SMALL-SCALE CO-MANAGEMENT FOR THE SUSTAINABLE USE OF XILINGOL BIOSPHERE RESERVE, INNER MONGOLIA

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Abstract

There exists an externality between the private cost of livestock breeding and the societal cost of livestock breeding in Xilingol Biosphere Reserve (XBR), Inner Mongolia, which has led to extensive grassland degradation. The property rights regime "household production responsibility system" (HPRS) was adopted in 1980 to increase livestock production in XBR. Though HPRS has been successful in increasing production, it has led to ecological degradation of the grassland because it promotes private economic interests at the cost of the societal interest (grassland conservation) because of inefficient enforcement of stock rate. To compensate for this shortfall, the *Wei Feng Zhuan Yi* or "Fencing Grassland and Moving Users" (FGMU) Policy was initiated in 2002 to restore the grassland. Based on structured and open-ended interviews conducted with government representatives and herding families in all management units of the XBR, we will discuss the current property rights regime and describe why FGMU may further degradation of the grassland. We propose an alternative property rights regime, small-scale co-management, to concurrently promote both the individual economic interests and grassland conservation by improving the enforcement of stock rate. We believe this shift in property regime should be accompanied by providing alternative occupations for herders.

Introduction

Common pool resources (CPRs) are natural or human-made resources where one's use subtracts from another's use and where it is often necessary but costly to exclude beneficiaries from using the resource (Ostrom et al., 1999). The grassland of the Xilingol Biosphere Reserve (XBR) in Inner Mongolia, China, designed to protect the biodiversity of a steppe ecosystem and to maintain well-being of local people, is a common-pool resource that has undergone declines in biological productivity, loss of biodiversity and native species, and soil erosion (Lin, 1990; Longworth and Williamson, 1993; Chen et al., 2002). This degradation endangers the livelihoods of pastoral herders who depend on the grassland for its ecological and economic functions.

Dust storms arising from grassland degradation in China affect cities such as Beijing and Tianjin, and travel as far as Japan, Korea, and the United States, raising questions of transboundary pollution (NOAA, 2001). Restoring grassland in XBR and other areas of China is important for people affected by dust storms in addition to improving conditions of pastoral people.

The improper design of property rights is intimately tied with environmental problems: when property right institutions are inefficient, owner interests may diverge from societal interests (Tietenberg, 2000). This has been the case in XBR, where the property rights regime "household production responsibility system" (HPRS) was adopted in 1985 to promote economic efficiency of the grassland. Since the establishment

of HPRS in 1985, XBR's GDP has grown from 102.83 million yuan to 2.51697 billion yuan in 2000 (Li and Ali, in press). However, the degradation area increased from 76% to 81.7% of the total grassland during the same period (Tong et al., 2002). This data shows that economic development was accomplished at the price of grassland conservation, the societal interest.

Because of grassland degradation under HPRS, the FGMU policy was initiated in 2002 to restore grassland. We gathered detailed information about HPRS and FGMU through structured and open-ended interviews conducted with 13 government representatives and 19 herding families in all management units of the reserve: Bainxile Farm, Beilike Farm, Bainkulun Farm, Maodeng Livestock Farm, and all sumus (villages). Using information obtained in interviews, we will assess FGMU to describe why it may further degradation of the grassland. Rather than managing the grassland with both HPRS and FGMU, we suggest shifting to a different property rights regime, co-management, to promote both private economic interests and grassland conservation.

The ecological and social condition of XBR is demonstrative of the ecological situation of most of Inner Mongolia. However, with the classification as a biosphere reserve, XBR is in the unique position to make initiatives in conservation and restoration that can be adopted in other parts of Inner Mongolia, and Xinjiang and other provinces where desertification is progressing at a rapid rate. The discussion in this paper, therefore, is relevant to other areas facing grassland degradation.

Property Rights

Xilingol Biopshere Reserve has had a complex and constantly-evolving history of property rights. Before 1955, Xilingol was operated by a feudal system, whereby nearly all livestock were owned by nobles, and most herders were employed as grazing or milking workers (Li and Ali, in press). Employees received salary and the opportunity to obtain their own livestock through the Suluke contract system. Under this system, herders rented livestock from nobles, and every year 70-80% of the newborn livestock belonged to the lessor, and the remaining to the herder. In 1945, when socialism developed, the Suluke system was altered so that herders were able to keep 30-40% of the newborn livestock rather than 20-30%.

Small-scale communes were established with the support of the government in which families owned livestock and lands collectively in 1955. The herders self-organized to raise livestock, harvest grass, and make dairy products. Four state farms, Bainxile, Maodeng, Bainkulu, Beilike, were established during this time.

China went through the economic reform period in 1980, and consequently, "private" ownership of land was introduced to Xilingol Reserve under the "double contract household production responsibility system" (HPRS), under which two contracts may be arranged with herders, for rights to either grassland or livestock (Thwaites et al., 1998). Through this system, the land was divided and appropriated to individuals under contract. Though not in fee-simple absolute, this enables farmers to privately manage grasslands with little governmental interference.

