Desertification and Restoration of Grasslands in Inner Mongolia, China

By

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Abstract

Desertification is a principal natural resource issue in China. Grasslands cover 400 million hectares or 40 percent of China's total land area and are the largest ecosystem threatened by desertification. Of these grasslands, 90 percent have been degraded to some extent. Grassland degradation results in ecosystem instability and threatens economic development. A series of land reforms, beginning in 1947, have led to a rapid shift in land tenure and stewardship practices on grasslands. These changes have led to continual decline in productivity. Overgrazing and conversion of grassland to cropland are the primary causes of grassland declines. Protection and restoration of grasslands are a key component of China's fight against desertification. Extensive efforts to reverse grassland degradation have had partial success. Current strategies in Inner Mongolia demonstrate the potential of an integrated approach to combating desertification. The Xilinguole League pilot study site provides an illustration of integrated desertification combating activities, which includes programs that address both the causes and effects of desertification. The following programs observed on-site will be described and evaluated: tree planting, grassland closures, resettlement of displaced herders and farmers, and demonstration households and agro-pastoral feeding activities. Recommendations will address the continual need for off-farm jobs, improved rangeland management practices, and the promotion of range grazing with a standardized adaptive stocking rate.

Key words: grassland degradation, ecological resettlement, overgrazing, land-use change, grassland rehabilitation

Introduction

The purpose of this paper is to provide background information on China's grasslands that includes changes in livestock numbers, management, and policy over the past fifty years. A detailed description of a desertification-combating program in Xilinguole League, Inner Mongolia is provided and used as a case study. Through primary observation and secondary literature, recommendations are made that would improve the sustainability of current desertification combating efforts. Development of a system of sustainable use of China's grasslands is a critical aspect of desertification combating. The need to improve the grazing system will be highlighted and potential solutions will be suggested.

Grassland and rangeland degradation has long been a national concern because of the adverse effects of desertification and subsequent soil erosion, salinization, and dust storms. Severe degradation is defined by a 30 to 50 percent decline in productivity. By this definition, one third of all rangelands in China are severely degraded (Wang et al).

Rangelands are a critical ecosystem in China largely because of their predominance on the landscape. With over 400 million hectares, grasslands represent 40 percent of China's total land area. While China represents 22 percent of the global population, it has only seven percent of the world's arable land (Wang et al 2004). Increasing population pressure and growing standards of living are increasing the demand placed on grassland ecosystems. Sustainable and rational use of these delicate ecosystems is one of China's predominate environmental challenges. Grasslands represent an important renewable resource that supports a large rural population engaged in livestock production. To date, desertified areas affect over 40 million people and

include many of the poorest of China's population (Miller in press). Grassland degradation severely impedes economic development because it threatens productivity, watershed protection, biodiversity, and air quality. The majority of China's grasslands occur in the autonomous regions of Tibet, Inner Mongolia, Xinjiang, Qinghai, Sichuan, Gansu, Yunnan, and Ningxia. 75 percent of these grasslands occur in semi-arid and arid regions. As of 1998, approximately 80 percent of these grass and rangelands were considered suitable for livestock grazing (Sheehy 2004, Wang et al 2004), however, overgrazing has reduced vegetation cover and destroyed valuable plant species. This has transformed species composition, leaving the most unpalatable forage for livestock. The loss of biodiversity and vegetation is a threat to a large number of wildlife species, such as the wild yak and the Mongolian gazelle. In addition, rangelands have an important role in the terrestrial carbon budget. Research indicates that China's grasslands may constitute a significant above and below ground sink for global carbon, storing 16 percent of the total carbon stored in the world's grasslands (Miller in press).

Desertification in China

About 2.7 million square kilometers, or 27.9 percent of China's total land area is affected by desertification. Problems associated with desertification cost China 6.5 billion USD annually (UNCCD 2003). Water erosion is responsible for 48 percent of desertification. Wind accounts for 44 percent and salinization contributes eight percent. Another five million hectares are considered to be susceptible to desertification (Deng 2005).

In northern China, 25 percent of desertification is caused by over cultivation, 28 percent by over-grazing, 32 percent by denudation, nine percent by industrial and

transportation projects and six percent by sand dune encroachment (Deng 2005). In the region of Inner Mongolia, over grazing is the primary cause of land degradation. The removal of vegetation is an immediate cause of desertification. This can be traced back to four distinct activities: agricultural production, overgrazing, deforestation for fuel and construction materials, and inappropriate irrigation practices that lead to salinization.

Climate change and reduced snow melt might also be a factors contributing to grassland degradation (UNCCD 2005). The region continues to suffer from drought and there is evidence of climatic shifts (Deng 2005). The relatively high latitude of China's arid and semi-arid regions are believed to be more susceptible to climate change. Annual primary production in Inner Mongolia is highly sensitive to climatic variation and land-use changes. Fluctuations in CO^2 could have significant impacts on primary production. Studies show that in typical steppe in middle Inner Mongolia increases of CO^2 would reduce both soil organic matter and primary production (Xiao 1995). Temperature and precipitation changes are expected to vary throughout China but in the North China Plain, trends suggest the temperature is warming (Shen 2001). Over time Inner Mongolia's grasslands may become less productive and less resilient to grazing pressure.

Sandstorms are low-level atmospheric disturbances caused by diurnal winds carrying sand particles through the air (Deng 2005). For thousands of years dust and sandstorms have occurred in Northeast Asia. In the past 50 years the frequency, geographic coverage, and damage associated with sandstorms has increased (UNCCD 2005). Dust and sand storms are among the most serious problems in Northeast China. Storms have caused considerable hardship, loss of income, communication disruption, and human health problems. In some instances, human casualties, destruction of

livestock and mass loss of crops can occur. It is a transboundary environmental issue that affects Mongolia, the Korean Peninsula, Japan, and occasionally, the United States.

Population and Livestock Growth

The primary forces exacerbating grass and rangeland resources in China are human and livestock population growth. Figure 1.1 shows livestock population growth in Inner Mongolia from 1947 to 2003 (Inner Mongolia Statistical Yearbook 2004). In 1947, livestock totaled 8.4 million and in 2003 had increased to 71.1 million. Sheep and goats experienced the greatest total growth. While livestock numbers increased, the total usable grassland area fell as a result of declining productivity.

Figure 1.1 Livestock population increased steadily from 1947 to 2003, with the greatest growth occurring among sheep and goats.

