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China's new rural "separating three property rights" land reform results in grassland degradation: Evidence from Inner Mongolia

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ABSTRACT

China is currently implementing the "separating three property rights" (STPR) reform to consolidate rural land. This reform divides rural land property rights into three components: nontradable ownership, nontradable contractual rights and tradable land use rights. The STPR reform adopts the rental of grassland use rights, a market-oriented approach, as the main arrangement for grassland consolidation. However, this arrangement may undermine the cornerstones of grassland restoration, which are the security of grassland property and payments for ecosystem services (PES) policies. As an alternative to the market-oriented approach, cooperatives are also encouraged to consolidate grassland use rights. We used a natural experiment approach to systematically examine how two different land consolidation arrangements affected key grassland ecosystem services in Inner Mongolia. In rented grasslands, all ecosystem services except provisioning services degenerated severely. Traded grassland use rights were perceived as insecure, which led to predatory land use by tenants. In contrast, cooperative-managed grasslands showed no serious degradation in ecosystem services. However, these cooperatives limited their group size by chief kinship to avoid the free-rider problem; thus, they are unlikely to become a primary channel of grassland consolidation. Because PES policy subsidies are still allocated to grassland contractors rather than to tenants, these policies are irrelevant to the conservation of rented grasslands. Based on our analysis, we suggest several ways to improve this new rural land property reform to avoid a major wave of grassland degradation in China.

1. Introduction

Over the past several decades, China has struggled to reconcile the contradictions between establishing a market economy and maintaining social justice during its rural reforms (Huang & Rozelle, 1996; Lin, 1992). Because of the country's market orientation (Cao, 2000; Harvey, 2005), the core target of reform has been first to clarify the property rights system through privatization and monetization and then to achieve a free-flowing and marketable allocation of rural land (Zhou, 2004). This approach is based on the "economic efficiency principle" of rural land property reform (Yang et al., 1992). However, the Chinese government must also follow the "social justice principle," which entails maintaining the public-owned land system and protecting rural people's livelihood (Chen & Han, 2002). Since 1978, China has tried to strike a balance between the two principles and has focused on compromise in new institutional arrangements to gradually reform its rural land property rights system (Ho, 2001).

The first milestone of rural land reform was the household responsibility system (HRS), a dichotomous system of property rights (Lin, 1988). Under the HRS, the ownership of rural land belongs to the collective, whereas the "contractual and use rights" belong to rural people, leaving rural people free to manage their household-contracted land. The HRS facilitated the rapid increase of food production in China beginning in the 1980s (Lin, 1992). Within a few decades after the establishment of the HRS, stocking rates doubled or even tripled in the northern pastoral regions, especially in Inner Mongolia (Jiang et al., 2006, Supplementary information 1), which led to widespread overgrazing (Kang et al., 2007; Li et al., 2012). Meanwhile, the HRS caused the collapse of community cooperation (Li & Huntsinger, 2011), led to the loss of traditional ecological knowledge (Zhang et al., 2013), and

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reduced the mobility and flexibility of pastoralists (Li et al., 2007; Li & Li, 2012). Additionally, before 2002, the government could legally adjust household-contracted land (Ma et al., 2015); thus, the land contractual and use rights of rural people were not secured, which discouraged sustainable land use practices by local herders (Thwaites et al., 1998). As a result, overgrazing, loss of mobility and land property insecurity have caused large-scale grassland degradation in China over the past three decades (Li et al., 2007), resulting in declines of biodiversity, primary productivity, and key ecosystem services (He et al., 2012b; Qi et al., 2012; Tong et al., 2004) and the worsening of environmental problems, such as desertification and dust storms (Kang et al., 2007; Wu et al., 2015).

To confront these problems of land degradation, the Chinese government accepted a popular theory that "securing land property is required to achieve the goal of conserving rural lands" (Fraser, 2004; Hanna et al., 1995). In 2002, the central government legislated against any adjustment to household-contracted land property rights. At the same time, the government enacted several payments for ecosystem services (PES) policies to support the recovery of degraded grasslands, including the "returning grazing land to grassland" policy and the Beijing and Tianjin Sandstorm Source Control Program (Yeh, 2009). These PES policies determined the "proper carrying capacity" for each grassland region (Nyima, 2015), encouraged herders to reduce grazing intensity, and compensated them for their economic losses with governmental subsidies. In practice, herders are motivated by these policies to conserve their own grassland. These policies slowed down the increase of stocking rates (Liu et al., 2017, Supplementary information 1), promoted grassland conservation and reduced the frequency of sandstorms (Lü et al., 2011). A national survey reported that herders requested that the government maintain a long-term and stable PES policy (Han et al., 2011). Therefore, since 2011, the central government of China has implemented a national PES policy known as "the subsidy and reward policy for grassland ecological conservation." The Grassland Monitoring and Supervision Center (GMSC), part of the China Ministry of Agriculture, declared that the average overgrazing rate of national grasslands declined from 44% to 17% during this PES policy period from 2011 to 2015 (GMSC, 2016). Currently, the strengthened grassland property rights and PES policy subsidies are widely considered the cornerstone of China's grassland management system (Wu et al., 2015). However, these fundamental policies may lose their effectiveness under the current rural land reform.