The HPRS was adopted to increase production in the reserve by enabling herders to become wealthy through hard work. In addition, it was believed that private

management would increase the sustainability of the grassland because herders would be more likely to internalize social costs of livestock breeding.

As organizations of the Communist Party, the farms and sumus have a top-down structure, where policies are created at higher levels and implemented at lower administrative units. For example, in Bainxile Farm, the planning and implementation of the HPRS is carried out at a "subfarm" level, so that each local administrative unit may decide how it is best designed and applied to a particular region.

Herders have the option to raise an allocation of common livestock on behalf of the farm through a revised Suluke system, in addition to privately owned livestock. Though they are given the right buy and sell this livestock, it is not privatized; the farm obtains a proportion of the profits and the remaining is kept by the herder. This has provided a strong motivation to increase wool yield and livestock survival rate, and has enabled people who do not possess their own livestock to obtain profits from herding. However, we found that the system does not help the poorest herders, since only herders with the financial ability are eligible to raise sheep.

Currently, land-use rights are held by the four state farms, four townships, and Xilinghot City. The reserve administration, after a decade of efforts, controls only the core areas of the reserve, only 0.3% of the reserve's area (Han, 2002). The small area of legal use limits the ability of the reserve administration to protect the entire ecosystem, and can only protect isolated islands.

The results of our study indicate three major property-rights regimes co-existing now in XBR. About 0.3% of the XBR area is managed as state property, and includes the core areas of the reserve, where grazing is forbidden. The other two are both components of the HPRS, which we name System 1 and System 2 as below. In both of these systems, the "harvest grassland," or the grassland in which grass is harvested in autumn to serve as winter feed, has been divided and appropriated to households according the number of people in the family. There is a slightly higher allotment for herders who were once farm employees, and herders who raise the Farm's sheep under the Suluke system.

(1) *System 1* – This is the dominant regime in XBR, found in all units except subfarms 1, 2, 5, and 6 of Bainxile Farm. The "grazing grassland," or grassland upon which livestock may graze, has been divided and appropriated to individuals under contract, according to the number of people in the family. Some farms adopted System 1 within the last five years, and previously operated by System 2.

(2) *System 2* - This regime is found in subfarms 1, 2, 5, and 6 of Bainxile Farm. Each herding family is granted an area in which to build his ranch; the herder is permitted to let his sheep wander in the area "around the house." No boundary lines are drawn, thus this property regime assumes characteristics of both private and open-access property. Before 1999, herders were permitted to "homestead," to obtain their use-right land, like on the Great Plains in the United States under the Homestead Act of 1862. Now herders are required to receive permission from the subfarm before establishing residence.

The general perception of managers in XBR is that grassland is better sustained under System 1. Interviewees responded that there is greater biomass in the grassland operated by System 1, and they cited private management as the reason for it. Because of

this perception, the remaining grazing grassland under System 2 will be divided and appropriated to individuals in 2003, and thus all herders will operate under System 1.

Under HPRS, the government must play the role of judge to resolve conflicts generally related to boundaries. Interviewees reported that after the transition from System 2 to System 1, there are greater conflicts between herders. If herders cannot solve the conflict independently, they will take the problem to the local government which can resolve the problem by using boundary maps if available, or if not, by hiring a surveyor. Government officials responded that problems are generally easy to solve. Generally, herders are satisfied with the judgment, but sometimes, they disagree and the conflict remains unresolved. Interviewees under System 2 responded that this system of management produces fewer conflicts, and those that arise are easy to solve. The most common conflict is the mixing of sheep owned by different owners when they graze in the same area. However, serious conflict is possible when the government permits families to settle in close proximity. For example, one herding family reported physical conflict that involved a lawsuit when the government permitted a household to settle in what was perceived as too close.

There has been a dramatic increase in production as had been hoped with the application of HPRS. There has also been the creation of a wealth gap. Respondents perceive two reasons for poverty under HPRS, (1) a lack of manpower in the family, generally due to sickness or death (2) laziness. The government generally provides welfare in the form of food or money to impoverished herders.

A fourth, unofficial property regime exists, co-management. This occurs generally between friends and relatives, who hire a shepherd to manage their sheep collectively. Often, they will pool their privately owned lands together and allow their sheep to graze in common. Though each herder holds the land privately, he is willing to share with others in exchange for the reduced cost of shepherding. Another form of cooperation between herders is building fences together, done by herders who live adjacent to each other. Building fences cooperatively is still costly for herders, however.

Causes of Grassland Degradation

Degradaded grassland accounts for 81.7% of the total land area of XBR, and it is in serious threat of desertification (Tong et al., 2002). Degradation occurs in areas under all three forms of management: state, System 1 and System 2 of HPRS. Longworth and Williamson (1993) have described the degradation of the grassland as related to inappropriate governmental policies. We believe the reasons for grassland degradation are (1) agricultural reclamation (2) increase in population of herders (3) the externality of livestock breeding.