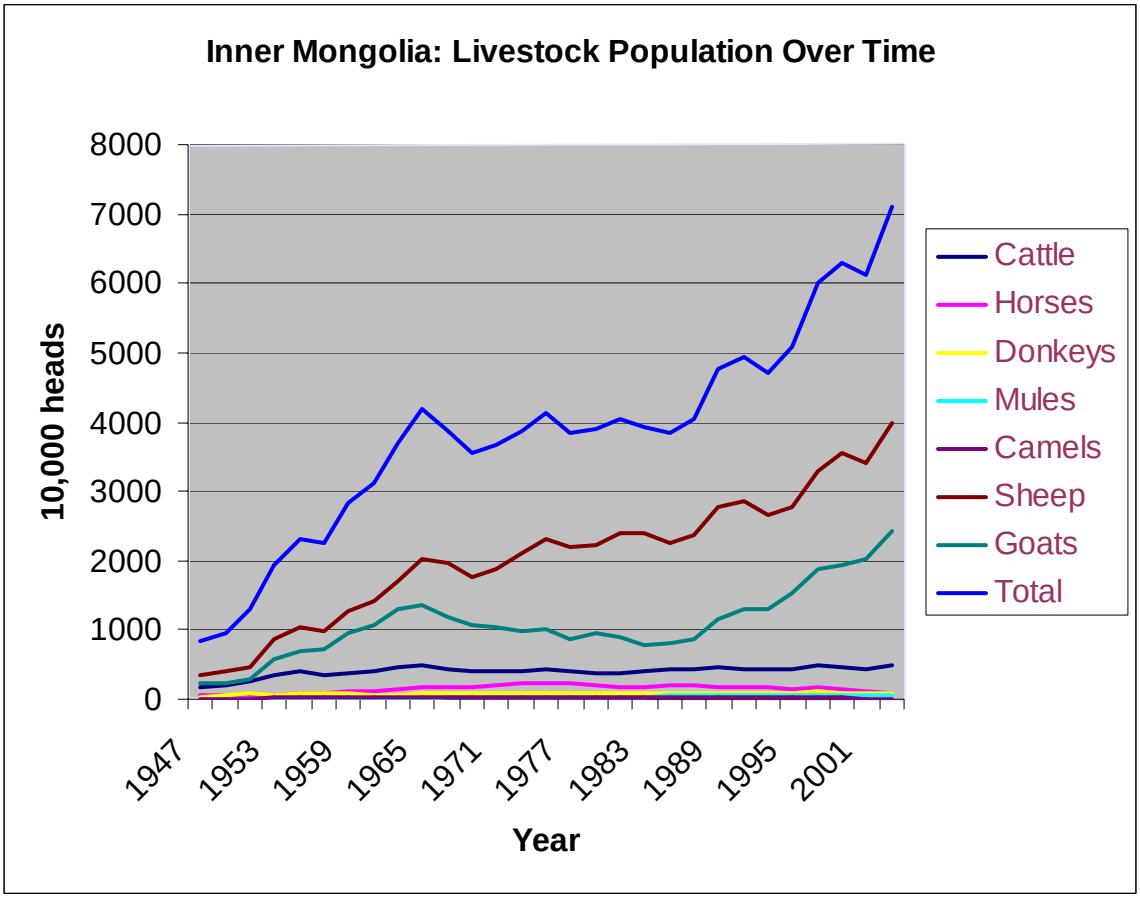
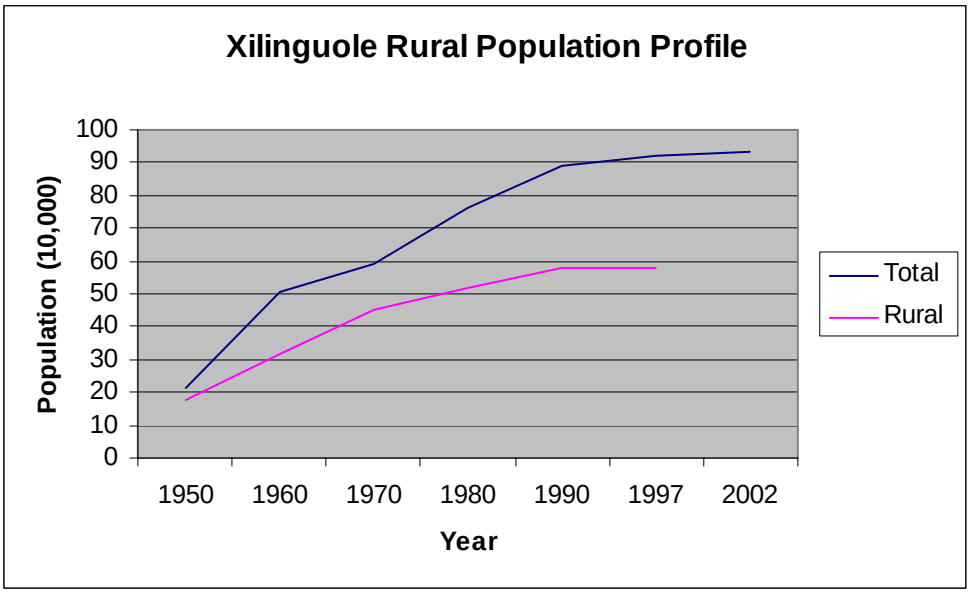


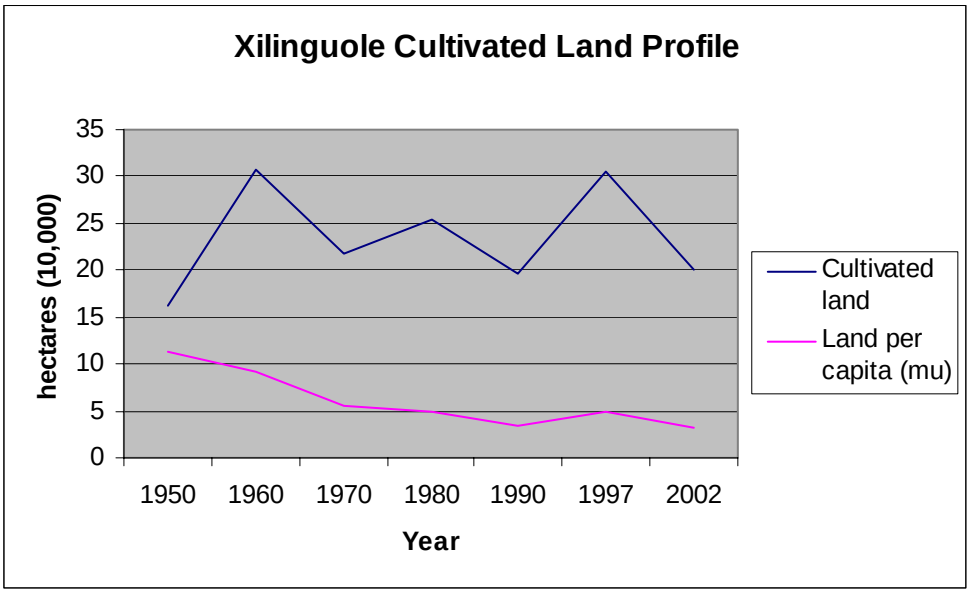
Figure 1.2 plots total population growth and rural population growth in Xilinguole League. The rural population of Xilinguole also climbed during this period; however, the growth rate is slower than that of livestock. This reflects an increase of animal units per capita.

