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Reversing Desertification in China

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Introduction

China is a country of almost 1.3 billion people (Permanent Mission of the People's Republic of China to the United Nations office at Geneva and other International Organizations in Switzerland, October 10, 2003), but only contains seven percent of the world's total arable land. Due to its large population and its reliance upon money from agricultural exports to purchase needed industrial items, the success of China's agricultural sector is critical. In response to these needs, China has developed the world's largest agricultural economy, producing a wide range of crops and livestock (Worden et al., 1988). Chinese farmers have long used fertilization and irrigation to increase a variety of crop outputs. The majority of grazing livestock are sheep and goats. Most of these animals are grazed on the semiarid steppes and deserts in the north, west, and northwest (Ibid.). Unfortunately, not all of China's agricultural resources have been properly developed and managed. Some of China's agricultural land is in danger of becoming artificial desert through overuse of the land, particularly overgrazing by livestock on the steppe grasslands in the north (Figure 1: Map of China). This process is known as desertification. This paper outlines the extent of and causes of grassland desertification in the steppe landscapes in northern China and suggests some regional-scale livestock management steps that might be taken to reverse the trend of grassland desertification in China.

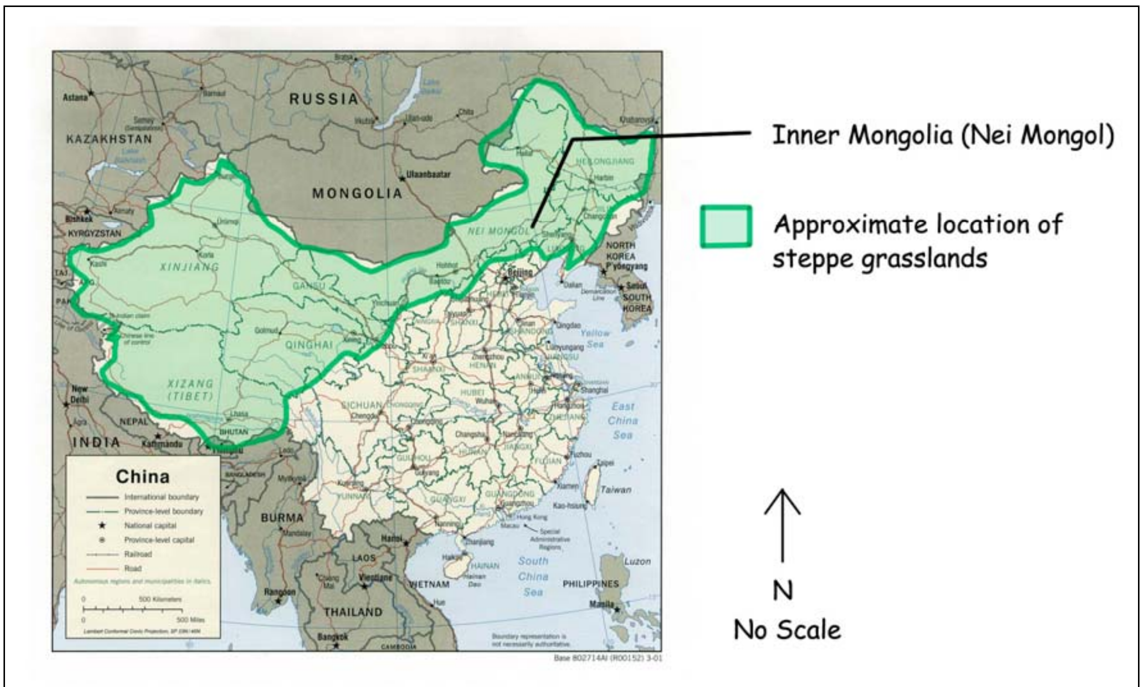

Figure 1: Map of China
SOURCE: Adapted from map at http://geography.about.com/library/maps/blchina.htm