Natural grasslands, such as XBR, have co-evolved with disturbances such as fire, drought, and grazing. For millennia, nomadic pastoralism was practiced on the Inner Mongolian grassland while retaining a stable grassland ecosystem. In the 1950's this traditional land-use pattern dramatically changed. Han Chinese began moving to Inner Mongolia in large numbers, urged by Central Government to expand cultivation as part of the "Great Leap Forward." However, agriculture can be only be performed successfully in areas with at least 350 mm annual precipitation, so the area is unsuitable for agriculture and has resulted in degradation. In addition, the 1994 policy created in Beijing requiring

cropland claimed by construction to be offset by agricultural reclamation elsewhere may have aided grassland destruction in XBR.

Population has increased dramatically, but livestock breeding has remained the primary industry. Between the establishment of the reserve in 1985 to 2000, the population has grown from about 100,000 to 173,000 and livestock numbers have nearly tripled from 708,675 to 1,921,425 (Li and Ali, in press). With overpopulation, each herder has a smaller area of land to raise the amount of sheep he needs to obtain income, which leads to overstocking. Thus the rise in population accompanied by the continued emphasis on livestock breeding have contributed to grassland degradation.

Another reason for grassland degradation is the externality of livestock breeding. Zhang and Li (2002) have shown the externality of livestock breeding in Bainxile Farm occupies 17 % of the total income from stockbreeding. This environmental cost is much higher than the average level of 5 % in some developing countries (Pearce, 1996).

The externality enables herders to stock beyond carrying capacity. Table 1 shows a microeconomic financial analysis of lamb-selling for an above-average household in Bainxile Farm, Subfarm 5.

TABLE 1: Microeconomic financial analysis of herder household

	Sheep Units	Stock Rate	Production Cost	Grassland Fee	Income	Net Income
True Scenario (Stock rate violated)	277	13.33 mu/sheep	40320	3465	63000	19215
Ideal Scenario	135	18 mu/sheep	33794	3047	55400	18559

This table shows the short-term gain of overstocking for a herder household. Overstocking is related to the need for income and the higher private discount rate than social discount rate; that is, though overstocking may degrade grassland in the long-term, the herders trade off the certainty of the present with the uncertainty of the future, which is based on weather conditions.

Restoring the grassland means (1) internalizing the externality of livestock breeding (2) decreasing the population of herders (3) minimizing agriculture on the grassland.

Problems with the current HPRS Regime

The HPRS has not been successful in conserving the XBR grassland because it is ineffective in internalizing the externality of livestock breeding, which it aims to do so by controlling stock rate. Because it is very difficult for central or local governments to monitor the stock rate of each household, the government has limited the area of harvest grassland to each household as an indirect limitation on stock rate. However, this measure has failed to work because of the inability to stop users from purchasing grass in excess of the amount provided by their harvest fields (Li and Ali, in press).

Most herders and government administrators believe that the degradation of the grassland is due to poor weather rather than overstocking of the grassland. An engineer at the Grassland Supervision Agency, one of the people responsible for calculating the carrying-capacity stock rate, said, "Too many sheep plays a small role in the degradation of the grassland, it's due to bad weather." With this view, the government has not required herders to follow calculated stock rates and no monitoring has occurred at all. Government officials also cite the reduction of livestock due to drought as a reason why stock rates need not be enforced.

"Fencing Grassland and Moving Users" Policy

The Central Government has demonstrated their concern about the environment in Inner Mongolia by pledging RMB 4.7 billion (US$ 573 million) over the ten years to mitigate grassland degradation (U.S. Embassy, 2000). With this first important step in place, the local government has taken several initiatives, the major of which was implemented in 2002, called the *Wei Feng Zhuan Yi* or "Fencing Grassland and Moving Users" (FGMU) policy. RMB 2.35 billion has been provided for the implementation of the FGMU for 2002-2004 as the first payment of three by the Central Government. The FGMU Administration was established in Dec. 2001 with a staff of 6 people, with the task of monitoring and applying penalties. The FGMU Policy has several components.

(1) Forbidding Grazing. Under the Forbidden Grazing (FG) policy, livestock are not allowed to graze on FG-designated lands either seasonally or year-round. In the grassland to 1 km either side of roads extending through the reserve, and the area 1 km around Xilinghot City, grassland is assigned year-round FG status beginning spring 2002. In the rest of the reserve, grazing on the grassland is forbidden in spring. Because 2002 is a "transitional year" for this policy, this seasonal restriction was only carried out on 384 km^2 of the reserve, consisting of select areas the government has deemed as sensitive, important, or degraded. In 2003, the spring restriction will be implemented throughout the entire reserve.