Figure 1.2 Xilinguole League's population continues to climb. The rural growth rate indicates an increase of livestock per capita over time.



While population and livestock numbers climb, land per capita experienced a decline. From 1950 to 2002, cultivated land experienced great fluctuation. Increases followed by dramatic drops reflect abandonment of cultivated land after crop failures on marginal land. This land does not usually return to grassland, but is placed in the category of wastelands. Figure 1.3 plots changes in cultivated land and land per capita from 1950 to 2002.

Figure 1.3 Cultivated land fluctuated dramatically from 1950 to 2004. Land per capita was steadily reduced.



History and Policy in the Grasslands

Accelerated population growth of human and livestock populations can be related to a series of national government policies that resulted in migration to western provinces, cropland conversion, and increased livestock numbers. Land reforms in China began in 1949. With the establishment of The People's Republic of China in the 1950s, there began a drive for national food self-sufficiency. Widespread immigration to the west occurred and cultivated land increased dramatically. In the study site of Xilinguole League, cultivated land increased 124 percent from 1952 to 1953. The Great Leap Forward (1958 to1961) marked the second period of reforms aimed at attaining food security. Again in Inner Mongolia, large areas of grassland were converted into cropland. In Xilinguole League, cultivated land increased 157 percent from 1959 to 1960. The Cultural Revolution (1966 to 1976) was the third drive to increase agricultural production. Here the government directed herdsmen to eat only food produced

independently. An additional 53,333 hectares were converted in Xilinguole League at this time (UNCCD 2005).

Land conversion was further encouraged by The Offset Policy of 1995. This policy required provinces to offset land developed from farmland in another area. This led to the conversion of grassland to farmland, particularly in Gansu, Qinghai, Ningxia, and Xinjiang (Runnstrom 2000).

In Inner Mongolia, long-term land use rights were slow to arrive. Although property rights and land leases were reformed during the 1980's with the Household Responsibility System, the law did not come into effect in Inner Mongolia until 1999 (Brogard 2003). Livestock, however, was distributed as private property in 1989. During this ten-year period, livestock population exploded in an example of the "tragedy of the commons." Without individual responsibility, there was no sense of land stewardship and no governance in place to regulate livestock numbers. Once pastureland was allocated, the government assumed that individuals would be forced to stock the land at acceptable levels and invest in pasture improvement. In Inner Mongolia, the desired effect of privatization actually exacerbated the problem by concentrating communal use on more marginal lands (Miller in press). In addition, by allocating pasture land to individual households herders no longer moved between seasonal pastures. This increased the tendency toward continuous year-round grazing. Mobility is a significant factor in rangeland declines. In Inner Mongolia and Mongolia, the highest levels of degradation were found in areas with the lowest levels of livestock mobility. This was even more significant a factor than livestock density (Sneath 1998).

Other grassland management policies have led to overgrazing. Previously, carrying capacity was dictated only by heads of livestock. There was no consideration for production capacity or the ecological status of the grassland. Without consideration for the grazing capacity of various animals, taxes were derived by heads of livestock. In addition, is was rare for local officials to enforce a grazing ban or attempt to reduce herd sizes. This law was not revised until 2002 (UNCCD 2005).

Institutional factors are also a significant barrier. The primary agency responsible for grassland management is The Bureau of Animal Husbandry. This is a relatively weak agency and grassland laws are difficult to implement and regulate. The powers of the Bureau of Forestry and the State Forestry Administration often conflict. The two agencies have distinct focus areas in desertification control but share common goals. Cooperation is an area of weakness (UNCCD 2005).

In total, during the period of 1986 to 1996, at least 970,000 hectares was converted primarily to rain fed cropland in Inner Mongolia (Sheehy 2004). Satellite images from 1999 suggest that 15,667 hectares out of 298,000 hectares of cultivated land have become desertified (UNCCD 2005).

Measures Against Desertification

China's government is acutely aware of the severity of desertification. Since the 1950's, the government began research on desertified land and initiated strategies to combat shifting sands. Beginning in the 1970's, China pursued motivated programs to mitigate the widespread ecological damage. Examples of such programs are the Green Great Wall Project, frequently referred to as the Three-North Shelterbelt Program that focuses on the northwest, the north central, and the northeast. Other significant programs

include, The National Project for Prevention and Control of Sandification, the Coastal Shelterbelt Program, The Plain Farmland Protective Shelterbelt Program, and The National Program of Shelterbelt Development along the Middle Reach of the Yellow River.

Early restoration projects focused on forest coverage. As a direct result of these programs, forest coverage in China grew from eight percent in the 1950's to 18.2 percent in 2002. More than 16 million hectares of farmland and ten million hectares of grassland are currently within satisfactory ecological condition (UNCCD 2005).

In 2002, the PRC presented a 10-year program that focuses on five northern provinces suffering from land degradation in dry land ecosystems. The investment will total 54 billion RMB (6.5 billion USD). Partnerships at home and abroad will provide an additional 1.5 billion USD over the next 10 years. Over 700 million USD will be focused on the areas around Beijing (UNCCD 2005).

The greatest increase in investment will be provided to the State Forestry Administration, which is the central organization involved with China's National Action Plan to Combat Desertification (NAP). The NAP involves six key forest ecological projects. There are three phases to the program; 2001-2010, 2011-2030 and 2031-2050. One primary goal of the program is to control 22 million hectares of desertified land by 2010.

The major strategies of the six programs involve direct interventions to the spread of desertification with shelterbelts, wind breaks, soil conservation, and control of water run-off in catchment areas. In addition, the programs will involve community level development projects, natural resource management improvement strategies, and non-

farm alternative income generating activities (UNCCD 2005). Beginning as early as 1996, the central government has created the following six key ecological improvement projects:

1) Natural Forest Protection Program
2) Returning Cultivated Lands to Forests or Pasture Program(Grain for Green*)*
3) The Combating Desertification Program in Wind-Sand Source Areas Affecting Beijing and Tianjin
4) Phase Four of Three-Norths forest shelterbelt system development
5) Water and soil conservation in key areas
6) Protection and improvement of natural rangelands.

