Synopsis

Restoration and Management of the Inner Mongolia Grassland Require a Sustainable Strategy

Land degradation is one of the major environmental problems worldwide and has become particularly severe in recent decades in China, with its rapid economic developments. China has an enormous area of grasslands, covering 41% of its territory (3.93 million km^2), and grasslands are regarded as among the most important natural resources because of their ecological and economic importance. However, anthropogenic activities have led to large-scale land degradation across the vast Inner Mongolia grassland, the main grassland region of China and part of the Eurasia Steppe that stretches from East China to Hungary. Grassland degradation of this magnitude could alter regional and even global environments, but such degradation can also directly affect the livelihood of millions of people who have lived in the region for generations (1, 2).

Inner Mongolia covers an area of 1.1 million km^2 and has a population of 20.3 million. Recent surveys have shown that nearly 90% of the grasslands now are degraded to varying degrees, which is more than twice as much as was estimated 10 years ago (3). On average, current grassland primary productivity is only about 50% of that of the undegraded steppe. The land degradation in this region is generally believed to be a major reason for the increasing frequency of severe sandstorms and dust storms in northern China (particularly in Beijing and adjacent regions) in recent decades (4, 5). Because the environmental and economic future of the Inner Mongolia grassland is at stake, scientifically sound ecosystem management strategies are urgently needed for the sustainability of this region.

GRASSLAND DEGRADATION AND SOCIOCULTURAL TRANSITION

Hunshandak Sandland, which is part of the Inner Mongolia grassland, is one of the four major sandy lands in China. It has an area of 53,000 km^2. The proportion of shifting sand dunes in this region increased as follows: 2.3% in the early 1950s, 8.2% in the mid-1970s, 13% in the 1980s, 50% in 1996, and 70% in 2002. Hunshandak is also one of the largest strong-wind fields in China, with the highest velocity reaching 34 m s^{-1} at some times of the y. Wind erosion has caused many environmental problems, and grassland ecosystems have become deprived of biodiversity and productivity, often accompanied by the invasion of toxic species (e.g., Chinese *Stellera,* swordlike iris, *Achnatherum*). Large animals that used to roam the steppe (e.g., Mongolia gazelle, roe deer, foxes, wolves) are now rarely seen. Grassland degradation has also had environmental impacts on both surrounding and remote places (e.g., Beijing and Tianjin, Japan, Korea, United States) by affecting water and air quality through long-distance transport of dust and pollutants (2, 4, 5).

What has caused the degradation of the Inner Mongolia grassland? Some blame it on the drier spring climate in recent years (6). But the interannual fluctuations in temperature and precipitation in recent decades are within the normal range observed over the last 5000 y, and climatic fluctuations cannot possibly account for all the ecosystem changes. Many others suggest that major changes in land use are the primary impetus for grassland degradation in this region (7). Mainly as a result of the immigration of the Han people since the 1970s, the human population of the grassland area has increased rapidly (Fig. 1A). During the same period, the number of grazing animals (mainly cattle and sheep) has increased 18-fold since 1949 (Fig. 1B), whereas grassland available per animal has decreased sharply (Fig. 1C). Importantly, these environmental changes were accompanied by a sociocultural transition: the traditional nomadic lifestyle of the local people was gradually replaced with modern settlement.

DEVELOPING A SUSTAINABLE APPROACH TO GRASSLAND MANAGEMENT: INSIGHTS FROM A DEMONSTRATION PROJECT

To alleviate the problem of grassland degradation, the Chinese government has invested huge amounts of money in planting trees in the Inner Mongolia region in the past 20 y (e.g., the Three North Shelter Belt, also known as the Green Great Wall) (8). Recently China decided to provide 60 billion RMB (US$ 7300 million) for efforts to combat dust storms during its 10th Five-Year Plan Period (2002–2006), and an additional 10 billion RMB (US$ 1200 million) for the Cleaning the Air of Beijing project (partly motivated by the Olympic Games to be held in Beijing in 2008). Although government policies encourage large-scale tree planting in semiarid and arid areas in the past, such projects have proven economically costly and ecologically unsustainable. In fact, most of the trees planted in the past have either died or are dying, and they did not result in the anticipated ecological effects.