For herders affected by the springtime restriction, this means having to pen-raise livestock in the spring. This implies buying more feed from nearby agricultural areas or depleting their winter supply of grass growing in their harvest grasslands. Pen-raising also requires more labor and greater transportation costs for grass-cutting. This is expensive for the herder, and many herders and government officials have expressed concern over the finances herders will have to incur for this policy. In addition, the current breeds of sheep found in the reserve, fat-tail or fine-wool, are not suited for pen-raising. In the pens, particularly in spring, sheep feel hot and uncomfortable, and consequently there is greater chance of epidemic. For herders affected by the year-round FGMU restriction, they must pen-raise sheep year-round or change their profession. Since year-round pen-raising is not an option for most herders, many will change their profession.

It is generally believed by the administration that the FG policy will assist the grassland in two ways, (1) it will enable grass gain foothold during an ecologically sensitive period, spring, when new seedlings have begun growing and (2) cause herders to reduce their stocks because of the excess cost incurred by pen-raising.

As 2002 is a transitional year, most towns and farms provide compensation of money or feed to herders affected by this policy. For example, corn is provided to the herders in Beilike Farm. Beginning spring 2003, no compensation will be provided to herders for extra costs incurred by this policy.

(2) Moving Users. To combat overstocking, the government will facilitate a transition to new occupations. This involves moving users, because of the region's scarce resources and fragile ecosystem, which make it unsuitable for industry or urbanization. RMB 100 million (US$ 12 million) over three years will be spent to move 15,000 herders to cow-raising villages, agricultural villages, and urban areas from desertified areas and areas designated as year-round FGMU. Reminiscent of the migration of thousands of farmers during the American Dust Bowl, these "ecological immigrants" will need to learn new skills to develop new trades.

One way the government has provided alternative occupations for herders is through the establishment of cow-raising villages. Cow-raising is considered to be better for the grassland ecosystem because they are suitable for pen-raising and use fodder more efficiently than sheep and goats. Currently, there are two cow-breeding villages in XBR, managed by Xilinghot City; "Old Cow Village" was created over 9 years ago by Xilinghot City, and "New Cow Village" was established in 2002 by Bailike Farm. Currently, the government is facilitating the transition to New Cow Village by providing the herders a house and pen worth 30,000 yuan at a subsidized cost, 5,000 yuan. The government does not provide other subsidies for raising cows.

In the year-round FG area around Xilinghot City, herders will be required to move to a cow-raising village, or another village with an adequate water supply. Most families in this area have moved to a cow-raising village, and 5 have moved to an agricultural village. In other areas, the move to a cow-raising village is voluntary and is determined by an application procedure. One poor herder with no livestock or savings reported that she was denied admission to the cow village. Because very poor herders are not chosen to move, and because they generally do not have the initial investment to move, cow-raising villages do not help the poorest herders.

A villager in Old Cow Village reported that the villagers of the town have a fixed customer for milk, a private company from Xilinghot City. Since the disaster, the price of milk has decreased due to an oversupply of milk in the market, and the company has taken the villagers' milk and without paying for over three months. Thus, cow raising may not be a profitable venture to explore as an alternative profession to sheep and goat raising.

Ecological immigrants may decide against moving to a cow-raising village because the initial investment of 5,000 yuan for a house and pen may be too high, or because herders are doubtful that the shift to cow-raising will be profitable because of the oversupply of milk in the market.

Another way the government encourages moving users is by providing incentives to herders living in the year-round FG designated area to move to Xilinhot City. In China, the worker registration system generally prevents newcomers from being legal city residents. In this case, city residence is approved. Movers are also provided 4,500 yuan to support them while they find a job. The government has stated that a small percentage herders have taken up this opportunity to move.

(3) High-Yield Agriculture. To compensate for the shortage of the feed due to grassland fencing for restoration, high-yield agriculture is being promoted to serve as an alternative way to supply more fodder from a small plot of land. The local governments subsidize household small-scale agriculture. For example on Bailike Farm, the local government provides half the cost of initiating corn-planting. In Arshan County, the government pays half the cost of constructing deep wells needed for agriculture. Officials reported that deep wells over 30 m are needed for agriculture. In addition, the city of Xilinghot depends on water from Xilin river for its water supply. It has already been determined that water use has exceeded productive capacity (Jiang and Liu, 2002). Agriculture threatens this water supply. In addition, lands reclaimed for agriculture have a high probability of becoming desertified once agriculture is ceased.

(4) Tree planting. A high emphasis has been placed on tree planting, which is important to provide shield against sandstorms. Similar work was done successfully during the American Dust Bowl of the 1930's. However, this is a prescriptive policy that does not treat the causes of desertification and hence should not be treated as a solution. In addition, tree-planting is often water intensive, and may require excessive groundwater pumping, and trees may have a low survival rate in the arid region of XBR.