History of Chinese Agricultural Lands and Causes of Degradation

In northern steppe landscapes, the arid and frigid climate, as well as the scarcity of resources, make crop agriculture difficult. Instead, the grazing of livestock has become the center of the economy in the northern regions. For generations, a mobile way of grazing and raising livestock (pastoral nomadism) had been the norm for most rural people in these regions (Ning, 1997). Historically, herdsmen used the native rangelands on a seasonal basis, moving their livestock to new pastures as forage was depleted in one area (Sheehy, 1990). Each family moved about four or five times during the summer (Public Broadcasting System, 2003), and there was no fixed abode (National Research Council, 1992).

Widespread pastoral nomadism would not last, however. From the Communist party's victory in 1949 until his death in 1976, Mao Tse-tung's influence permeated all areas of Chinese life. The policies during the Maoist era centered on the belief that China's people are its most important resource, and that through cooperation and hard work, its people could overcome all obstacles. One of the obstacles that could be overcome was the limitation of the natural environment (National Research Council, 1992). During the Maoist period, many peasants and Han Chinese were moved to marginal steppe rangelands to "reclaim" the land for growing crops. These marginal lands had been used previously for grazing livestock (people during this time were encouraged to "grow grain everywhere"). Irrigation made crop agriculture possible in these marginal landscapes. In addition, China's population doubled between 1949 and 1990 from 540 million to 1.1 billion people (Ibid.). The combination of population pressure and the expansion of agriculture caused a reduction in rangelands available to graze livestock. Finally, the numbers of livestock that grazed on the remaining rangelands increased. Between 1949 and 1985, the total number of sheep and goats in China increased from 42 million to 156 million (Worden et al., 1988). Today, northern China's grasslands support the world's largest sheep and goat populations (National Research Council, 1992). Historic nomadic grazing patterns, when the number of livestock was less, allowed periods of rest that permitted desirable forage species to recover. When too many livestock are grazed, though, even traditional nomadic grazing patterns can cause overgrazing, soil compaction, and soil erosion.

The Chinese government, through a variety of policies, has taken steps to help curb the process of soil degradation in the northern steppes. One of the ways that the Chinese government has attempted to slow degradation is by reducing the amount of traditional nomadism. Some livestock are now fed grain to reduce their impact on grasslands (although this takes grasslands out of production for livestock in favor of growing grain). For the livestock that are grazed, the Chinese government believes that communal grazing lands would give herders access to grazing and incentive to better manage the land, as the values of grazing rights would vary with market conditions and the state of the grassland (Charles Sturt University, 2003). Although some portions of China (such as Tibet, some parts of Inner Mongolia, and some parts of northeastern China) still support nomadism, the vast majority of China's herdsmen are no longer truly nomadic. The pattern most common in northern China's steppes is the seasonal migration of grazing animals to take advantage of distant grasslands during the summer and the return in winter to a fixed home base (Ibid.). In Inner Mongolia, herders bid to win grazing rights to specific parcels. In return, the owners are required to build a house and dig a well.

Some believe that this "sedenterization" of the herders (i.e., making the nomadic herders sedentary) tends to lead to overgrazing because there is not enough land in the parcel to adequately graze livestock (Ellwood, 1995). Livestock are taken out to graze every morning, then brought back to the herdsmen's dwellings each evening. The next morning, the livestock are taken to the same pastures to graze again (Sheehy, 1990). Without fences, these pastures are shared commons. Overgrazing by livestock has caused grassland degradation, but degradation is a historical issue in China. Zhenda and Shu (1983) write that 120,000 square kilometers of desertified land was formed during early historical times in North

China. Desertification has accelerated in the past few decades. Within the last half of the twentieth century, about one-third of the grasslands in the main pastoral regions of China have been degraded (Xiang and Zhuo, 1996). The desertified area caused by overgrazing accounts for approximately 29.4% of all the desertified land in China.