Over the past few decades, more than 250 million rural people in China have left their land and villages to start a new life in factories and cities (Long et al., 2009; Long et al., 2011; Long et al., 2012). These people, officially designated "rural migrant workers," were once food providers but have now become net food consumers. The amount of farmland abandoned or rented out by rural migrant workers has undergone an explosive increase over the past ten years. The National Ministry of Agriculture reported that the proportion of rural land across the whole nation that was rented out was 4.5% in 2006, 17.8% in 2011, and 33.3% in 2015 (Han, 2016). These social changes have created pressure for China to develop modern intensified agriculture through huge capital investments, cutting-edge technologies, and innovative management systems (Zhao et al., 2012). As part of these reforms, the fragmented household land system must be consolidated to meet the needs of modern agribusiness (Long et al., 2010). A social justice problem has also emerged: even when rural migrant workers work and pay taxes in cities, the national household registration system still identifies them as rural people; thus, they are not entitled to social welfare in the cities where they live (Li, 2008), and their social security depends mainly on the household-contracted land that they have left behind. The Chinese government must prevent rural migrant workers from losing their household-contracted land until their social security is otherwise provided for (Long et al., 2010; Maëlys et al., 2009). Therefore, the central government rejected the "complete privatization proposal" in current rural land reform (Chen & Han, 2002).

To solve this dilemma, China has gradually developed a new rural land reform plan known as "separating three property rights" (STPR). The STPR reform does not affect the public ownership of rural land but divides the households' contractual and use rights into two parts: nontradable household contractual rights and tradable rural land use rights (Han, 2016). This institutional arrangement is designed as a compromise between ensuring rural people's social security and meeting the demands of modern agribusiness. The STPR is not a brand-new policy for China; similar policies have been tentatively implemented in agriculture and pasture areas in many provinces since 2003 and under many names, such as "farmland transfers" or "grassland transfers" (Gongbuzeren et al., 2016). However, studies in Chinese agricultural regions have shown some negative effects of trading farmland use rights. Land tenants, who have land use rights but not household contractual rights, tend to prefer short-term gains to long-term sustainable harvests from their rented farmlands. For example, farmers applied less organic fertilizer to rented farmlands than to farmlands they owned (Gao et al., 2012). While tenants manage rented farmlands and produce food, they are usually not eligible to receive any subsidies from the agricultural authorities (Huang et al., 2011). Thus, subsidies cannot adjust tenants' management behaviors and lose their effectiveness in relation to rented farmlands. These negative effects of trading farmland use rights may also occur in pastoral regions.

As an alternative to the market-oriented approach, political leaders and scholars have promoted a community-based cooperative approach to consolidate grasslands (Deng et al., 2010; Tang & Gavin, 2015). The supporters of this cooperative approach believe it can rebuild public management of grasslands through grassroots democracy, restore traditional knowledge in rangeland management, and realize the sustainable use of grasslands (Cao & Du, 2011). However, many scholars have criticized rural cooperatives in present-day China as "fake" cooperatives that fraudulently obtain governmental subsidies and organize very few cooperative affairs (Yan & Chen, 2013). Therefore, the effectiveness of the cooperative approach remains uncertain and must be proved in practice.

The central government authorizes local governmental agencies to create detailed regulations for executing the STPR reform. According to public choice theory, local officials are self-serving individuals whose chief interest is not to achieve regional sustainable development or to better serve the local people but rather to gain their own promotion and benefits (Blumm, 1994). In practice, the legislative process and environmental management performed by local governments are usually distorted by the officials' focus on their performance evaluation, which determines their promotion and other benefits (Wang, 2013). Therefore, some scholars view the legislative process of local government as "a slot machine" because it is unpredictable or arbitrary (Blumm, 1994). We cannot assume that local governments will implement the STPR reform with no compromises.

We hypothesize that the SPTR reform undermines current fundamental grassland conservation policies and causes new environmental management problems in pastoral regions (e.g., Inner Mongolia) − that is, the new rural reform leads to the unintended intensification of grassland degradation. To test the above hypothesis, this study is designed to address the following questions: (1) How do family-managed, cooperative-managed, and tenant-managed (rented) grasslands differ in terms of the kind and amount of key ecosystem services they provide? (2) What causes the differences in ecosystem services among the three types of management group? (3) What insights and implications can this study provide to improve China's rural reform policy for pastoral regions? We frame our questions in terms of *ecosystem services*, which are benefits that people derive from nature, because this concept links ecology and economics and bridges science and policy (Costanza et al., 1997; Millennium Ecosystem Assessment, 2005).