(5) Import high value-added livestock. Most local governments are encouraging and subsidizing the transition to a breed of European sheep, which are meatier and are suitable for pen-raising, because (1) herders' income will be constant or similar with fewer livestock and (2) pen-raising, though agriculture-intensive, is perceived to be better for the grassland. However, the cost of this livestock, and required pen-raising, is often prohibitively expensive for herders, even if the government subsidizes the transition. The fat-tail and fine-wool sheep are breeds in the reserve are unique. Another drawback is that changing the breed of sheep on in the reserve reduces genetic diversity of livestock. The transition to prime cattle is also subsidized.

Forbidding Grazing on the Grassland

The FG policy may increase degradation of the grassland due to the prisoner's dilemma effect, caused by the low ability of the central agency, the FGMU administration, to impose correct punishments.

To determine the probability of imposing correct punishments, the possibilities for cheating must be examined. Cheating is possible generally in two ways, transporting sheep to another banner to graze and allowing the sheep to graze at night, when monitoring is more difficult. Cheating may also be possible during the day, but for the purpose of this study, assume the probability of getting caught this for this infraction is zero.

In order to graze sheep in another banner, transportation is required. Herein lies the risk of getting caught. If the herder is stopped by a monitor for questioning, and he does not have a good reason as to why his sheep are in the vehicle, he may be caught. However, if the herder provides a reasonable excuse (a lie), it is likely he will get away with it. Once in the banner, a different administrative unit, the monitor does not have the

authority to prohibit the sheep from grazing there, and the herder can graze his sheep without being caught.

Night-cheating is possible for both wealthy and poor herders, with generally the same risk of getting caught. It is more likely that wealthy herders are able to cheat by taking their sheep to another banner, because they have greater access to facilities that can help them cheat, such as cars.

Assume the central agency has complete information about the actions of the herders and assigns punishments for all violations. We demonstrate the resulting scenario with a two-person model of a central-authority game with incomplete information in Figure 1 (Ostrom, 1990). In this ideal case, x, the probability of punishing cooperators, those who comply with FGMU, is 0, and y, the probability of punishing defectors, those who do not comply with FGMU, is 1. If both persons cooperate (C), then they will each receive 10 units of profit. If both defect (D), they will each lose 2 units of profit. If one cooperates and the other defects, the defector will lose 1 unit of profit and the cooperate will only gain 9 units. The route that most benefits both persons is then (C,C).

However, in XBR, the central agency does not have complete information about the actions of the herders: it does not assign punishments for all violations, because of the ability to graze in a banner outside the reserve. This scenario is represented in Figure 2 (Ostrom, 1990). Let us assume that the central agency makes no errors in punishing cooperators, but that due to the ability to graze in another banner, the central agency has a low probability of sanctioning defectors. Assume the probability of sanctioning defectors is 10%. Then x= 0, and y= .1. In this case, the herders' face a prisoner's dilemma, and they will choose to graze in another banner rather than cooperate (Figure 3).

Another drawback of FG is that it causes a heavy loss of income for the herders. The 2002 net incomes of sixteen herding households interviewed in XBR and the projected 2003 net incomes with FG were calculated (Table 2). The incomes, already low, show dramatically lower net incomes: 8 herders suffered losses this year, while 12 will serve losses next year.

Table 2: Net incomes of sixteen herding households in XBR in 2002, and projected net incomes for 2003 with FG (RMB).

Herder	Net Income (2002)	Projected 2003 Net Income with FG
1	-1672.5	-6592.5
2	6350	3950
3	-2552	-3368
4	-10689	-14553
5	20712.5	-1487.5
6	-3142.5	-8782.5
7	62887.5	33247.5
8	2250	-10710
9	-5850	-8250
10	1060	-6140

11	9900	300
12	-21660	-28860
13	16475	5075
14	2550	-5850
15	-3974	-7718
16	-4340	-9380

Restoring the grassland

As stated above, restoring the grassland means to internalize the externality of livestock breeding. Under the current management regime of the XBR, there are several options that might achieve this affect.

(1) **Increase Environmental Tax.** The grassland fee could be increased to make the total cost of livestock breeding representative of its true cost. However, this would require quantifying the social cost of grassland degradation and establishing the appropriate tax rate, a difficult task.

(2) **Tradable Grazing Permits.** The market preconditions must be suitable in order for tradable grazing permits to achieve grassland conservation. Some inappropriate conditions are the presence of market power and transaction costs (Tietenberg, 2000). Currently, China does not operate under a complete free market, so the transition to tradable grazing permits will be difficult. In addition, tradable permits require extensive monitoring by a central authority agency, and the distribution of permits presents another problem.

(3) **Enforcing Stock Rate.** This method of internalizing the externality of stockbreeding is probably the most feasible for XBR. The method of stock rate enforcement could be performed by the herders individually through private management, nationally or locally through state management, or collectively through co-management. In any case, enforcing the stock rate will require changing the current property rights regime in XBR.

Redesign of property rights in XBR

Externalities may arise from the improper design of property rights systems (Tietenberg, 2000). One of the most common examples is the *res nullius* or "open-access" regime where ownership or control of a CPR is unassigned. Hardin (1968) argued that the open-access use of a common-pool resources leads to its destruction, with "rational" users obtaining direct benefits and only partial (shared) costs. There are several options for shifting property regime to achieve enforcement of stock rate and hence eliminate the externality of livestock breeding.