The following highlights NAP activities:

1) a ban on logging in natural forest areas;
2) reforestation of hillsides and waste lands;
3) establishment of windbreaks and shelterbelts to control wind erosion;
4) closure of degraded rangelands and forest areas to allow for natural vegetative recovery;
5) replacement of annual crop production in vulnerable semi arid environments with perennial tree crops and or improved pastures; and
6) sand dune stabilization through a mixture of re-vegetation with tree, shrubs, and grasses (including aerial seeding) and/or use branches, twigs, crop residues pushed into the sand to form a lattice square grid.

One of the six key programs in the NAP is commonly known as the Grain for Green program. This was launched in 2000 and has expanded to 224 counties in 20 provinces. China has spent at least 900 million USD on the project and converted 1.2 million hectares of farmland and over one million hectares of barren land. The objective is to convert underproductive farmland to forests and grasses. China plans to convert an additional 2.2 million hectares to forest and rangeland and to plant 2.6 million hectares of barren land.

Grain for Green provides heavy subsidies for farmers. Farmers may receive 1,500 to 2, 250 kg of grain/ha/yr, depending on the type of land. The central government also

provides farmers with seed and saplings for the first planting cycle, and an annual living expense of 40 USD per hectare converted (UNCCD 2005). Reports on the duration of these subsidies vary. Since the success of the program is largely dependent on the subsidies, there is concern that if the economic gain from the trees planted is not sufficient then farmers will revert back to growing annuals after the subsidies are withdrawn.

Despite these aggressive efforts, China's fight against desertification has typically been characterized by localized successes shadowed by overall degradation. Reports state that desertification continues to expand at a rate of two million hectares per year. Of the total grassland area, 0.3 percent is improved every year, while 0.5 percent is further degraded (Nan 2005). Livestock numbers continue to climb despite efforts to recognize a carrying capacity, reduce grazing, and rehabilitate pastureland (Sheehy 2004). The driving forces of degradation have not been eliminated as indicated by steadily accelerating rates of soil-eroded land over time. Table 1.1 displays the rates of soil-eroded land over the past 50 years (Shi, 2005).

Table 1.1 Rate of Soil-eroded Land Expansion / Year (square km)

1950 to 1970	1975 to 1985	1990 to 1995	1995 to 2000
1,560	2,100	2,460	3,436

In addition, severe sandstorm events are more frequent now than a decade ago. In 2002, Beijing experienced up to 23 times the average. Mongolia experiences as many as 30 sandstorm events per year, while northern China experiences 20 days per year in the most affected areas (UNCCD 2005).

Land Use Change

Inner Mongolia has experienced significant land use change events over the past fifty years. Land conversion to croplands is still the greatest concern in Inner Mongolia. While the ruinous effects of cultivating marginal lands are widely understood by policy makers, as of 2000, grasslands were still being converted into agriculture production.

For example, within Xilinguole Banner in Zhenglanqi County, 4.2 percent of the total land area has been converted from cultivated land to rangeland since the initiation of the NAP. Simultaneously, 11.1 percent has been converted from grassland to cultivated land. At this time, 37.6 percent of the land area continues to experience degradation (Deng 2005).

Conversion of farmland or grassland into forestland is a concern. Implemented programs invest significant resources into afforestation. There is undeniable value in tree planting for shelterbelts and windbreaks. Many trees have ecological benefits and provide farmers with an economic alternative to annual crops. Conversion from grasslands to forest, however, can alter the water balances and soluble salt fluxes (Esteban 2004). Increasing forest cover increases the leaf area index and trees develop deeper root systems. This results in greater evaporative losses and decreased moisture content in the soil. Trees may out compete grasses and shrubs for moisture. In addition, where grassland watersheds are afforested there is a reduction of groundwater recharge and a decrease in stream flow.

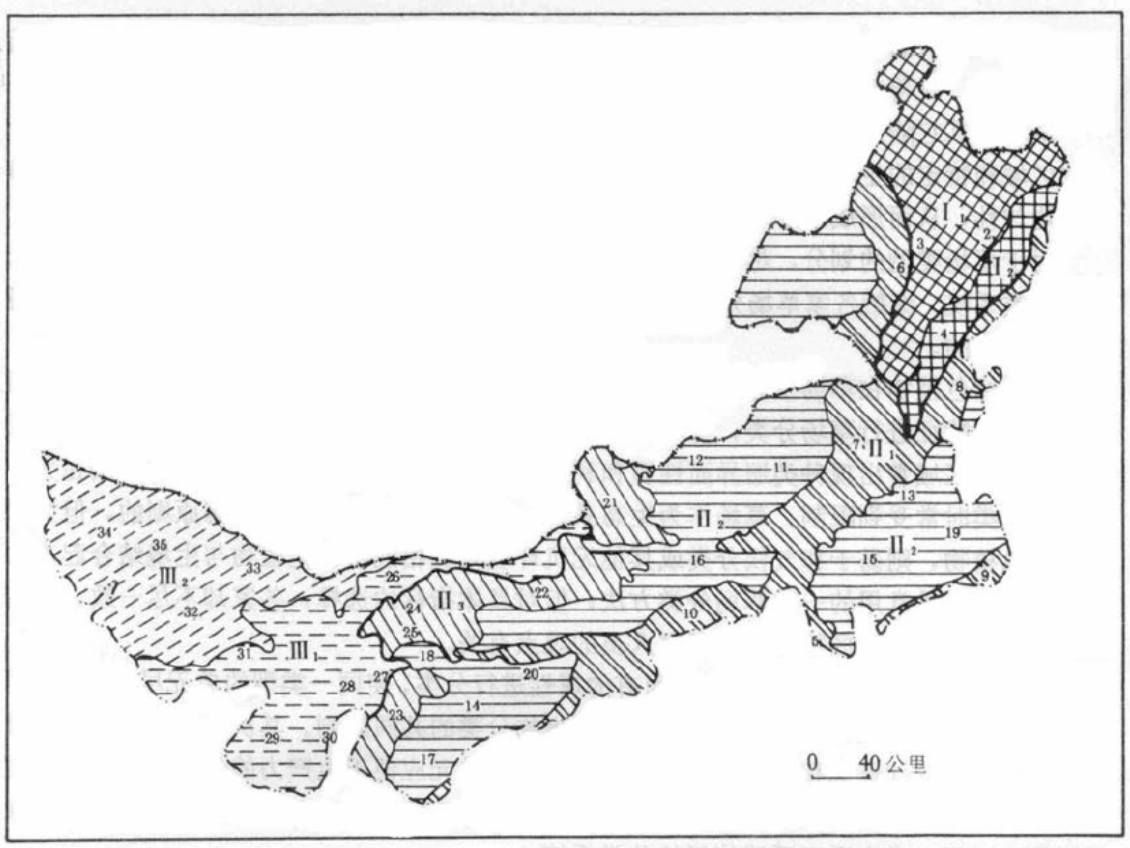
At the provincial level, Inner Mongolia's forested area decreased 29 percent from 1985 to 2000 (Deng 2005). It is not spatially clear, however, where afforestation and deforestation occurs in Inner Mongolia. Studies show that land conversion programs

