for this environment, rehabilitation and improvement in grassland condition and productivity should focus on finding a management systems for natural grassland.

2.1 A snapshot of a herding household

Low temperatures limiting grassland productivity, and the cost to transport fodder onto the grasslands or carry livestock to lowland markets appear to be major impediments to the resident livestock industry.

On the short visit to the grasslands there was only time to talk with one herding household regarding their livestock production. The household we visited appeared to be one of the more affluent in the area. The household kept 1000 sheep in two flocks, comprising 800 ewes, 20 rams and 180 wethers. The main products are lambs and wethers for the lowland meat trade. Lambs are born in April and sold in August at around 30 kg liveweight. A number of wethers are kept and sold as 2—3 year olds. This is a form of risk management, to ensure that if anything should happen to the crop of lambs in a particular year, the household still has wethers to sell to produce income. In 2006 the herder recorded that 800 lambs were born but 100 died. Assuming a median lamb price of 200 Yuan (range: 180—250 Yuan), these deaths represented a gross income loss for the household of 20000 Yuan. The reason given for the loss of lambs was the deep snows and low temperatures in late winter—early spring, which affected the ewes' ability to graze and produce milk. The real reason could be stated that 'livestock management' failed to obtain sufficient conserved fodder to provide adequate nutrition through the winter—spring period when the risk of severe weather is high. The risk of heavy snowfall should be accepted as a normal factor of livestock management on the Bayanbuluk Grasslands, rather than being viewed as a disaster when it happens. As we shall see, the cost of doubling the amount of purchased fodder in preparation for winter conditions would have cost much less than the ¥20000 gross income that was lost due to the lamb deaths.

In addition to the sheep, the household ran 40 cattle (30 cows, 2 bulls and 8 calves) and some 60 horses. The total purchased fodder for the 2005—2006 winter was stated to be 6 t of hay and 6 t of corn (maize), at a total cost of 10000 Yuan. Seventy percent was fed to the sheep, 20% to the cattle and 10% to the horses over the two-month period of February and March, and, no doubt, used tactically when the stock could not be turned out to forage and graze. Assuming 30 days of feeding in that 2-month period, for 1000 sheep, then in simple terms this represents 0.14 kg of hay and 0.14 kg of maize per head per day. In a severe winter, when the livestock spend most days in pens, such a feeding regime would be seriously inadequate. Ewes that are 4 months pregnant would require a dry matter intake of between 2%—3% of their bodyweight per day (0.6 kg for a 30 kg ewe), containing 10 MJ of Digestible Energy and 8% Digestible Crude Protein. Requirements increase in early lactation to 16 MJ of Energy and 12% Digestible Crude Protein (McFarland et al, 2006). To those figures should be added a further 5% to maintain homeostasis in very cold conditions, and a further 5% is needed in the energy intake to balance the energy expended in walking and foraging when the livestock are turned out to graze in winter. Inadequate feed is a likely cause of the range of lamb birth weights of 2.5—4.5 kg and poor milk production by the ewes. All other things being equal, higher—but not excessive—birth weights normally correlate with higher survival to weaning (Lindsay, 1988). The number of lambs weaned per 100 ewes mated is a good measure of productivity and likely profitability. What seems to be missing is an understanding of the importance of adequate nutrition to produce productive flocks and herds, and not flocks and herds that barely survive through winter. Faced with flocks and herds where productivity is low and death rates are high, the natural inclination by herders will be to keep as many livestock as possible in order—in their eyes—to maintain some level of production and minimize the risk of making a financial loss. This, however, compounds the problem, resulting in increased grazing pressure on the grasslands and less feed per head in winter.

Signs of certain livestock nutritional deficiencies were evident around the grasslands. Energy and protein intake are limited in winter and the underlying reasons for the reported lamb deaths, as mentioned earlier, could have been a combination of inadequate milk production by the ewes, low birth weights and inability to survive cold. Apart from inadequate energy and protein nutrition, mineral deficiencies, particularly of calcium, iodine, selenium and sulphur could be present. Maize grain is recognised as being deficient in calcium (Underwood and Suttle, 1999), and feeding maize meal without suitable mineral supplements could contribute to calcium deficiency. Wool shedding is a sign of inadequate energy and protein nutrition, and possibly inadequate mineral nutrition (sulphur, iodine). The 'break' in the wool occurs in late winter—early spring, when nutrition is at its worst, resulting in very thin, weak fibre growth at that time. Mineral deficiencies on the Bayanbuluk Grasslands have been researched and identified. Mineral blocks are available from the Livestock Department of the Bureau of Agriculture and Animal Husbandry. These blocks contain calcium, copper, iodine, iron, manganese, phosphorus, potassium, selenium, sulphur and zinc, and use salt (NaCl) as the attractant and intake regulator. In demonstrations I initiated involving herders and farmers in Inner Mongolia, farmers found that it was financially beneficial for them to purchase mineral blocks, costing around 10 Yuan per 5 kg block. Farmers observed increased birth rates, increased birth weights, increased lamb growth rates and decreased general health problems in their flocks.