(1) **Privatized property.** Privatization has often been thought of as the solution to solving CPR management, because individuals bear the full economic consequences of their decisions, they have the incentive to fully take them into account (De Alessi, 1998). However, it is not possible for the XBR, because of the uneven distribution of resources

such as water on the grassland. This is why state ownership of the grazing grassland was initially introduced on the grassland. In addition, exclusivity is unworkable on a private scale because fencing is often too costly for herders and limits the migration of wildlife. Private management may lead to further degradation of the grassland due to externalities that exist when "the private calculation of benefits or costs differs from society's valuation of benefits or costs" (Griffin and Steele, 1986).

(2) **State property.** This involves a "command and control" approach with a central authority system. However, it is difficult to nationalize the pasture through an economic approach or administrative order (Han, 2002). Additionally, establishing and maintaining a central authority system is costly, and runs the risk of causing a prisoner's dilemma.

As shown above, it is difficult for a central authority system to forbid grazing on the grassland through FGMU. It is also difficult for the central authority to enforce other actions of herders, such as forbidding the purchase of grass (Li and Ali, in press). Limits on stock rates are also difficult to impose, because of the great expense of monitoring the large population in XBR. In addition, stock rates are difficult to impose through "command and control" because of cheating by misreporting stock numbers or hiding livestock with friends.

For a central authority agency to monitor stock rates, it must know the characteristics and carrying capacity of all areas of the land, and the particular actions of all herders (Ostrom 1990). Considering the population and vast expanse of XBR, this is a difficult and daunting task, perhaps impossible for a single or local agency.

(3) **Small-scale co-management.** A co-management regime seems to have the most potential in solving grassland degradation. There are several types of co-management regimes, but they generally involve "the collaborative and participatory process of regulatory decision-making among representatives of user-groups, government agencies, and research institutions" (Jentoft et al. 1998). Co-management may involve partnerships and/or various degrees of power-sharing between stakeholders, research institutions, and local and centralized government systems. By receiving input from herders and other organizations, co-management has the potential to better serve private herding interests while promoting the public interest (grassland conservation) more than traditional regimes, where managers may not be completely informed about the actions of herders.

Community-based management begins from the premise that people have the inherent ability to understand and take action to solve their problems (Ferrer and Nozawa 1997). Ostrom (1990) points to examples where CPR users have come together to forge solutions rather than waiting for other institutions to impose regulations. Certainly, this is the case in XBR, where users have come together to form new co-management regimes to promote economic efficiency. This coming-together also shows that the herders have the ability to take initiative and cooperate amongst themselves.

We propose "small-scale" co-management as the appropriate property-rights regime to enforce stock rate in XBR, where a group of self-organized families pool their use-right lands together and jointly manage the sum area of grassland. Co-management teams should be self-organized and voluntary rather than enforced, to promote a spirit of cooperation. Each team should select a leader(s), monitor(s), judge(s), and other roles they believe are necessary. These roles may be rotational. The teams should establish

their own set of rules for the grassland and establish penalties. They may calculate an appropriate stock rate based on the carrying capacity of the grassland.

Participation of herders in the management of the XBR grassland has been proposed by several authors (Xirimo 1994; Thwaites, 1998; Li and Ali, in press). Small-scale co-management is a feasible way to incorporate the herders into the management of XBR. In our model, we advocate a "bottom-up" rather than "top-down" approach where herders make most of the decisions regarding the management of the grassland. In this paper, we will not outline in detail the functioning of the proposed co-management regime; we believe this is the job of the herders and the local governments with whom they will cooperate.

The formation of a priori principles for successful co-management may make a system too rigid to change to new problems that may arise in the establishment of new co-management regimes (Steins, 1999). In this light, the suggestions presented in this article should be used as guidelines for adaptive management that is able to change for shifting situations.

Suggestions for implementing Small Scale Co-management

Training of herders

Training provides an opportunity to provide herders knowledge about sustainable grazing, initiating and designing co-management, and perhaps most importantly, establishing a sense of togetherness and belonging (Ching et al. 1998). Training should be initiated by the government to co-management volunteers. In training sessions, herders can be introduced to various existing co-management models, for example, the notably successful co-management regime in Switzerland where grazing rights are held in common (Teitenberg, 2000). Thus the herders may obtain ideas about how to develop their own management regimes. The herders should be taught to break down the notion that overstocking represents wealth, and that overstocking brings poverty to all.

Community bonding was common in the era of nomadic herding and state farms, but with the division of land and livestock under the HPRS, there is now a more individualistic approach to livestock grazing. Training can be an open forum where herders are able to develop a sense of community and voice concerns. It may help dissolve their individualistic nature help them realize that grassland degradation must be reversed as a collective force. During sessions, herders and government officials can begin to understand individual and mutual concerns and be able to perceive their respective roles in a co-management regime.