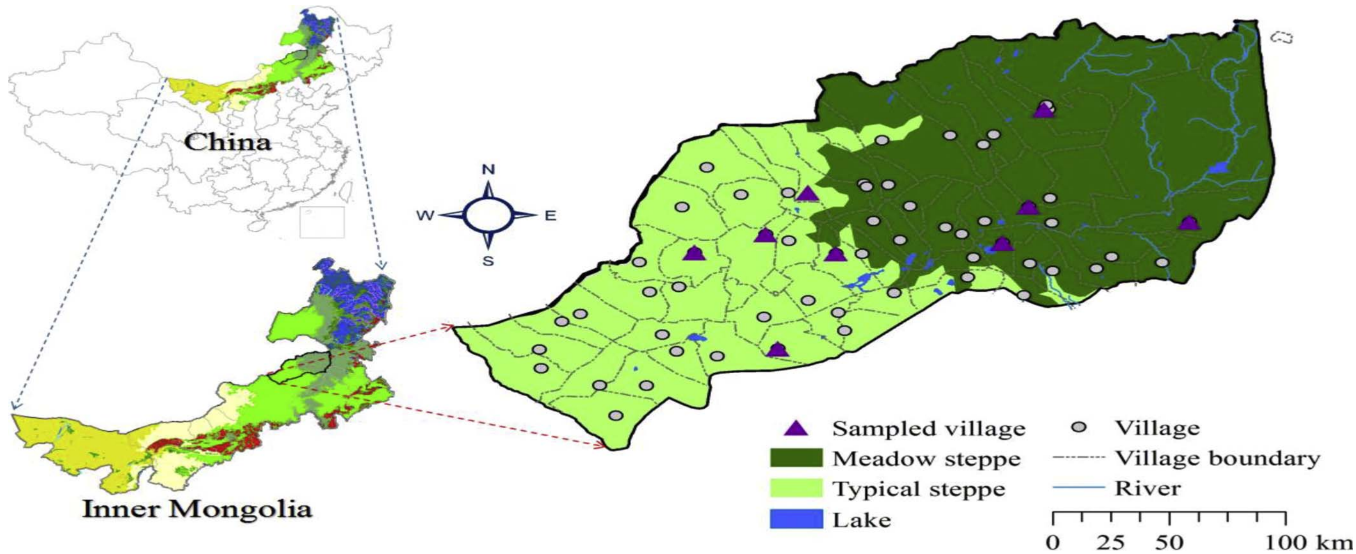

Fig 1. Study region location and distribution of sampled villages.

2. Study area

This research was conducted in East Ujimuqin Banner, a county located in the central part of the Inner Mongolia grassland. East Ujimuqin Banner covers a total area of 47,300 km^2, spanning from 44°44′N to 46°10′N and from 115°10′E to 120°0′E. The climate is semiarid, with an annual average temperature of 1.6 °C and annual precipitation of 300 mm. As precipitation gradually decreases from east to west, vegetation changes from meadow steppe to typical steppe (Fig. 1). The biomass is generally higher in meadow steppe than in typical steppe because of the greater amount of annual rainfall. In this region, snow does not melt in winter. Both normal snows, which accumulate gradually over the winter, and blizzards can cause snow disasters when the snowfall buries all the plants. During such disasters, livestock cannot graze outside until spring, and herders must increase their expenditure on forage to avoid the mass death of livestock due to long-term starvation. There are approximately 27,800 herders in this county, all of whom are ethnic Mongolian people. The grassland use includes grazing and mowing; the latter is the mechanical harvest of grass for forage during snow emergencies or sale.

The government had implemented the HRS policy to assign livestock and grasslands equally on the per capita basis to households before the 1998 (Li et al., 2007). The area of grasslands contracted to each household varies from 600 to 1300 ha in this region. During 2002–2009, the government carried out the "returning grazing land to grassland" policy and the Beijing and Tianjin Sandstorm Source Control Program to recover degraded grasslands in this region, especially by large investments in fences to demarcate the boundaries between household-contracted grassland plots. These fences clearly delineated the boundaries of land property for each household, which were determined using a global positioning system. The government has implemented the subsequent "subsidy and reward policy for grassland ecological conservation" in this region since 2011. This policy contains two subsidized projects. Herders who participate in the first project can obtain 90 yuan per ha as compensation for giving up grazing on grassland, and the second project pays herders 27 yuan per ha to reduce grazing intensity. In East Ujimuqin Banner, most herders participate in the second project, meaning they must reduce the stocking rate to meet the official recommended rates for their grasslands. The government has set standards of 55% remaining biomass in the cold season and 65% remaining biomass in the warm season as the limits for the maximum stocking rate. The method is a rough estimation of stocking rate that is similar to the traditional local Mongolian grazing rule: "Take half and leave half" (Pan et al., 2016).

Grassland use rights trading has been a booming business in this county since 2008, and one-third of the total grassland area (totaling 13,330 km^2) was rented out during 2005–2015. The local government has created strict and complicated regulations to manage the trade of grassland use rights. Moreover, the local government has encouraged herders to consolidate grassland by forming animal- husbandry cooperatives since 2005. The head of the village takes the lead in organizing the herdsmen in the village; then, they file an application with the local authorities to form a cooperative. Approval of the application usually takes less than 15 working days. As a result, there is one cooperative in each of the 60 villages in the county.

3. Methods

3.1. Experimental design

This study employed a natural experiment to evaluate the effects of the STPR reform on grassland ecosystem services. The natural experiment is a classic empirical research method that is widely used in economics (Meyer, 1995), social sciences and ecology (Diamond, 1983). It includes a random experimental design and a comparison of responses between control and experimental groups. A randomly designed natural experiment can establish causal relationships between treatment and dependent factors and can rule out the potential causes of other factors beyond the treatment factor. A natural experiment is similar to a randomized, controlled experiment; the only difference is that experimental treatments in a natural experiment are manipulated by nature or other factors rather than by researchers. Therefore, this methodology is the best approach when studying influences on land reform because researchers cannot manipulate the stakeholders and their grasslands by placing them in different land property situations for a randomized, controlled experiment. In addition, the natural experiment is essentially a stratified sampling survey.

The treatment factor in this natural experiment is the land consolidation approach with two treatment levels: tenant-managed (or rented) grasslands and cooperative-managed (or cooperative) grasslands. In addition, this experiment considered family self-managed grasslands (family grasslands) as a control group since they were not affected by the STPR reform.

This study employed a nested experimental design to collect ecological, social and economic data. First, we randomly selected nine villages from the 60 in the county. The sample included five villages in typical steppe and four villages in meadow steppe (Fig. 1) to represent the regional vegetation. The proportion of households that rented out their grasslands ranged from 30% to 80% in these sampled villages. In each selected village, we randomly selected three households that had rented out their grasslands for more than four years as well as three households that managed their own grasslands. Each village had only one cooperative group, which constituted the cooperative sample. Although random sampling is crucial to rule out the possibility of false positive results, it was limited in the cooperative group. Therefore, we are cautious in discussing the results of the cooperative group. Since one tenant refused to answer our survey, this experiment ultimately involved 27 family grasslands in the control group, 26 rented grasslands, and 9 cooperative grasslands. The sample accounted for 1% of the total number of herder households in this county.