Households on the Bayanbuluk Grasslands have Grassland User Rights (GUR) certificates. Land allocation is based largely on the number of household members and the number of livestock owned at the time when the GUR certificates were issued. A 'seasonal' rotational grazing system exists whereby pasture is used for a season and then rested from grazing—provided the land is not grazed by other livestock. The household that we visited had fenced winter pasture, unfenced summer pasture in the mountains, and unfenced spring and autumn grazing land. Comparing grazing areas, livestock numbers (all livestock converted to Dry Sheep Equivalents, DSE) and the period of grazing, the stocking rates do not appear to be excessive. If the figures in the table 1 reflect the level of stocking rates employed across the Bayanbuluk Grasslands, then the reasons for the grassland degradation may not be stocking rates *per se*, but some other aspect of pasture management, such as allowing repeated defoliation of plants by grazing repeatedly in the same area.

The household uses shepherds on horseback to control where their livestock graze each day. This may hold true for spring, summer and autumn, but in winter it seems likely that the livestock are allowed to graze where they will. Livestock are trucked into the area for summer grazing. If these animals graze the same areas that are used for spring and autumn grazing by the households that are resident on the grass land, then the annual pasture stocking rates will be significantly higher. Then, contrary to the figures below, stocking rates may be a major contributor to grassland degradation.

Table 1 Estimation of stocking rates based on information from the herding household

Season	Area (hm^2)	DSE	Period	Stocking rate equivalent to (hm^2/(DSE·a))
Winter	418	415	4 months (December – March)	3.1
Spring & Autumn (1)	311	415	5 months (April –June, October – November)	1.8
Summer	118	415	3 months (July – September)	1.1

(1) Spring and autumn grazing occur on the same land, but with a summer grazing rest between the spring and autumn grazing, DSE: Dry Sheep Equivalents.

3 Discussion

A number of inter-related problems—or chalenges—relating to the sustainability of the grassland and the livestock industry on the Bayanbuluk Grasslands are evident from the preceding description. It is worth listing them:

(1) Grassland degradation, loss of biodiversity;

(2) Increasing areas of unpalatable plant species and loss of grassland productivity;

(3) Soil erosion, increased runoff and flash flooding down stream;

(4) Maintaining profitability in a livestock industry with high transport costs, occasional severe winters and inadequate livestock nutrition;

(5) Cost of fodder and cost of risk management in preparation for severe winter conditions;

(6) Maintaining biodiversity in order to continue to attract tourists to the area.

From this list we can infer some objectives for both scientists and administrators on the one hand and herders and farmers on the other.

Objectives for scientists and administrators:

(1) Improve grassland condition (biodiversity and productivity);

(2) Support local industries (livestock and tourism industries in particular);

(3) Decrease grassland degradation effects on areas and people who live downstream of the Bayanbuluk Grasslands.

Objectives for herders and farmers:

(1) Remain viable and profitable;

(2) Improve livestock productivity;

(3) Gain more productivity from the grassland;

(4) Solve the problem of high costs of winter fodder.

If these lists are anywhere near true, as I suspect they are, they show that the objectives of the scientists, administrators, herders and farmers are similar.

3.1 Improving grassland condition

The lack of success in finding plant species and varieties to introduce to the Bayanbuluk Grasslands to assist in grassland improvement dictates that grassland rehabilitation and improvement must be based on improving the management of the naturally occurring plant species. Such plant communities have evolved and developed over long periods of time to be well adapted to local conditions (Hu et al., 2009). What is required is a management system that maintains biodiversity, keeps unpalatable 'increaser species' in balance with other pasture components, increases the growth of palatable species and helps to increase soil organic matter.