Desertification

Desertification refers to the "changing process of the environment in which desert-like landscapes appear in formerly non-desert regions and results from the destruction of equilibrium in fragile ecosystems by excessive artificial economic activities" (Zhenda and Shu, 1983). Zhenda and Shu (1983) write that there are several characteristics of desertification. Desertification takes place within the period of human history and that excessive artificial economic activity is the major cause of desertification. Desertification is gradual and marked by wind erosion, roughening of the land surface, development of shifting sand in patches, and the formation and expansion of sand dunes. Desertification results in a sudden drop in biological production and a decline in productive capacity of the land. Finally, once the process of desertification has begun, the desertified land area will increase under the continued influence of both natural and artificial factors, especially wind (Ibid.). Grassland degradation is particularly severe in arid and semiarid [steppe] regions where the soil is loose. These environments are quite fragile because they do not receive much precipitation, the winds are strong, and there is much evaporation. During the last half of the twentieth century, the climate in these arid and semiarid pastoral regions has become even drier, due to reduced precipitation, stronger winds, more evaporation, and more frequent drought (Runnstrom, 2000). The plant communities are also unstable and susceptible to change due to human use (Zhenda and Shu, 1983).

Manifestation of Desertification

Research indicates that heavy levels of grazing have negative impacts on steppe grassland ecosystems. It is understood that these negative impacts lead to desertification. Tukel (1984) compared two areas of steppe rangeland in Turkey: one was a continuously grazed public range, and the other was a nearby area that had been protected from grazing for thirty years. Tukel found that total ground cover, composition, and dry forage yields were significantly decreased on the continuously grazed public range when compared to the protected range. In a similar type of study, Bock et al. (1984) found that a protected upland site supported 45% more grass cover than an adjacent continuously grazed area. Shang et al. (2003) ran simulation studies to evaluate the potential changes to steppe ecosystems under different grazing intensities. Although it was acknowledged that a grazing intensity of zero percent above-ground biomass removal (AGBR) was most beneficial for grasslands, this level is not practical for grazing livestock.

Researchers explored the impact on grasslands under other grazing intensities. They found that soil moisture decreased markedly and the degradation of soil properties accelerated under grazing intensities greater than 50% above-ground biomass removal. At 50% AGBR, a decline in grassland production over time was observed, but at 25% AGBR, grassland production stayed stable. Thus, the results indicate that 25% AGBR is significant for preserving the soil from degradation and maintaining high grassland production. The degree of grazing also impacts the botanical composition and species diversity of degraded grasslands (Dong et al., 1987; Wang and Guo, 1993; and Suguira et al., 1998; in Wang et al., 2002). For example, as degradation due to grazing increases, high quality grasses preferred by grazers tend to decrease, while thorny annuals and those that contain tannins tend to increase (Kawanabe et al., 1998, in Wang et al., 2002). Wang et al. (2002) studied grasslands in a steppe region of Heilongjiang Province of northern China. The study region contained three natural grasslands differing in grazing pressure, and therefore differing in degradation (Wang et al., 2002). The study analyzed the differences in species composition and spatial heterogeneity among grasslands impacted by varying levels of grazing intensity. The original dominant species at the study region was *Stipa baicalensis*, a typical steppe grassland species. The most notable findings were that the least degraded grassland (that subjected to light grazing intensity) had the highest species diversity, and almost the highest number of plant species (it had one plant species less than the moderately-grazed site). The lightly-grazed grassland exhibited high species diversity when compared with the more degraded grasslands. In the lightly-grazed grassland, *S. baicalensis* occurred frequently; in the highly-grazed grassland, the occurrence of *S. baicalensis* was low. In addition, several species of erect-type grasses or grasses that do not form clones under light grazing dominated the non-degraded grasslands. These plant species can be used as indicators of well-managed grasslands in northern China.