3.2. Measuring ecosystem services

Four types of ecosystem services are commonly recognized in the literature, including supporting (ecosystem processes), provisioning, regulating, and cultural services (Millennium Ecosystem Assessment, 2005; Power, 2010; Ford et al., 2012). In our study, a number of ecological variables and indicators were selected to represent these four types of ecosystem services (Table 1). We used species diversity and biomass production-related measures for supporting services; livestock production measures for provisioning services; litter biomass, vegetation height and carbon sequestration measures for regulating services; and the number of forb species with showy flowers and with medicinal uses for cultural services. Vegetation height was used as an indicator of regulating services because taller vegetation tends to have higher tolerance for snow disasters. This list of ecosystem services from these grasslands is certainly not complete, but these variables together represent the key ecosystem services in the region.

3.3. Vegetation and soil survey

Field sampling was carried out during August 10–30, 2015, corresponding to the annual peak of standing biomass in this region (Li et al., 2012). In each of the 62 selected grasslands, the aboveground biomass of the plants was randomly sampled using five 1 m x 1 m quadrats.

Table 1
Results of ANOVA analysis of differences in each ecosystem service indicator among family, cooperative, and rented grasslands. Boldface denotes a significant difference at the level of $\alpha = 0.05$.

Ecosystem services type	Ecosystem services indicator	F value $_{(df1,\ df2)}$	p value
Supporting services	Aboveground biomass	$64.81_{(2,248)}$	< **0.0001**
	Root biomass (0–10 cm)	$151.11_{(2,248)}$	< **0.0001**
	Root biomass (10–30 cm)	$138.31_{(2,248)}$	< **0.0001**
	Species richness	$34.76_{(2,248)}$	< **0.0001**
Provisioning services	Grazing intensity in growing season	$48.88_{(2,58)}$	< **0.0001**
	Grazing intensity in cold season	$37.44_{(2,58)}$	< **0.0001**
	Animal production	$7.73_{(2,58)}$	= **0.0011**
Regulating services	Vegetation height[a]	$71.61_{(2,248)}$	< **0.0001**
	Litter biomass	$17.72_{(2,248)}$	< **0.0001**
	Soil organic carbon (0–10 cm)	$9.18_{(2,248)}$	< **0.0001**
	Soil organic carbon (10–30 cm)	$11.38_{(2,248)}$	< **0.0001**
Cultural services	Number of forbs with showy flowers	$2.57_{(2,248)}$	= 0.0786
	Number of medicinal herb species	$10.96_{(2,248)}$	< **0.0001**
	Biomass of medicinal herb species	$1.62_{(2,248)}$	= 0.2000

[a] Vegetation height contributes to scenery and thus also to cultural services.

Thus, the field sampling consisted of 310 quadrats in three groups. In each sampled grassland, we first randomly chose a starting quadrat in the center and then moved in four directions from the first quadrat by selecting a random distance between 100 and 1000 m, thus obtaining another four sample quadrats. Thus, biomass sampling consisted of 135 quadrats in the family grassland group, 130 quadrats in the rented grassland group, and 45 quadrats in the cooperative grassland group. For each quadrat, live and dead plants were clipped at ground level after the vegetation height was measured; the dead parts were removed and combined with litter, and all live plants in each quadrat were sorted by species. Belowground biomass was sampled by randomly taking three 6-cm-diameter soil cores from depths of 0–30 cm within each quadrat. Soil was rinsed from the roots with water using sieves of 1-mm mesh. All plant materials in each quadrat were oven-dried at 65 °C for 48 h to constant weight and then weighed.

The three soil cores from the same quadrat were mixed as one composite sample, hand-sorted to remove rocks and plant materials, and air-dried. Then, a subsample of 10 g of soil from each composite sample was dried at 105 °C to determine soil moisture. The remaining soil was passed through a sieve with 1-mm openings for soil organic carbon (SOC) analysis. We used the Walkley–Black-modified acid-dichromate $FeSO_4$ titration method to measure the SOC of each soil sample (Sparks et al., 1996). The SOC content was corrected based on the soil moisture content.

To evaluate changes in plant community structure, plant species were classified into five plant functional groups (PFGs) based on their life forms: perennial rhizomatous grasses (PR), perennial bunchgrasses (PB), perennial forbs (PF), shrubs and semi-shrubs (SS), and annuals-biennials (AB). We identified the "poisonous plants" as those plant species that are harmful to animals, based on the traditional knowledge of the local people. We recognized flowering forbs based on recordings of flora rather than by counting real flowers in the quadrats. Flowering forbs and medicinal-use species are listed in Supplementary information 2.

3.4. Interviews with local herders

In July, September and October 2015, we conducted semi-structured interviews with each household to obtain information about its number of livestock, grazing and mowing intensity, PES subsidies, and household income. We also asked about household members' perceptions of the security of their grassland use rights and about recent ecological changes in their grasslands. We counted livestock to verify the numbers reported by herders. The number of livestock was standardized to sheep units (SUs) based on daily forage consumption: a cow, horse, or camel is equivalent to five SUs, and a goat is equal to one SU.

3.5. Data analysis

Statistical analyses were performed using the R software (version 3.2.4, R Core Team, 2016). As a first step, we used one-way mixed ANOVA to compare differences in ecosystem services and plant community attributes among the three differently managed groups of grasslands. The nested experimental design contained many correlations among vegetation type, village, and household factors. Therefore, the mixed ANOVA defined these factors as random effects. Duncan's multiple range test was used to compare differences among groups.