Around the world, pastoralists and scientists have found that short duration, high density rotational grazing provides the benefits that I have just listed—and more (e.g. Gammon, 1984; Kirby et al., 1986; Norton, 1998; McCosker, 2000). A short duration, high density rotational grazing system involves grazing a flock or herd on a relatively small area of pasture for a short period of time (1—2 days). Ideally each plant should be grazed only once. After that the livestock are moved to other small areas for similarly short grazing periods. Pasture that has been grazed is rested and allowed to regrow. Eventually, all the small areas on a grazing property have been grazed, and the livestock start the rotation again, returning to the area that was first grazed and which has had the longest pasture recovery period. The required recovery period will vary through the year according to soil moisture, temperatures and growth rates. Commonly a rotational grazing system will allow for pasture to be rested after grazing for around 21 days. This requires that the grazing property be divided up into 21 areas where grazing lasts on each area for just one day. Alternatively, the grazing property could be divided into 11—12 grazing areas, each of which is grazed for two days before the livestock are moved to the next grazing area.

The benefits to grassland productivity from the system I have just described are:

(1) Since the grazing animals are kept close together they are effectively in competition with one another, and do not have the time to be selective about what they graze. As a result most species are grazed, and not just the highly palatable 'decreaser' species. Thus the 'decreaser' species are better able to compete with the 'increaser' species, and the proportion of palatable plants in the pasture will start to increase.

(2) Since the plants are rested after grazing, rather than being continuously grazed, they have a chance to grow to a larger size before the next grazing, and, thereby, produce increased biomass through the year. The pastures become more productive and livestock nutrition improves.

(3) Larger plants produce larger root mass, which will senesce and regrow at different times of the year, thereby, contributing to increased soil organic matter. Larger plants may also produce increased soil organic matter via increased above ground litter if it is not consumed by the grazing animals.

Further benefits of a short duration, high density rotational grazing system include:

(1) Decreased livestock worm burdens. Worm eggs are dropped on pasture to which the livestock will not return for around 20 days. By the next grazing a large number of the worm eggs will be dead.

(2) In summer and early autumn pasture may grow faster than the livestock can consume it. In such a situation, some of the grazing areas can be removed from the grazing rotation, and these pasture areas set aside to produce hay for winter—spring fodder. As we have seen, increasing winter fodder would be of particular benefit to herders and their livestock in this area.

Grassland is already managed using longer term, seasonal rotational grazing. Either livestock resident on the grasslands are moved to higher summer pastures, or lowland livestock are trucked onto the grasslands for summer grazing. What I am advocating is a trial of short duration, high density rotational grazing within the existing seasonal grazing system.

This leads to the question of whether short duration, high density rotational grazing can be practiced without fencing? (With the rapidly increasing price of steel, internal fencing—and possibly boundary fencing—is becoming prohibitively expensive for herding households to buy and erect.) An alternative method is required to maintain the livestock in the area where the herder wishes them to graze. Shepherding on horseback, motorbike or even on foot would seem to be the first and most obvious alternative. This will require the shepherd to know where he or she is within the grazing property and where he or she wishes to graze the livestock. Knowledge of and reference to fixed landmarks will assist, as well as observing where the grassland has been recently grazed and where it is not grazed. A 'high tech' option may be the use of GPS for locating position on the grassland, and possibly for recording way points in order to plot the herd's or flock's location each day. Clearly, such an advance would require a great deal of trialling, development and extension.

Another alternative to controlling the area grazed each day may be through the location of some animal attractant in the centre of the selected grazing area. Such attractants might include (1) portable watering facilities (e.g. a portable water trough fed from a water tank on the back of a three-wheel tractor), (2) location of mineral supplement blocks, or (3) a combination of (1) and (2). These are new suggestions, which, to my knowledge, have not been tested.

In Inner Mongolia, grassland management in spring has been found to be crucial to the year's pasture productivity (Li, 2009). Resting pasture plants from grazing in spring allows the plants to re-establish themselves after winter, and regrow their above-ground and root biomass after little or no growth through winter. Such 'grazing rest' or 'deferred grazing' results in larger plants with better root systems and larger photosynthetic area than plants that are continuously grazed through spring (McFarland et al., 2006). When 'deferred grazing' is coupled with short duration, high density rotational grazing, it is probable that grassland productivity will increase significantly. Conversely, intensive grazing early in the growing season can have a dramatic, negative impact on pasture productivity for the rest of the growing season (McFarland et al., 2006).

3.2 Increasing fodder reserves for winter and spring feeding

Spring 'deferred grazing' requires that herders have sufficient stored fodder to provide adequate nutrition to their livestock during this period in addition to their fodder requirements through winter. I suggest that developing local fodder options will be crucial to the future success of the local livestock industry. Further, I suggest that the search for suitable fodder introductions is more important than the search for pasture introductions for these reasons:

(1) Improved winter and spring fodder reserves will assist directly in improving livestock nutrition and productivity;

(2) Adequate fodder reserves in spring will allow the grassland to be rested from grazing at this important time of the year through the system of 'deferred grazing';

(3) The Bayanbuluk Grasslands already have a high diversity of palatable pasture species.