Restoration Options

The previous section, "Manifestation of Desertification", outlined studies that showed that overuse of grasslands can lead to desertification. Reversing desertification is important to maintain as much productive grassland as possible and to prevent soil erosion. It is unlikely that desert existed in the past where desertified land exists today. An analysis of ancient towns and sites in northern China indicates that the historical environment there was not desert (Zhenda and Shu, 1983). The Mu-us Sandy Land, in north-central China, was fertile steppe grassland in historical times (Fullen and Mitchell, 1994). In Inner Mongolia, villagers recall that in the 1950s, the grass was dense and tall, whereas today the grass is sparse and short (National Research Council, 1992). No areas of existing steppe grassland have a vegetation composition that can be considered the climax composition (Scholz, 1995 in Ning, 1997). Because overgrazing is one of the major causes of desertification, alternative livestock management techniques may aid in reversing desertification. The Chinese government has been interested in improving degraded grasslands for several decades. The practice of "enclosing pastures" appeared in China at the beginning of the 1960s and has been used to delimit pasture boundaries, to divide pastures for rotation grazing (explained in "Potential for Reversing Desertification in China"), to restrict livestock access to grasslands, and to combat desertification (Li, Y.T., 1995 and 1996; in Shengyue and Lihua; and Ning, 1997). In the Xilingele steppe (in Inner Mongolia), numerous authors have shown that the fencing of degraded grasslands can aid restoration (Yong, 1984; Liu et al., 1987; and Jiang, 1989; in National Research Council, 1992). At Inner Mongolia's Ih Nur Pilot Demonstration Area, a comparison between grazed rangelands and rangelands fenced to keep livestock out showed several results. The dry weight of perennials within the fenced enclosure was greater than the dry weight of perennials outside the enclosure, the total standing crop inside the enclosure was greater than that outside, and the forbs preferred by livestock were greater inside the enclosure than outside (Sheehy, 1990). Recovery of degraded grasslands is not immediate, however. The self-reversion capacity of a given grassland will depend upon its level of degradation; as desertification develops from slight to severe, the restoration capacity declines (Zhu and Liu, 1989; in Shengyue and Lihua). Experiments conducted in one Chinese grassland research institute indicate that protective fencing can increase the productivity of degenerated grasslands in northern China by 25 to 50% within two years (National Research Council, 1992). Significant improvement, especially in the recovery of fine forage grasses, may occur in two to three years after fencing, and a "normal" state can be approached in five years (Jiang, 1989; in National Research Council, 1992). At Yanchi, in northwest China, areas enclosed by fences and employing the recommended stocking density of one sheep per 0.87 ha, have stabilized and revegetated within five years.

Potential for Reversing Desertification in China

It is clear from the previous discussion in this paper that fencing rangeland to keep livestock out, coupled with managing animals in response to degraded vegetation conditions, can help reverse desertification. Fencing has been successful in some rangelands in some parts of China, but the fencing solution may not be so simple. The grazing of livestock in China is a complex issue. On the one hand, China has a large population which must be fed, and livestock herders need to make a living. On the other hand, the amount of grassland available for grazing livestock is less today than it has been historically, and the greatly increased numbers of livestock that are grazed on grasslands pose a threat to the viability of those grasslands. While fences may be effective in restoring grasslands, the cost of fencing pastures all over China may be cost-prohibitive (Ning, 1997). The traditional nomadic method of continuously moving relatively small livestock herds typically was not damaging to the environment, but the traditional nomadic way that herders once grazed livestock has not been encouraged by the Chinese government. Traditional, nomadic pastoralism depended on raising a variety of livestock types and the frequent moving of the livestock (National Research Council, 1992). But the Chinese government's position is that the nomadic way of grazing livestock is inefficient and destructive to the environment, and that to "sedenterize" herders is to raise their standard of living (Ibid.).