In the second step, we established a structural equation model (SEM) to integrate the field survey data with the household interview information and to validate the impacts of the STPR reform on ecosystem services. The SEM was derived from the following conceptual frame. First, grassland managers would adjust their strategies according to the security of land use rights and subsidies, which were impacted by the STPR reform. Long-term contracts and adequate subsidies may sharply reduce grassland use intensities, which can be considered

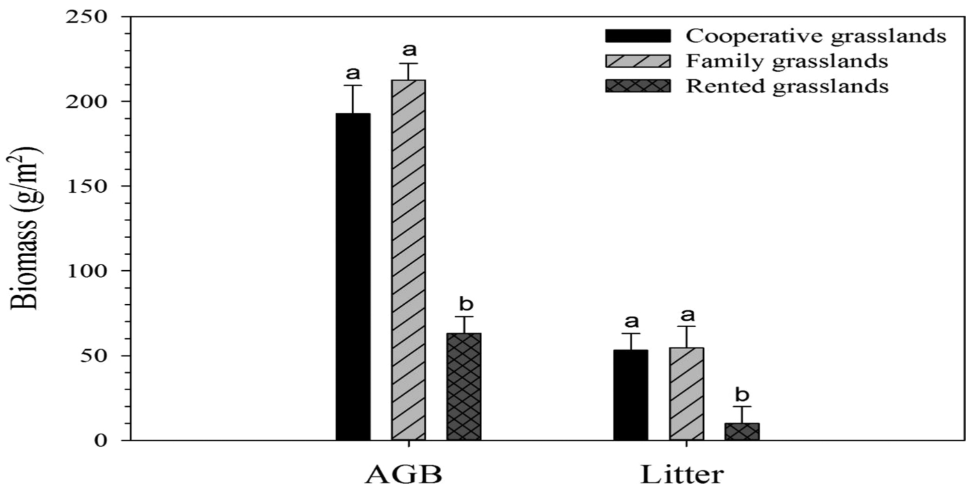

Fig. 2. Aboveground biomass (ABG) and litter biomass in family, cooperative and rented grasslands. Different letters denote significant differences among groups ($p < 0.05$).

provisioning services in our study. Short-term contracts and insufficient subsidies would dramatically increase provisioning services. Therefore, we defined the direct paths among the contract term of grassland use rights, subsidies for PES policies and the indicators of provisioning services. The other paths of the SEM were formed by the well-known relations among the four ecosystem services. Detailed indicators of provisioning services would negatively impact indicators of supporting services. Indicators of supporting services may positively correlate with indicators of regulating and cultural services. We used goodness-of-fit statistics to determine the best-fit model, such as χ^2, adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA).

4. Results

4.1. Supporting services

The aboveground biomass of family and cooperative grasslands was significantly higher than that of rented grasslands ($p < 0.0001$, $F = 48.88_{\ 2,248}$, Table 1). The average aboveground biomass was 212.58 ± 9.76 g/m^2, 192.77 ± 16.64 g/m^2, and 63.07 ± 9.95 g/m^2 in family, cooperative, and rented grasslands, respectively (Fig. 2). Compared to family grasslands, rented grasslands lost almost 70% of aboveground biomass, but there was no significant difference between family and cooperative grasslands. At the same time, family and cooperative grasslands retained more litter than rented grasslands ($p < 0.0001$, $F = 48.88_{\ 2,248}$): 53.12 ± 9.90 g/m^2, 54.68 ± 12.56 g/m^2, and 10.02 ± 9.96 g/m^2, respectively. This finding indicated an 80% greater loss of litter biomass from rented grasslands than from family grasslands.

Root biomass also showed significant differences among the three groups in both the 0–10-cm soil layer ($p < 0.0001$, $F = 151.11_{\ 2,248}$) and the 10–30-cm soil layer ($p < 0.0001$, $F = 138.31_{\ 2,248}$). The average root biomass in the 0–10-cm layer was 889.74 ± 34.39 g/m^2 in family grasslands and 798.35 ± 46.17 g/m^2 in cooperative grasslands but was only 363.52 ± 34.67 g/m^2 in rented grasslands. Similarly, the average root biomass at the depth of 10–30 cm was higher in family and cooperative grasslands (581.81 ± 15.49 g/m^2 and 495.09 ± 26.44 g/m^2, respectively) than in rented grasslands (228.23 ± 15.78 g/m^2) (Fig. 3). Thus, compared to family grasslands, rented grasslands had lost 60% of root biomass at the 0–30-cm depth, but the loss for cooperative grasslands was not significant.

Plant species diversity in family and cooperative grasslands was significantly higher than in rented grasslands ($p < 0.0001$, $F = 34.76_{\ 2,248}$). The average plant species richness was 16.29 ± 2.67 species/m^2 in family grasslands and 15.76 ± 2.77 species/m^2 in cooperative grasslands but was only 10.31 ± 2.66 species/m^2 in rented grassland (Fig. 4A). On average, rented grasslands had lost 37% of species compared to family grasslands.