Fuel prices and, therefore, transport costs are going to rise significantly as world oil supplies diminish

(Strahan, 2007). Hence, while livestock can be walked to markets in the lowlands around the Tianshan Mountians, transporting fodder by truck from the lowlands onto the Bayanbuluk Grasslands will become more and more expensive.

A number of Alfalfa (*Medicago sativa*) introductions have shown promise as highly nutritious fodder plants. Is there also a place for root fodder crops? A number of varieties of turnips and swedes (*Brassica spp*) are adapted to cold environments, need a relatively short growing period, and can produce many tons of nutritious fodder per hectare. Fodder crops of turnips have been grown in Yunnan at medium to high altitude for many years (Wilkes, 2006). If it has not been researched already, I would advocate the testing of turnip and swede varieties as sources of winter—spring fodder.

4 Conclusion

In the short and cursory visit to the Bayanbuluk Grasslands it was not possible to investigate any aspect of pasture management in depth. But clearly 'business as usual' is not an option if the area is to have a sustainable livestock industry and a growing tourist industry. I have attempted to show that the objectives of scientists, administrators, herders and farmers are likely to be similar. There are opportunities to work together to develop a sustainable livestock production system specifically adapted to the Bayanbuluk Grasslands. Such development should start with modest trials until confidence is gained in the new techniques. Management techniques that I believe hold promise include (1) short duration, high density rotational grazing superimposed on the current seasonal rotational grazing system, (2) deferred grazing in spring, (3) improved mineral nutrition of livestock and (4) local production of winter fodder, including production of successful varieties of Alfalfa, removing grassland from the grazing rotation for hay production in summer and trialling production of root crops (especially turnips and swedes). There is an important role for scientists, extension staff and administrators to assist herders and farmers to make changes towards sustainable production, and to monitor and evaluate that change is heading in the desired directions of improving grassland condition and more productive livestock.

Long term objectives should include improving livestock productivity through methods including better year-round nutrition and better risk management of severe winter weather. If these could be achieved, herding households would require less animals to maintain household incomes, with less animals to feed through winter and spring. Grazing pressure on the grassland could be reduced, more areas given over to producing winter fodder, and the beauty of the Bayanbuluk Grasslands could be sustained for all to enjoy.

Acknowledgements

I wish to acknowledge the support of the Xinjiang Institute of Ecology and Geography which made possible my visit to the Bayanbuluk Grasslands. I should also like to thank Professors Qian YiBing and Hu YuKun who accompanied me, and Mr. Wu Mer and Professor Bao AnMing, who provided additional insights.

References

Gammon D M. An appraisal of short duration grazing as a method of veld management. Zimbabwe Agriculture Journal, 1984, 81: 59–64.

Hu Y K, Li K H, Gong Y M, et al. Plant diversity-productivity patterns in the alpine steppe environment of the Central Tianshan Mountains. Journal of Arid Land, 2009, 1(1): 43–48.

Kirby D R, Pessin M F, Clambey G K. Disappearance of forage under short duration and season-long grazing. Journal of Range Management, 1986, 39: 496–500.

Li Q F. Case study 6: Alashan Plateau, Inner Mongolia. In: Squires V R, Lu X S, Lu Q, et al. Rangeland Degradation and Recovery in China's Pastoral Lands. United Kingdom: Cambridge Agricultural Bureau International, 2009. 180–182.

Lindsay D R. Breeding the flock. Melbourne: Inkata Press, 1988. 34.

McCosker T. Cell grazing—the first 10 years in Australia. Tropical Grasslands, 2000, 34: 207–218.

McFarland I, Curnow M, Hyder M, et al. Feeding and managing sheep in dry times. Bulletin 4697 (Department of Agriculture and Food, Western Australia), 2006, 8–10, 27–28.

Norton B E. The application of grazing management to increase sustainable livestock production. Journal of Animal Production Australia, 1998, 22: 15–26.

Strahan D. The last oil shock. London: John Murray, 2007, 78–80.

Underwood E J, Suttle N F. The mineral nutrition of livestock (3rd ed). United Kingdom: Cambridge Agricultural Bureau International, 1999. 69.

Wilkes A. Innovation to support agropastoralist livelihoods in northwest Yunnan, China. Mountain Research and Development, 2006, 26(3): 209–213.