Community-building can be an important way to promote people to follow rules and regulations. Successful compliance may arise from the need for social acceptance. In tight communities, only small penalties may need to be applied to violators to serve as reminders of the value of following regulations.

Role of the Local Governments

The local governments should play the roles of instructor, supplier, and judge. The government should divide and distribute land, and provide necessary infrastructure to

co-mangement teams, such as meeting halls. It should provide training sessions to prepare herders for co-mangement and so they may experience community bonding. As herders become self-dependent in co-management, the local government may withdraw support and play a minimal role. The government may retain its role as judge, to resolve conflict within and between teams.

Currently, co-management exists on the regime, but it is not always successful, that is, there exists violations of the stock rate under co-managed regimes. This is because co-management is currently unstructured, with no leadership or monitoring roles or established regulations, and because co-management does not have the support of the local governments as instructor, supplier, and judge. When relevant actors are identified in co-management regimes and local governments work together, co-management will have a better chance towards success.

Benefits of Co-management

Enforcement of stock rate is prohibitively expensive on a top-down scale at either a central or local level in XBR, because of the large population. Because monitoring and penalty application will be done by the herders themselves rather than a central or local authority, enforcement costs will be reduced. The herders themselves can decide details about the carrying capacity of the land, also reducing enforcement cost. They may also have a better idea about local carrying capacity because of their experience with using the pasture.

Currently, because herders are not involved in the decision-making process, they feel frustrated and left out, with little understanding about how and why a decision was made. When one herder watched his son's herd being confiscated as a penalty for grazing in FGMU territory, he said he felt as if he was being "robbed." When people know how and why a decision was made, and are able to participate in the process, they may be more likely to cooperate in the management of the resource.

Co-management may allow Inner-Mongolian people to use their unique cultural traditions and ideas regarding property to design their management model. Often, in developing property systems, the concepts and rules regarding property of one's own society, or the "ambient" society (in this case modern China) are equated to those of traditional societies. This may not be the case; for example, in traditional societies of the developing world, the distinction between "public" and "private" law and rights is not always made (Benda-Beckmann 2000). When designing management strategies that involve people of traditional societies, the "jamming" of traditional ideas of property rights into foreign cultures' legal notions may lead to misunderstandings that have important consequences when trying to incorporate local people in the sustainable management of common pool resources.

Advantages of Small-scale

Why "small-scale"? To determine the advantage of a small-scale co-management system, it is useful to look at the commons theory proposed by Hardin (1968). By overgrazing, Hardin proposed that a herder may obtain one unit of profit, while the loss to other users of the grassland CPR is –1. Each individual herder has a loss of –1/x, x

being the number of herders who are using the grassland. When x is small, -1/x is large, and the loss to each individual herder is greater. The incentive to punish violators, those who overgraze, is greater. This will prevent tragedies of the commons that may occur in large-scale CPR management.

Another model can show the benefit of small-scale co-management. In a small-scale CPR, the relative loss incurred by degradation is higher, so it may become more important to users to penalize defectors. For example, assume a CPR contains 100 units of resources. Suppose one user degrades one unit of this resource. His contribution to the degradation of the grassland is 1/100. If the CPR is small, perhaps 10 units, and a user degrades one unit, his contribution to the degradation of the CPR is 1/10. His infraction is relatively larger, and it becomes more important to the users to punish his activity.

When co-management of a CPR is done in small-scale, users may have a greater ability to communicate with each other. They may have a better chance at community bonding, which will encourage them to follow rules of social behavior. They may also have a greater voice in management, whereas in a large CPR with many users, an individual may have a more difficult time controlling the actions of people he may or may not know.

How small is "small-scale"? This should be determined by herders and the local governments based on the distribution of natural resources on the land and its carrying capacity, and how many people the herders feel comfortable working with.

Direct Benefits to Herders

As stated earlier, co-management should be established on a volunteer basis. To encourage herders to participate in co-management, herders should be made aware of the following direct benefits available to them.

(1) The government will provide costs of initiating collective management, by providing necessary infrastructure such as meeting halls, monitoring vehicles, etc. The government may subsidize or provide other costs in facilitating the transition to comanagement.
(2) Teams may obtain more diverse tracts of land with access to resources such as water, suitable winter grazing land, etc. that may not be available on presently held lands.
(3) The government may provide incentives such as reduced taxes.
(4) In teams, individuals will experience reduced shepherding costs
(5) In teams, individuals may have the opportunity to save money through collective deep-processing of livestock (Xirimo, 1994).

Running Out of Time

Co-management has the potential to reverse the degradation trend, but it must be recognized that the management of natural resources is always experimental. However, we do not have much time to experiment. If the present degradation trend continues, XBR may rapidly become unlivable. In this light, some fast-acting measures need to be

taken to reverse degradation, that is, finding a transition to alternative occupations. This may or may not involve moving users.