have not only converted farmland, but also grasslands to forestland (2005). Changes associated with the water balance may occur at the regional level where intensive afforestation has occurred, however, it is not known to be significant problem at this time.

Pilot Demonstration Site Description

Inner Mongolia Autonomous region is located in northern China with a total land area of 1.183 million square kilometers. It has been recognized as a major source of dust and sand, contributing 27 percent of the total dust storms affecting northeast Asia. Inner Mongolia has over 34 percent of the degraded grasslands in China and over 58 percent of the rangeland in Inner Mongolia is degraded (Sheehy 2004). The center of Inner Mongolia lies at 36-46 degrees North, 96 to 118 degrees East. It is part of the arid and semiarid areas of Central-East Asia. On average it receives less than 300 mm annual precipitation and 94 percent falls in the summer and autumn. There are six deserts or sandy-lands from west to east in Inner Mongolia. Vegetation is sparse and sand and dust material is abundant.

Figure 1.5 Ecological Zones of Inner Mongolia



LEGEND

I Forest	**II Steppe**	**III Desert**
I_1 Needle-leaf forest	II_1 Forest (or meadow) steppe	III_1 Steppe desert
I_2 Broad-leaf forest	II_2 Typical steppe	III_2 Typical desert
	II_3 Desert steppe	

(Houston 2004)

The central government selected four demonstration sites in Inner Mongolia as focus areas for restoration and development. Hunlunbuir, Xilinguole, Ordos, and Alashan are the leagues that were selected as demonstrations sites. Location, socio-economics, and ecological situation were evaluated in the selection process. The four areas each represent a major grassland ecozone. Hunlunbuir represents mountainous meadow grasslands. Xilinguole represents typical grasslands. Ordos banner represents dry grasslands, and Alashan represents desert grasslands (UNCCD 2005).

Xilinguole has a continental climate with warm summers and intensely cold winters. The mean annual temperature is between -2 to -6 degrees C, with January between -20 to -28 degrees C. Annual precipitation is between 100 to 150 mm, however, this is quite variable. Most precipitation is received in the summer.

Soil texture is described as coarse and the fertility is low. Soil organic matter is less than two percent and Nitrogen is less than 0.10 percent. Soil Phosphorous levels are 1.65 part per million and Potassium is less than 100 parts per million. 36.95 percent of the soil is categorized as Kastanozems and 24.85 percent is categorized as Luvic Kastanozems (Deng 2005).

Vegetation is distinct from the rangelands to the eastern and western deserts. Eastern Gobi Desert Steppe consists of drought-adapted shrubs and sparsely distributed low grasses. The dominant shrubs include Caragana species (*C. bungei* and *C. leucocephala).* Other shrubs include gray sparrow's saltwort (*Salsola passerine*), gray sagebrush (*Artemisia Xerophytics*), *Potaninia mongolica*, and *Nitraria sibirica.* Low grasses include needle grass (*Stipa gobica* and *S. glareosa*) and bridlegrass (*Cleistogenes soongorica*).

Xilinguole is covered with 70,000 square kilometers of sandy land. With 61 communities and townships in the region, over 330,000 people are affected by grassland degradation. The population density is 4.7 per square kilometer. Livestock is a major source of income with a population of 5.7 million heads.

Table 1.2 Xilinguole's Grassland Area and Degraded Grassland Area

	1980s	1990s
Total Rangeland Area (ha)	2,054,400	1,995,400
Deteriorated Area (ha)	971,133	1,925,133

There are three main zones in Xilinguole. The western part is driest and grazing is entirely banned. The area is fenced and protected with an emphasis on restoring shrub lands. The middle zone receives over 300 mm of precipitation each year. Here aerial seeding, tree planting and small watershed management is the focus. In the eastern zone precipitation is over 350 mm each year. Crops are more common, grazing is banned and attention is given to the regeneration of shrubs and other vegetation.

Active measures were taken to prevent dust storms and shifting sand dunes. A 420 km long green belt, with a width of three to five km was established through fencing closures, aerial seeding, and tree planting. A total of 1,282 square kilometers is included in this project. In addition, fodder bases now exist on the most favorable sites to provide food for livestock in feedlots. To date, over 27,210 people and 156,000 heads of livestock have been removed from the grasslands. Between 2001 and 2002 the number of livestock in Xilinguole Leauge was reduced nearly 16 percent. The number of large animals was reduced 6.8 percent, sheep and goats were reduced by over 18 percent and hogs were reduced by 21.6 percent (Inner Mongolia Statistical Yearbook 2004). These numbers indicate that herders are moving away from raising sheep, goats, and hogs. The relatively minor reduction of large animals indicates a shift in pastoral methods. Many herders were encouraged to enter into the dairy industry. Herders have reduced cattle numbers by switching to imported, high-productivity cattle, which are raised in stalls. They supply fresh milk to a processing plant that was opened by a private company (UNCCD 2005).

Inner Mongolia is one of the most under-developed western regions of China. All of the demonstration sites have depressed economies. These regions represent 69 percent

of the total land area but, in 2002, these regions yielded only 29 percent of Inner Mongolia's GDP (UNCCD 2005). Primary industry still contributes a relatively high proportion of the GDP. The animal husbandry sector of Xilinguole represents 66.3 percent of the total commercial value of agriculture. Agricultural productivity is low and cultivation takes place on marginal land. The average net income of farmers and herdsmen in these areas has improved greatly but income levels are still below the national average. In Xilinguole, the net income was 1,940 RMB (235 USD) in 2002. The national average was 2,476 RMB (300 USD). The most destitute can be found in these pilot study areas. In 2002, there were 74, 348 people that lived below the absolute poverty line of 625 RMB (76 USD) in Xilinguole.