The challenge is to raise as many livestock as possible, with the least damage to the grasslands on which the livestock graze. Agricultural reforms during the 1980s gave renewed importance to the indigenous systems of livestock production. With the Household Responsibility System, livestock became a private resource, while the rangelands remained a public resource, and several families often are assigned the same plot of land on which to raise their livestock. The Household Responsibility System is ineffective in some areas where the rules that are intended to prohibit herders from using another's grasslands are difficult to enforce. Some believe that the policy of private livestock ownership and public grazing lands intensifies overgrazing by leading to the "tragedy of the commons"; herders may carry the responsibility of protecting public rangelands. If the herders owned the lands on which their livestock grazed, their self-interest might create a balance between land and livestock (National Research Council, 1992).

Although it would seem logical to reduce the number of livestock in China, and thus reduce the impact on grasslands, a reduction in livestock is not feasible given China's large population and the increasing demand for animal products. Better solutions attempt to combine fencing with changes in the grazing patterns rather than attempting to reduce the number of livestock. In addition, it has been shown that it may not be beneficial to keep livestock off grasslands altogether because, although grasslands may be regenerated in the short term, they will likely be grazed at a later date. In addition, "grazing offers a potentially important tool for conservation management because of its influence on habitat structure and biodiversity" (Collins et al., 1998; in Adler et al., 2001). Assuming that increased spatial heterogeneity of grasslands implies higher quality grasslands, Adler et al. (2001) showed that the immediate effect of grazing on spatial heterogeneity of vegetation depends on an interaction between the spatial pattern of grazing and the preexisting vegetation. By managing the distribution of grazing based on the existing vegetation at a given site, it may be possible to increase spatial heterogeneity (Adler et al., 2001).

For purposes of conservation, livestock management techniques may begin to include a more thorough assessment of preexisting vegetation at a given site. This assessment of preexisting vegetation could then inform managers of more suitable livestock grazing techniques. One potential technique is to control the duration of the grazing period. Information taken from the study reported by Sheehy (1990) was used to develop a proposed deferred-rotation grazing system at Inner Mongolia's Ih Nur Pilot Demonstration Area. "Deferral" means to delay grazing until a critical growth stage of the plant is passed (e.g., flowering, seed ripening). Such deferral is intended to permit seed production, seedling establishment and restoration of plant vigor. Deferral, along with moderate rates of stocking, promotes the full growth potential of range vegetation. "Deferred rotation" involves altering the deferral period between pastures, and a given field is not grazed at the same time two years in a row. Deferred grazing may require more fencing, water supply development and time spent monitoring grass growth, but deferred grazing can help to maintain better range condition because the damaging effects of early grazing are reduced, and a period of rest is provided for the field that takes the early graze (Adams et al., 2000). In the Sheehy (1990) proposal, several pasture units would be involved in the deferred-rotation grazing system, where each pasture unit would be deferred from grazing during a different season over a four-year period. Sheehy indicates that rangelands would likely be improved under this deferred-rotation grazing system because key species (*Stipa baicalensis*, *Cleistogene* spp., and *Lespeueza spp.*) would be able to complete their reproductive cycles and increase vigor.

Conclusion

Desertification of Chinese steppe rangelands in northern China began centuries ago but has accelerated in recent decades. Population pressures, decreases in grasslands available for grazing livestock (sheep and goats), increases in the numbers of livestock and resultant overgrazing, and changing agricultural policies have contributed to desertification. While it is clear that fencing to keep livestock of grasslands is beneficial to the grasslands, this solution may not be feasible in some parts of China due to the remote location of many herders and the enforceability of policies intended to control grazing. Even though the grasslands may reestablish, they will eventually be grazed again, and the effectiveness of simply keeping livestock out of grasslands today may not be an effective long-term solution. Better solutions may combine a combination of some fencing with alterations in grazing patterns. One potential solution is the deferred-rotation grazing system. Other livestock management solutions have yet to be determined. The Chinese government is very interested in solving the complex problem of desertification. Many research institutes are currently operating in China, and they are conducting a variety of research studies on animal husbandry (National Research Council, 1992). Their research will help to identify solutions to the problem of desertification in China.

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