Plant community attributes, particularly the composition and relative abundance of PFGs, also differed among the three management groups. Compared to the other two groups, rented grasslands experienced a sharp decrease in aboveground biomass for all PFGs except SS (Table 2). The aboveground biomass proportion of PR was significantly lower in rented grasslands than in the other two groups ($p = 0.0139$, $F = 4.35_{\ 2,248}$), although the proportions of other PFGs did not show

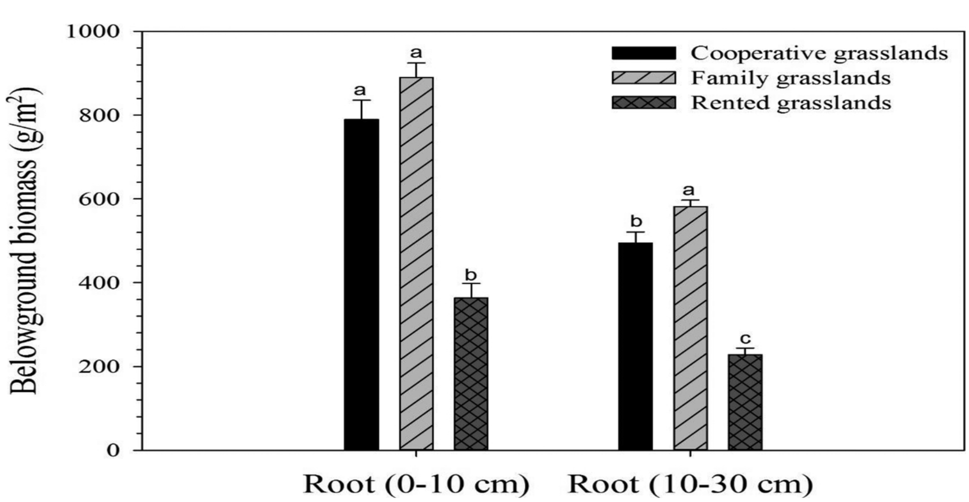

Fig. 3. Root biomass of two soil layers (0–10 cm and 10–30 cm) in family, cooperative and rented grasslands. Different letters denote significant differences among groups ($p < 0.05$).

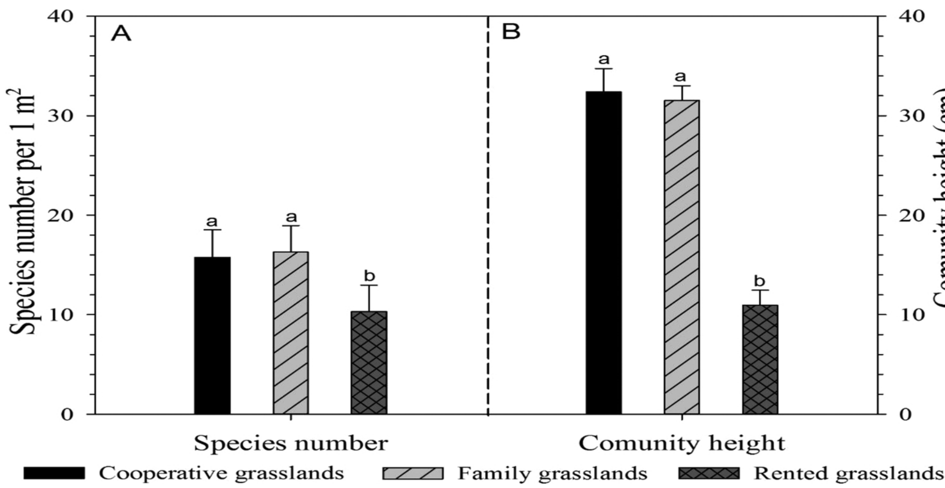

Fig. 4. (A) Community species richness of family, cooperative and rented grasslands, indicated by plant species number per 1 m^2. (B) Vegetation height of the abovementioned three types of grasslands, which is related to vulnerability to snow disaster and ecosystem aesthetics. Different letters denote significant differences among groups ($p < 0.05$).

significant differences among the three groups (Table 2). In contrast, the proportion of PB species was significantly higher in rented grasslands than in the other two groups ($p < 0.0001$, $F = 16.62_{2,248}$). A number of r-strategists (e.g., *Eragrostis pilosa*, *Chloris virgata*), which produce little biomass but many small seeds, contributed to this increase. Significant declines in biomass coexisted with minor changes in the species biomass proportions in our study. The reasons were that hay mowing was a nonselective removal of biomass, and over-mowing of rented grasslands hid the selective effects of grazing in these rented grasslands.

Some particularly important species, including the two dominant species of typical and meadow steppe as well as legumes and poisonous plants, together play a foundational role in the generation of supporting services as well as other types of ecosystem services in the Inner Mongolian grasslands. Our results showed that aboveground biomass of these species differed among the three grassland management groups (Table 3). Biomass of the two dominant species was significantly lower in rented grasslands than in family and cooperative grasslands ($p < 0.0001$, $F = 15.97_{2,248}$ for *Leymus chinensis* and $p < 0.0001$, $F = 17.06_{2,248}$ for *Stipa grandis*). Biomass of leguminous species declined significantly in rented grasslands ($p < 0.0001$, $F = 14.94_{2,248}$), but there was no significant difference in biomass of poisonous plants among the three groups ($p = 0.3111$, $F = 1.17_{2,248}$).

Table 2
Comparison of changes in plant community attributes among family, cooperative, and rented grasslands. Plant community attributes include biomass (BM), biomass proportion (BMP), and species percentage (SP) of each plant functional group (PFG). PR, PB, PF, AB, and SS indicate perennial rhizomatous grasses, perennial bunchgrasses, perennial forbs, shrubs and semi-shrubs, and annuals-biennials, respectively. Boldface denotes a significant difference at α = 0.05.