Another reason for providing alternative occupations is to enable herders to have more options for their occupation and lifestyle. Currently, the rate for sustainable use of the grassland has been established by the Grassland Supervision Agency as 45 sheep/person in Bainxile Farm. Assuming a 100% lamb-selling rate, the per-capita income of a user on a farm who follows this rate is RMB 3015. The World Bank calculates poverty as earning $1.08 dollar per day or less, which equates to RMB 3153 per year. With 45 sheep, the average herder's salary is just above the poverty line. If the rate is revised, the 45 sheep/person limit may decrease, and herders' maximum incomes may fall below poverty level.

Restricting the number of sheep a family can own caps their incomes and does not provide them with an opportunity for growth. Livestock breeding is not a choice for most herders; many herders see it as the only way they can earn an income. Many herders are dissatisfied with their lifestyle, want a higher standard of living, and view herding as speculative and unprofitable. Herders want more occupation options to choose from.

Though herders view their profession as speculative, they perceive leaving their current job to try their luck in the city as even more risky. Many herders believe they have no other skills than livestock breeding, or have too much invested in their current situation to change. For these reasons, the transition to new occupations should be facilitated on a voluntary basis.

In particular, alternative occupations should be provided for poor herders, who have little to lose in making a transition to a new occupation. In addition, providing them with a means of livelihood will be cheaper than monthly welfare.

What kind of alternative occupation options should be provided? So far, heavy emphasis has been placed on high-yield agriculture. Agriculture (and Xilinghot City) require excessive groundwater pumping. Though no studies have been done on the replacement rate of underground aquifers, it has been determined that evaporation rate exceeds rainfall in XBR (Jiang and Liu, 2002). Excessive water-use in the low-precipitation, arid grasslands is not feasible and agriculture may increase chances of groundwater depletion. Cow-raising may not be profitable because supply exceeds demand of dairy products. A better approach would be to create low-impact jobs such as wind power production and developing ecotourism. The technical and economic feasibility of these possibilities should be researched further.

Conclusions

We propose small-scale co-management for the sustainable use of grasslands in Xilingol Biosphere Reserve. Small-scale co-management has the most potential in solving grassland degradation because it reduces the cost of stock rate enforcement. Small-scale co-mangement facilitates community bonding and increases the possibility of reporting violations as opposed to large-scale regimes.

While the selection of an appropriate property rights regime is important for the sustainability of the grassland, we would like to emphasize that it is only part of the solution. A comprehensive approach to sustaining the grassland and livelihoods of the

people would be to make available alternative occupations for the herders, possibly wind-power production and ecotourism.

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APPENDIX

Figure 1. The two-herders' game when the central authority has complete information.

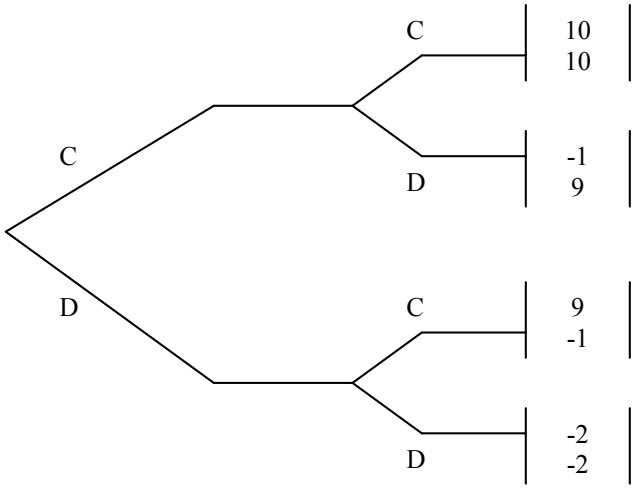

Figure 2. The two-herders' game when the central authority has incomplete information.

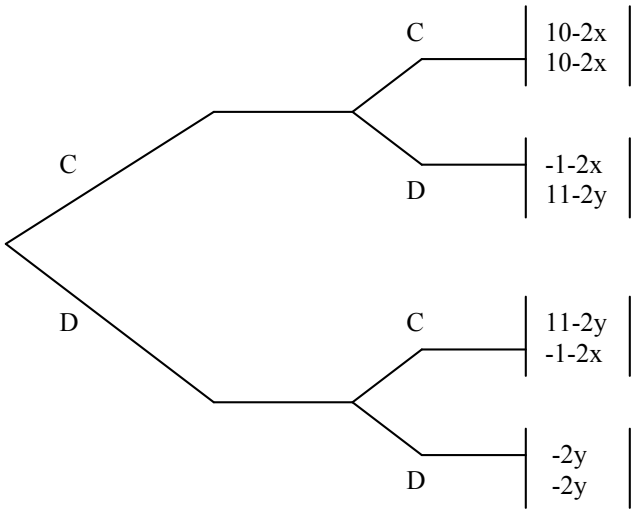

Figure 3. The two-herders' game when the central authority has incomplete information (x=0, y=.1).