Integrated Restoration Activities in Xilinguole

As part of the 2001 to 2010 National Action Plan, an integrated management plan has been designed that is intended to address poverty alleviation, while actively working to rehabilitate the grasslands. Below, Table 1.3 lists the primary activities, the quantities, and the total investment of each activity. In total, the project will cost over 14.5 million USD. It will directly benefit 900 households through resettlement. Some households will be selected for demonstration purposes to encourage other locals to adopt similar activities. If successful, such sites may attract further investment into similar models.

Table 1.3 Xilinguole League's Integrated Restoration Plan

Project Elements	Units	Amount	Unit Price (USD)	Amount required/Unit /000
Sand barriers	Ha	2667	403.44/ha	1,073
Tree planting	Ha	13,333	182.93/ha	2,439
Containerized seedlings stock	Seedlings	20,000,000	.04/plant	732
Closures	Ha	33,333	91.46/ha	3,049
Resettlement of displaced herders and farmers	Household	600	1,219.51	732
Demonstration households for agro-pastoral, integrated, stall-feeding activities:				
•Wind and solar power	Household	1	1,219.51	0.01
•Stall feeding	M^2	200	18.29/M^2	0.03
•Fencing and grazing by rotation	Ha	333	18.29/M^2	0.05
•Forage processing equipment	Household	300	4878.05	0.04
•Well digging and water Supply	Well	1	2439.02	0.02
•High-yield forage plots	Ha	0.67	1,097.56	0.06
•Livestock breeding and Improvement	Households	1	2926.83	0.24
Sub-total	Households	300	21951.22	6,585
Monitoring (equipment/labor)				146
Grand Total				**14,756**

(Adapted from UNDDP 2005)

Ecological Resettlement

Environmental degradation has led to a large population of ecological refugees. A growing population of herders and farmers can no longer meet their basic needs for fuel, water, and food from the declining grasslands. In 2000, as part of the Beijing-Tianjin Sandstorm Control Program, the central government started a program that is described as voluntary ecological resettlement. The strategy is to pull people out of poverty who live in extreme environmental conditions. The government assists residents by providing 3,500 to 5,000 RMB (423 to 605 USD) for resettlement. Migrant villages are established where the infrastructure for alternative economic activities are provided. In some areas vegetable planting, agriculture, or feedlot processing facilities are built. Nationally, there were 7.5 million people that fell into the category of ecological refugee. In 2002, there were still 5 million that needed to be assisted with resettlement (Li 2002).

Xilinguole is one of four of the original pilot sites for the ecological migration programs. Here the details of resettlement varied from village to village according to unidentified variables. An explanation of variability is not clear. Observations and interviews provide anecdotal information about the program.

Village Silang Cheng

Silang Cheng in Zhenglanqi Banner was established in 2002, it is one of the earliest cases of ecological resettlement. The village accommodates 200 households with a total of 560 people. Households receive about 368 square meters for pasture and home site. Approximately half the residents are ethnically Mongolian and the remainder are Han Chinese. Residents received a government subsidy of 15,000 RMB (1,816 USD), which is well above the average amount described by other sources. The government

initially provided residents with roads, wells, and electricity. Many homes have been equipped with bio-gas pits, which provide methane gas for stove cooking.

Dairy production is promoted as an alternative to herding. Residents receive low interest loans for investment in dairy cows. Villagers are discouraged from investing in sheep and goats. The village holds 500 dairy cows, or 2.5 per household. There is a nearby dairy distribution center, which collects milk directly from the village. Fresh and dried grass is fed to animals, as well as grain.

According to the village party secretary, Ma, his original grazing contract had a duration of thirty years. During the 1970's he and other herders were settled permanently onto designated pastures. His previous pasture is 30 kilometers from the new village. He had 20 head, which was primarily composed of sheep (approximately four AUM).

Mr. Ma stated that the nomadic system was gone. Ma adds, "Not all herders were willing to settle but most did because they wanted the subsidy. On the old grasslands life was difficult. Each spring there was a hazy wind that did not stop for three months." He was concerned about the rangelands prior to settlement and felt the condition was worsening but didn't see how things could be improved at the individual level. The resource pool needed management. He cites the Household Responsibility System as the root of the problem. He says farmers had the freedom to make their own grazing choices. People could expand their herds in a short period of time. This resulted in heavy grassland degradation. Grazing is now forbidden on his previous pasture. He reports that his old grassland has recovered after the exclusion of grazing. At this time, fodder is even collected from the old pasture to feed his dairy cows.

Ma feels confident about the future. He reports that dairy farming has brought him a 3,000 RMB (348 USD) annual net increase from herding. His land rights for the household are permanent and he claims that he could sell his property. He believes that his new lifestyle is a long-term solution. At this time, dairy product production is limited, while demand is still strong. If milk prices are stable, then he has a promising future.

Village Aolike

The village of Aolike, in Zhenglanqi banner followed a similar pattern of ecological resettlement. Here villagers were also resettled in 2001 and encouraged to enter into dairy production. Once they were settled they were trained to raise cattle through a government extension. In this case, the government provided fencing. They received a one- time subsidy of 10,000 RMB (1,211 USD) and received a low interest loans to invest in dairy cattle. After this initial investment, they were expected to individually expand and repay the loans after three years. Here most residents invest in cattle imported from Australia. There are over 200 head of cattle in the village or two head per household. The cows produce 300 days per year and yield about 7,500 RMB (908 USD) each per year. The price of milk is fixed around 6.6 to 7.0 RMB (.80 to .85 USD) per half a kilogram. Market access is convenient with an automated milking facility nearby. In addition, the dairy products manufacturer is also nearby.

One villager interviewed reported that the grasslands in the area were 80 percent degraded only four years ago. He states that life is improving significantly. Transportation is easier, electricity is accessible, and schools are nearby. There is welfare for the elderly and, overall, the living standard is improving. Households in this community had color televisions, motorcycles, and new brick homes.

Bagelai Production Brigade

Earlier attempts to mitigate the problem of overgrazing were also found in Xilinguole. Within the production brigade of Bagelai, in Zhenglanqi banner, the government intervened much earlier and community restructuring was significantly different than contemporary programs associated with ecological migration. Bagelai was incorporated into an unknown integrated desertification combating program that started in 1988. The government provided 75 percent of the funds for a fencing system, while the villages matched 25 percent of the cost and provided the labor. With the fencing system, herders are required to graze animals only nine months of the year. In the spring months, animals are fed in confinement. Each family is limited to their own land, which varies from 4.6 to 53.3 hectares. There are 75 households and 235 people in this administrative unit. There is no agricultural production in the area. Spring is strictly a period for the land to lie fallow. Families must purchase grain from the market. During the grazing periods, there is a limit of one AUM per 1.5 hectare.