BM_{PFG} (g/m^2)	Family grasslands	Cooperative grasslands	Rented grasslands	F value $_{(df1,\ df2)}$	*p* value
PR	63.42 (11.13)	46.32 (13.68)	16.75 (11.17)	$17.03_{(2,248)}$	< **0.0001**
PB	106.66 (19.21)	90.83 (24.01)	23.35 (19.28)	$17.24_{(2,248)}$	< **0.0001**
PF	26.16 (3.42)	26.42 (5.92)	10.41 (3.48)	$5.99_{(2,248)}$	= **0.0029**
AB	9.34 (2.15)	20.40 (3.73)	4.04 (2.20)	$7.21_{(2,248)}$	= **0.0009**
SS	4.58 (4.17)	6.11 (4.36)	6.04 (4.17)	$0.75_{(2,248)}$	= 0.4720
BMP_{PFG} (%)	Family grasslands	Cooperative grasslands	Rented grasslands	F value	*p* value
PR	33.81 (6.67)	25.37 (8.17)	18.76 (6.18)	$4.35_{(2,248)}$	= **0.0139**
PB	47.53 (9.13)	42.90 (10.98)	45.83 (9.16)	$0.15_{(2,248)}$	= 0.8618
PF	12.43 (2.88)	16.91 (4.99)	20.10 (2.94)	$1.74_{(2,248)}$	= 0.1769
AB	4.20 (1.64)	11.06 (2.84)	8.20 (1.67)	$2.73_{(2,248)}$	= 0.0670
SS	3.67 (4.21)	4.42 (4.53)	7.69 (4.23)	$2.97_{(2,248)}$	= 0.0531
SP_{PFG} (%)	Family grasslands	Cooperative grasslands	Rented grasslands	F value	*p* value
PR	12.95 (1.40)	11.44 (1.91)	12.22 (1.40)	$0.38_{(2,248)}$	= 0.6875
PB	14.88 (1.37)	15.63 (1.79)	21.21 (1.38)	$16.62_{(2,248)}$	< **0.0001**
PF	49.77 (3.41)	49.05 (4.26)	40.95 (3.42)	$6.39_{(2,248)}$	= 0.2000
AB	17.61 (2.96)	18.86 (3.74)	20.34 (2.97)	$0.70_{(2,248)}$	= 0.4986
SS	4.78 (1.03)	5.02 (1.37)	5.27 (1.04)	$0.15_{(2,248)}$	= 0.8630

Table 3
Changes in biomass of key species that are fundamentally important to the Inner Mongolian grassland. Boldface denotes a significant difference at the level of α = 0.05.

Species name	Family grasslands	Cooperative grasslands	Rented grasslands	F value$_{(df1,\ df2)}$	*p* value
Leymus chinensis	52.46 (8.55)	42.32 (10.84)	14.99 (8.59)	$15.97_{(2,248)}$	< **0.0001**
Stipa grandis	92.89 (19.40)	79.46 (23.80)	13.94 (19.47)	$17.06_{(2,248)}$	< **0.0001**
Leguminous plants	4.64 (1.14)	6.06 (1.39)	1.10 (1.15)	$14.94_{(2,248)}$	< **0.0001**
Poisonous plants	8.83 (2.38)	14.93 (3.90)	8.49 (2.41)	$1.17_{(2,248)}$	= 0.3111

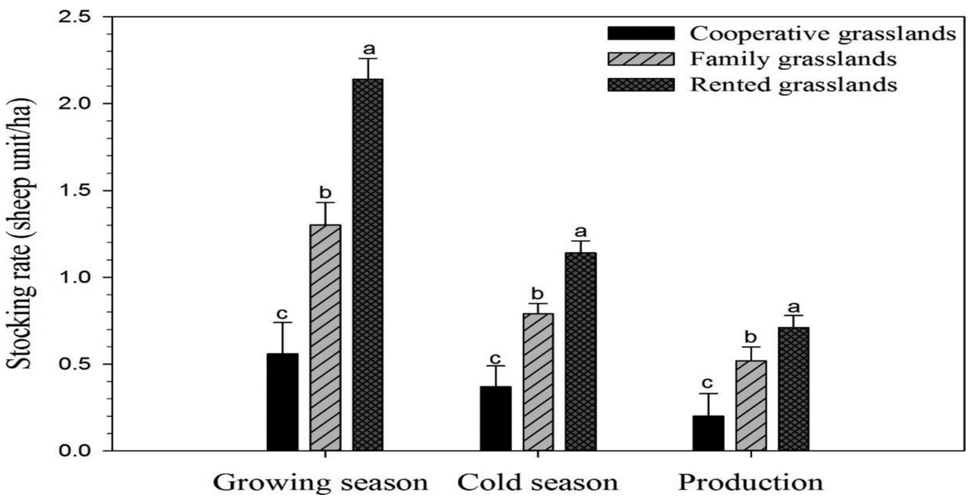

Fig. 5. Grazing intensities of growing season and cold season and animal production in family, cooperative and rented grasslands. Different letters denote significant differences among groups ($p < 0.05$).

4.2. Provisioning services

Rented grasslands carried more livestock than family grasslands and cooperative grasslands both in the growing season ($p < 0.0001$, $F = 48.88_{2,58}$) and in the cold season ($p = 0.0011$, $F = 7.73_{2,58}$) in 2015. In the growing season, the average stocking rate was 2.14 ± 0.12 SUs/ha in rented grasslands, 1.30 ± 0.13 SUs/ha in family grasslands, and 0.56 ± 0.18 SUs/ha in cooperative grasslands. In the cold season, the average stocking rate was 1.14 ± 0.07, 0.79 ± 0.06, and 0.37 ± 0.12 SUs/ha in rented, family and cooperative grasslands, respectively. The average sustainable carrying capacity of the grasslands in the area, recommended by the local government, is less than 0.97 SUs/ha for the growing season and 0.58 SUs/ha for the cold season; hence, only cooperatives met the official standard. While family grasslands exceeded the carrying capacity by 34% in the growing season and 36% in the cold season, rented grasslands exceeded the standards by much more: 126% in the growing season and 96% in the cold season. Similarly, tenants sold more livestock than families and cooperatives ($p = 0.0011$, $F = 7.73_{2,58}$). On average, tenants sold 0.70 ± 0.07 SUs/ha, whereas families and cooperatives sold only 0.52 ± 0.08 and 0.20 ± 0.13 SUs/ha, respectively (Table 1; Fig. 5).