From 2000 to 2003, scientists from the Institute of Botany at the Chinese Academy of Sciences carried out a grassland restoration demonstration project in Hunshandak (43°11′42″–43°56’47″N, 116°08’15″–116°42′39″E). The study area (Bayinhushu) covers 7300 ha^2 and has a population of 322 people in 72 households. An area of 2670 ha^2 was fenced off for restoration experimentation. The results showed that without grazing, the previously degraded grassland could recover rapidly through natural processes in 3 y. Compared with the control area, above-ground biomass increased by twofold, and plant cover increased by 60% on

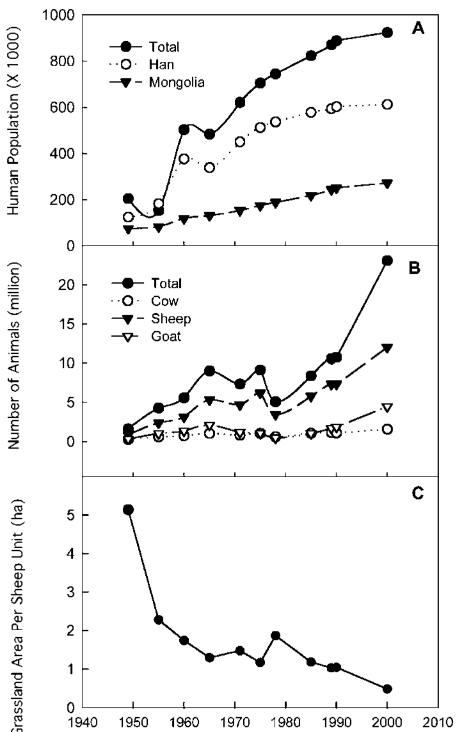

Figure 1. Changes of human population (A), number of grazing animals (B), and grassland area per sheep (C) in the Xilingol League, Inner Mongolia (in which Hunshandak is located), from 1947 to 2000.

shifting sand dunes and 300% on fixed sand dunes (9). In lowland areas, rapid vegetation recovery was evident even in the first y. By the second y, plant height was up to 143 cm, and fresh plant biomass was estimated to be 39.8 tons ha^{-1}. After 3 y, plant height reached 160 cm, and fresh plant biomass attained 48.8 tons ha^{-1}, similar to the production level of 50 y ago. Because of the adequate supply of high-quality forage, the survival rate of young animals increased by 10% and milk production by 200% from 2000 to 2002. The per capita income of herdsmen inside the demonstration area was two times higher than that outside. The local people, having directly benefited from the demonstration project, enthusiastically supported and adopted the restoration procedures developed by the scientists.

We have learned several important lessons from our demonstration project. First, degraded grasslands in Hunshandak Sandland can restore itself rapidly once grazing is stopped. However, we must note that once grasslands are degraded beyond their self-recovering capacity (e.g., most of the topsoil is gone), huge human effort, including ecological engineering, will be needed to restore them. Also, ecosystem recovery ability in the Hunshandak Sandland has much to do with its sandy soil, which can capture and store water more effectively than the chestnut soils under the typical steppe. For example, severely degraded grasslands on chestnut soils did not show any recovering characteristics during the same period of time. Thus, it is crucial to start restoring grasslands before they go past this degradation threshold. Large-scale grassland restoration must involve "spatially heterogeneous" integrated management—that is, much of the land should be left alone to permit natural recovery (10), and improved management schemes, such as delayed grazing or rotated grazing, should be implemented. Principles in landscape ecology (11) seem relevant in designing such spatial management plans.

Sustainable strategies for grassland restoration and management must explicitly integrate ecological, economic, and societal issues in the overall framework. There is a great need to educate the local people and policy makers that most of the grasslands can be restored with ecological and economic success if proper measures are rigorously implemented. The participation of local governments and herdsmen is of vital importance. On the one hand, a model of "nurturing the land by the land itself" needs to be adopted; but on the other, land-use practices must be diversified and optimized with the aid of scientific knowledge and advanced technological means in order to improve the economic conditions and quality of life for the local people.

The relationship between society and nature in the Inner Mongolia grassland has changed in response to the changing environment. There is little doubt that it will continue to change. The real question is, how can this dynamic relationship be sustained? To achieve environmental and economic sustainability while preserving the essential elements of the Mongolian culture in the region, we believe that future research and management efforts should embrace the tenets of sustainability science (12, 13), which is an emerging transdisciplinary field that focuses on the dynamic interactions between society and nature. Our experience in the Inner Mongolia grassland suggests that such a new scientific framework is crucial for successfully resolving the problems of grassland degradation and dust storms (14).

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