Community funded house building is a component of the program. Initially, the government subsidized construction for a group of homes. Thereafter, residents in the settlement loan money to newcomers entering the village.

Tree planting is integrated into the program. Villagers are required to spend 40 days each year planting trees. The county forestry bureau provides year round technical support for such activities.

The production brigade leader, Li, stated that once you start planting trees, the grass just naturally returns. The villages under his jurisdiction were so successful that they were able to begin selling willows to other villages to plant. The grasslands

recovered well during the fallow period and they were eventually able to increase livestock numbers**.** His brigade was highly successful and he was selected as a national model settler and his village is used as a model for combating desertification. In 1992, these strategies became formally certified as a means of combating desertification. This attention resulted in a generous Japanese land donation in 1994 that allowed further expansion of their activities.

At the age of 67, Mr. Li is a lifetime herder and has been village leader for 45 years. Prior to the project his large collective cattle farm did not earn enough for him to collect a salary. Now he earns 10,000 RMB (1,211 USD) from family production and 2,500 RMB (303 USD) as leader of the production brigade. He feels that desertification is well under control.

Ecological Resettlement Commentary

Ecological resettlement has become a necessary element of the NAP. The environmental conditions are inadequate to support humans in some areas of severe degradation. In addition, severely degraded sites cannot be rehabilitated without complete exclusion of grazing and human use. The ecological resettlement program provides an immediate solution for destitute farmers and shifts pressure away from severely degraded rangelands. In the case studies in Xilinguole, the basic needs of families were met and they were provided with alternative occupational training. Perhaps the greatest benefit of the program is the increased access to education.

Programs should be applied with careful evaluation of rangeland resources. All 5 million of Inner Mongolia's remaining herders could not feasibly be removed from the grasslands and resettled into the stall-feeding dairy industry (Inner Mongolia Statistical

Yearbook 2004). Livestock fodder is still primarily supplied from local rangelands. Sites for high-yield forage plots are limited by the productivity of the land. As of 2003, only 6.5 percent of Inner Mongolia's total land area was considered to be arable and little is highly productive (Zhou 2003). If too much pressure is placed on this resource, rangeland degradation will continue to occur.

Tree Planting and Agro-pastoral Sites

An agro-pastoral demonstration site in Zhenglanqi was observed where 10,000 hectares of land was converted to an agro-pastoral farm. The project was funded by the national government in 2002 and initially supplied 100 kg of grain and 200 RMB (24 USD) for the conversion. Prior to conversion the land was primarily used for grazing and growing food for subsistence. The government supplied the seedlings for the planting of 0.6 hectares of forested area. They will receive annual payments of grain and cash for each hectare converted. This subsidy will last eight years. After conversion, any grazing was banned on that area. The site has rotating belts of Sandthorn (*Hippophae rhamnoids)*, Scots pine (*Pinus sylvestris*), *Populus spp*., and alfalfa. Sandthorn is indigenous to the region and is a nitrogen fixer.

According to Zhang Kebin, a Beijing Forestry University Professor, the trees are irrigated when planted and then dependent upon rain. Species are selected according to site conditions, availability of stock, nitrogen fixing capabilities, use as fodder, and growth of consumable fruits. Local extension services provide advice to farmers for species selection.

Land conversion programs and tree planting represent a significant government investment. The sustainability of the program is a concern. The government only

provides seedlings upon initial conversion. The annual subsidies will be removed after eight years. Thereafter, farmers are dependent on trees to provide economic returns. Nationally, seedling survivorship is placed around 40 percent **(**Runnstrom 2000**).** If the trees do not provide annual economic returns such as, nuts or fruit, there is a strong possibility the trees will be sold for lumber. While it is illegal to cut trees, there are no enforcement mechanisms in place to prevent tree theft or deforestation after the subsidies are removed. There is no explicit education program in place to educate farmers on the ecological benefits of forest coverage. Even if these principles are understood, basic needs will be addressed before environmental concerns. Cropland conversion programs of this nature may only provide temporary ecological benefits.

Farmers need additional support and capacity building. Training in agro-pastoral techniques would help enable farmers to maximize the benefits of their government subsidies. Alternative energies and fuel-efficient stoves would help reduce the local need on timber resources. Incentive programs for maintaining vegetation coverage on their farms would encourage farmers to pursue innovative systems for maintaining standing timber, brush, and grass.

The process of seedling selection in tree planting programs needs further examination. The same species are selected for a wide range of site conditions and there is little variety in planting regimes. The arid environment of Inner Mongolia limits species diversity among trees. It may be more appropriate to focus on re-vegetation of native shrubs and grasses, which are more adapted to site conditions. There remains a need for more adaptive management.

Fenced Closures

The benefits of closures as a simple means of returning vegetation cover to degraded landscapes is well documented (Su et al 2004, Liu et al 2001, Sheehy 2004). A successful example of this was found in Zhenglanqi Banner, Inner Mongolia. The government provided funding for a fencing system that covers 400 hectares. The program started eight years ago and the site is now 50 percent covered with *Populus spp*. and *Salix spp*. No planting, seeding, or irrigation took place and it represents a low government investment. The land is contracted for protection for 70 years. After that, herders will be able to contract the site for low intensity grazing. This site was chosen because it was identified as a critical transition zone for the prevention of sand movement from north to south.

The success of closures is undeniable and an effective means of restoring natural and indigenous species. Long-term closures potentially would allow for climax communities to return. The closure in Zhenlanqi banner was rapidly re-vegetated due to proximity to a perennial riverbed. Other sites may not experience such dramatic results.

Critics of closures have emphasized that closures do not solve the landscape level problem because it reduces available grazing land and then concentrates grazing elsewhere. Certainly closures will not reduce livestock numbers but can be beneficial as part of an integrated program that addresses livestock reduction. In addition, there is concern that closures, such as the one in Zhenlanqi, prevents herders from access to water. Biodiversity is highest near water sources and grazing intensity is highest around water sources in free pasture (Kawamura et al 2005). This presents a direct source of conflict between herders and the NAP.

Concluding Development Strategies

The 2001 to 2010 National Action Plan for Xilinguole League represents a genuine effort to implement a well-integrated plan that addresses the economic needs for herders and farmers. There are encouraging attempts to experiment with alternative energies and innovative solutions for job opportunities. Positive attempts have been made to promote capacity building and self-development. The plan incorporates continual activities to combat desertification through tree planting, sand fixation, and closures.

