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COMMENT

A new approach to the fight against desertification in Inner Mongolia

The world's arid and semi-arid regions are severely affected by desertification. In China, wind erosion, water erosion, soil salinization and the freezing and melting processes have contributed to 2.64 million km^2 of desertified land, covering 27.5% of the country's land surface (State Forestry Administration, Peoples' Republic of China 2005). Although climate change could be a reason for desertification, anthropogenic factors such as overgrazing and overcultivation also contribute to degradation in grassland areas (Millennium Ecosystem Assessment 2005; Zheng *et al.* 2006). The Chinese government has adopted afforestation as the main measure to control desertification. Major projects, including the 'Three North Shelterbelt Programme' (also known as the 'Green Great Wall') and the 'Sandstorm Source Control Project around Beijing and Tianjin', are necessary to shield northern and eastern agricultural ecosystems against sand and dust (Zhou 2002). However, these countermeasures require substantial effort and investment, and, in the semi-arid and arid regions of Inner Mongolia, newly planted trees have often died of drought, while tree planting could also be responsible for exhausting the precious groundwater resources of these regions (Jackson *et al.* 2005). Alternative and more practical ways of combating desertification by using multi-disciplinary approaches observing both social and ecological principles are required. The Hunshandake Sandy Land restoration demonstration project conducted by the Chinese Academy of Sciences was an attempt to restore desertified grassland mainly through natural processes, and requiring limited investment.

Hunshandake Sandy Land (41°56′–44°24′N and 112°22′–117°57′E) is one of the four largest sandy areas of Inner Mongolia grassland (area *c*. 40800 km^2). Serious degradation of the area in recent decades has been attributed to population increase and overgrazing (Fig. 1) (Zheng *et al.* 2006). The four main habitats in the area are lowlands, fixed dunes, semi-fixed dunes and shifting dunes. The proportion of shifting dunes increased rapidly from 2% in the 1950 s to 16% in the early 21 st century (Chen & Guo 1960; Inner Mongolia Meteorological Administration 2004). Hunshandake Sandy Land has also been recognized as a dust source for the notorious dust storms affecting Beijing and surroundings (Liu *et al.* 2004).

From 2000 to 2005, a restoration project was conducted in Bayinhushu, a typical stock-raising village in the central area of Hunshandake Sandy Land, with an area of 7330 ha and a human population of 325 in 72 households. The local government began by thoroughly informing the local people about the restoration plan and, in April 2001, the most severely degraded 2667 ha of rangeland were fenced; grazing was thereby prohibited and mowing was then only by machine in September after each growing season. This ensured that natural processes were the only driver of restoration. In compensation, 67 ha of high-productivity lowland was cultivated outside the enclosed area. High-yielding Ying-Hong corn that has an aboveground fresh biomass production of 60 Mg ha^{-1} was planted as forage. All the production was used as silage after fermentation. A sprinkling irrigation system was installed to maintain the yield, but was not often used since sufficient groundwater was accessible during most growing seasons in the lowland, where the water table was only 1–1.5 m in depth. After necessary mechanisms to guarantee their living standard were installed, local herders accepted experimentation on the 2667 ha of unproductive land.

The restoration project had significant effects. Before the experiment, about 80% of the enclosed 2667 ha of rangeland was overgrazed and severely degraded with livestock reducing the aboveground dry matter biomass to a mean of 0.23 Mg ha^{-1}. When grazing pressure was eliminated, the average aboveground dry matter biomass in the fenced area increased to 3.6 Mg ha^{-1} in only three years (Fig. 2*a*) and the forage yield through mowing stabilized at around 4000 Mg yr^{-1}. The proportion of shifting dunes in this area decreased to 4% in 2005, approaching the level of the 1950s. In the unfenced area, the biomass over the six years stabilized at 2.0 Mg ha^{-1}; grazing pressure did not increase despite fencing one-third of the land (Fig. 2*a*) as prior grazing activity occurred largely in the unfenced area. The high-yielding corn supplement and the dry grass collected from the fenced area together reduced grazing pressure and alleviated the desertification trend in the unfenced area.

The high-yielding cornfields not only reduced overgrazing on the 2667 ha pasture, but also freed the local herdsmen from the annual household *c*. US$ 2370 cost of purchasing supplementary forage. The forage from the high-yielding cornfields and natural pasture combined was almost sufficient for the village's livestock in 2001. In the following years, a fodder surplus began to develop and the dependence on the cornfields gradually decreased owing to the rapid grassland recovery on the fenced pasture after degrading factors were removed. Every household had to pay the annual maintenance costs of the high-yielding cornfields, which averaged US$ 190 yr^{-1}. In contrast, surrounding villages that did not follow this management model suffered from constant fodder shortages.