The economic situation and harsh environment of Inner Mongolia result in a difficult eco-environmental question. Residents are vulnerable to drought and the adverse effects of desertification. Opportunities for enterprise and development are limited. While eco-tourism has become the answer to balancing economic development with environmental protection in much of China, such opportunities are limited in the arid rangelands. Economic development must proceed with caution in the brittle environment of China's rangelands.

Surplus Labor

There remains a need to provide training and opportunities for off-farm jobs. In Xilinguole Leauge, surplus rural labor continues to grow each year. Since 1978, primary industry job opportunities have declined while available labor in this sector has maintained (UNCCD 2005). Job opportunities could be promoted within rangeland restoration. Technicians could be hired locally and trained in monitoring and restoration methods. The government has a long-term commitment in both of these areas and local labor would be more economical. Agricultural processing facilities could be promoted

locally, thereby reducing transportation costs and increasing market access for local producers.

Herding Management

The primary shortcoming of the National Action Plan is the absence of any strategy to manage and improve herding practices. There are no additional measures to prevent further degradation from over-grazing. The ecological migration program removes herders from sites that have been most severely degraded. This reduces pressure, however, it does not prevent degradation on sites that are mildly or moderately damaged. Within Zhenglanqi, only 10.8 percent of the land area is severely degraded. The majority of the land area is moderately or only lightly degraded, 25.9 percent and 56.4 percent respectively (Deng 2005). While grazing has been excluded in many areas, there are still grasslands that are in use and have not undergone excessive degradation. How these grasslands can be properly maintained and managed to avoid declines in productivity is a pertinent question.

Active attempts to encourage appropriate grazing strategies are minimal. Model households used as demonstration sites have a role but most herders would lack the capital to invest in fencing and shelter systems for rotational grazing. Furthermore, it is not guaranteed that neighboring herders will ever observe these model households. Communication is limited in much of rural China and there is potential that the information will never be successfully transferred.

Promotion of Range Grazing

While rangelands are brittle, they are also resilient to reasonable levels of grazing.

A long term study in Inner Mongolia's Chifeng municipality supports these conclusions. Chifeng shares some vegetation characteristics with Xilinguole. It is characterized by typical steppe succession communities in the *Stipa grandis* association. These communities include Ural licorice, Jointfir ephedra, Chinese Stellera, and Mongolian thyme. Typical steppe communities begin growth in late spring to early summer, mature late in the growing season, and senesce in late September. This community is typical of vegetation found throughout Inner Mongolia and northeast China. Between 1985 and 1987, the response of vegetation to the removal of grazing was monitored. The study finds that in two to three years over 70 percent of perennial grasses and more than 50 percent of the most common forbs responded positively to protection from grazing. Many species that appeared to be absent from the exclosures were present after grazing removal (Sheehy 2004). This would suggest that under moderate grazing stress, rangelands can potentially recover through temporary exclusion of grazing.

Vegetation recovers relatively quickly compared to soil. Soil degradation is a significant concern in China's degraded grasslands. After the exclusion of grazing there is little information available on soil recovery in Inner Mongolia's severely degraded rangelands. One study conducted by Linze Inland River Basin Research Station of the Chinese Academy of Sciences, suggests that excluding livestock for five years in sandy degraded rangeland can significantly improve soil properties and restore soil fertility. In severely degraded sites there was not a significant improvement in the Carbon-Nitrogen ratio. Soil organic C and N concentrations, soil biological properties began to improve after ten years (Su et al 2004). This demonstrates that while rangeland degradation can

be reversed, recovery is slow once a site has reached severe levels of degradation. For this reason, a greater focus should be placed on preventative measures.

For thousands of years China's rangeland ecosystem sustainably supported nomadic pastoralism. A balanced system existed and could potentially be returned. Given that 80 percent of the rangelands are still suitable for grazing, the productive capacity of the rangelands could be maximized through rangeland grazing. Clearly, reducing the number of grazing units coupled with a well-organized rotational grazing system would help bring the system back into equilibrium.

Where rangeland is only moderately damaged a well-organized deferred grazing system should be used. This would allow key species to germinate before grazing begins in the spring. The temporary exclusion of grazing with a rotational grazing system during the initial stages of rangeland degradation would allow for adequate recovery.

Boundaries needn't be realized through expensive fencing systems. There is surplus rural labor and a tradition of free range management. Fencing is not economically rational in the context of Inner Mongolia. Grasslands are extensive and of low productivity per unit of area. Furthermore, grassland productivity is highly variably annually and seasonally. Fencing in productively variable sites prevents flexible management. Therefore, a fencing investment has marginal benefit for Inner Mongolia's rural poor who lack capital investment. Exclusion and rotation can be achieved by herder regulation in the field. Households could monitor seasonal exclusion by establishing their homes on-site.

Realizing a Carrying Capacity

A standard system to quantitatively assess the impact of grazing on rangelands for the purpose of recommending appropriate stocking levels has been established through the Canada-China Sustainable Agricultural Development Project (Houston 2004). A stocking rate guide was created that standardizes categorization of rangeland conditions. Ecological sites are established that include information on dominant plant species, important land characteristics, soil types, soil moisture regime, and potential plant communities. Vegetation is then collected to determine the percent by weight of increasers and decreasers of grasses, sedges, shrubs, and annuals. Thereafter, approximate stocking rates are determined by season and level of site degradation. This system is detailed in Houston's Framework for Range Conditions and Stocking Rate Guide. This system requires relatively basic field equipment and could be an economical and systematic way to determine a carrying capacity for various site conditions. Widespread use of this system has not yet occurred. Climatic variability and range condition changes would require that new assessments occur periodically. Knowledge and technology transfer could occur at the county level to ensure that assessment will continue to occur over time. This would simultaneously serve to create local off-farm jobs.

Discussion and Conclusions

Long term success depends on building integrated strategies that focus on the causes of desertification. Over the last 50 years, the PRC has learned a great deal about reversing the effects of desertification. These solutions often require constant inputs and can be easily negated. Without first addressing the causes of desertification, positive

long-term results will not be realized. Restoration programs are beginning to address the needs of locals by providing solutions for basic needs. Provision of simple amenities such as bio-gas pits can have far reaching affects in the fight against desertification. Central and local governments are beginning to successfully address poverty first. Remaining is the need to find ways for rangeland herding to be promoted and made viable within the context of modern China.

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