During the six-year project, the composition of the village's livestock also altered. The proportion of goats and sheep, which are believed more destructive to pasture than cattle, reduced to 38% in 2005 from a 2000 level of 55% (Fig. 2*b*). The change in livestock structure was an important factor in

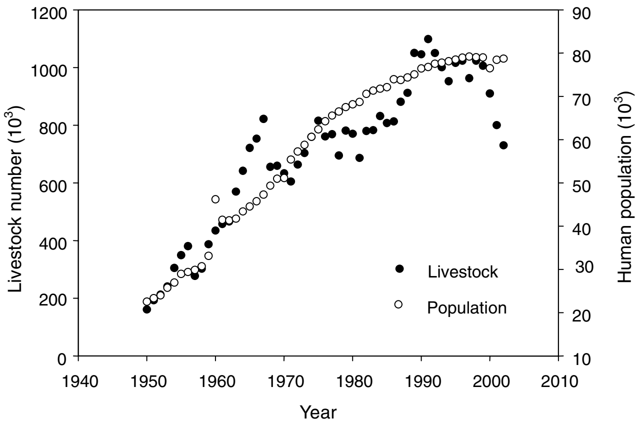

Figure 1 Livestock and human population 1950–2002 in Zhenglan Banner, county of Bayinhushu. Livestock declined after the 1990 s owing to lack of forage.

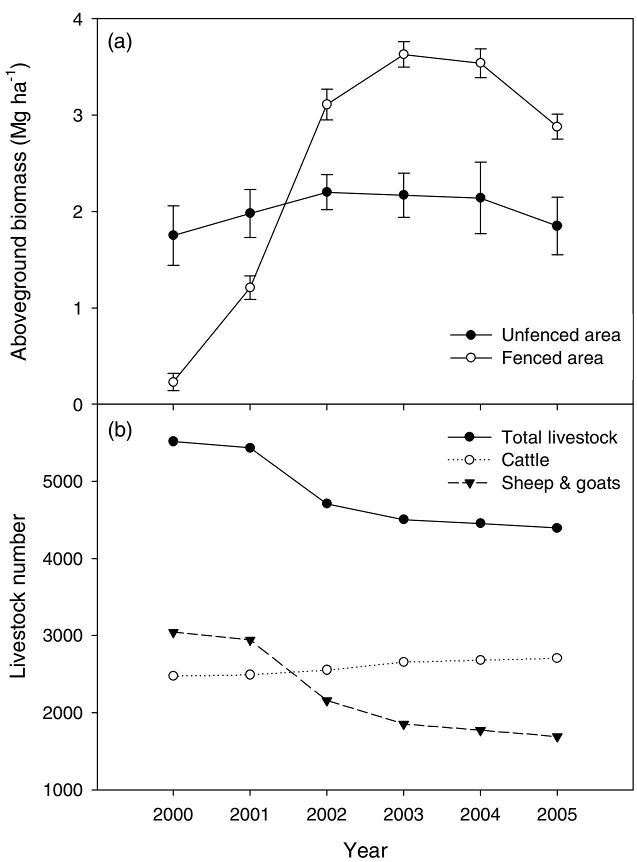

Figure 2 Aboveground biomass of fenced and unfenced areas (*a*) and livestock composition (*b*) in Bayinhushu village, 2000–2005. Data in (*a*) are means of the mean biomass in the four main habitats weighted according to the proportion of the area covered by each habitat determined by transect survey. Error bars indicate 1 SE ($n = 5$). Plots for fixed dune, semi-fixed dune and shifting dune areas were 4 m^2, and for lowland areas they were 1 m^2.

grassland protection, but it did not cause a decline in stock-raising income. On the contrary, the mean annual per caput income increased sharply owing to the removal of extra forage expenditure.

The high-productivity cornfields played a crucial role in enabling the recovery of the fenced area at the beginning of the project and should be preserved as a long-term regulator, relieving grazing pressure on natural pastures in times of hardship, such as the drought of 2005.

Such a restoration model could be defined as 'nurturing land by land', in other words increasing the productivity of small nutrient-rich areas of land to reduce the pressure on large but vulnerable areas, which could then be restored by natural processes (Bradshaw 2000). This is similar to the use of intensive cultivation or urbanization to effect conservation in reserves (Jiang *et al.* 2003). The current project has shown that restoration of degraded grassland ecosystems can occur naturally if the disturbance has not exceeded the resilience threshold. The existence of seed banks and favourable water and heat flux characteristics in the sandy soils were also important in vegetation regeneration. This restoration process is an example of the principle that natural processes should be adopted wherever possible in ecosystem restoration (Bradshaw 1996).

The establishment of high-productivity land was the most important contribution to the feasibility of this project. Although the infrastructure needed government investment (*c.* US$ 92 500 for irrigation and power facilities), the average cost per hectare (US$ 35 ha^{-1}) was one-tenth that of tree planting in the 'Great Green Wall' programme (US$ 383 ha^{-1}). Government could afford this cost if the great expenditure on inappropriate afforestation could be transferred to grassland natural restoration, which requires lower funding but, as this example shows, could be more effective than afforesting shelterbelts. Perhaps most importantly, 'nurturing land by land' is an arid and semi-arid grassland-tailored approach that may benefit both desertification control and sustainable development.

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