4.3. Regulating services

SOC in rented grasslands was significantly lower than in family and cooperative grasslands at both the 0–10-cm depth ($p = 0.0001$, $F = 9.18_{2,248}$) and the 10–30-cm depth ($p < 0.0001$, $F = 11.83_{2,248}$) (Table 1). SOC at the 0–10-cm depth was 23.6 ± 1.0 mg/g, 23.6 ± 0.5 mg/g, and 20.5 ± 0.6 mg/g and at the 10–30-cm depth was 17.4 ± 2.0 mg/g, 18.2 ± 1.9 mg/g, and 15.2 ± 1.9 mg/g in family, cooperative and rented grasslands, respectively (Fig. 6). Compared to the SOC content in family grasslands, that in rented grasslands decreased by 13% in the upper 30 cm of soil, while cooperative grasslands showed no significant change in SOC.

Vegetation was significantly shorter in rented grasslands than in the other two groups ($p < 0.0001$, $F = 71.61_{2,248}$, Table 1). The average vegetation height was 31.52 ± 1.49 cm, 32.40 ± 2.35 cm, and 10.95 ± 1.51 cm in family, cooperative, and rented grasslands, respectively (Fig. 4B). According to 50-year meteorological data from 1961 to 2010, the probability of snow disasters is less than 0.06 in family grasslands and cooperative grasslands (a snow disaster occurs when the non-melting snowpack depth exceeds 31 cm, burying all plants). However, the probability of snow disasters is 0.79 for rented grasslands because the non-melting snowpack needs to be only 11 cm in depth to bury the much shorter vegetation. Therefore, of the three management groups, rented grasslands were most vulnerable to snow disasters.

4.4. Cultural services

Flowering forbs showed no significant differences among the groups ($p = 0.0786$, $F = 2.57_{2,248}$, Table 1). However, vegetation in rented grasslands was shorter than in the other two groups. Thus, the aesthetic

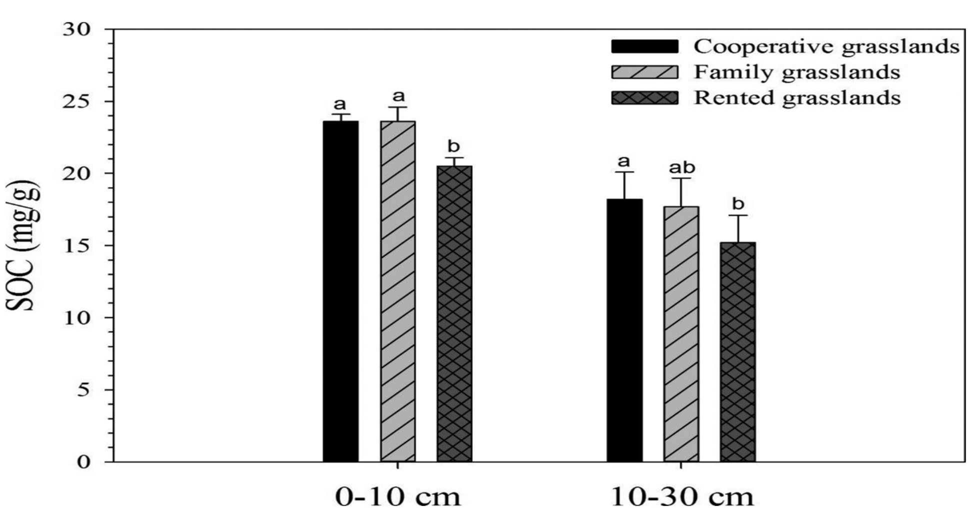

Fig. 6. Soil organic carbon (SOC) of two soil layers (0–10 cm and 10–30 cm) in family, cooperative and rented grasslands. Different letters denote significant differences among groups ($p < 0.05$).

appearance of rented grasslands was definitely poorer than that of family and cooperative grasslands. The number of medicinal herbs was significantly lower in rented grasslands than in the other two groups ($p < 0.0001$, $F = 2.57_{2,248}$). The average number of medicinal species was $1.81 \pm 0.58/m^2$, $1.48 \pm 0.56/m^2$, and $0.68 \pm 0.54/m^2$ in family, cooperative, and rented grasslands, respectively.

4.5. General information from interviews

4.5.1. Who rented out their contracted grasslands?

Our survey indicates that approximately 66% of the total number of grassland lessors (17/26) have migrated out of pasture regions. They are now living in towns and do not intend to live as herders in the future. Superficially, urbanization is the major reason that lessors rented out their grasslands. However, the underlying reasons are diverse. Four lessors have become successful businessmen and have a better quality of life in a town than in a village. Another 10 lessors are laborers in towns who do not earn more money than they would as herders but may obtain better health care and education for their children in the town. Thus, their well-being is improved in the urban area. However, other laborers must rent out their contracted grassland to pay debts. The remaining three lessors are young single men who lead a vagrant life in town. Because their parents passed away, they cannot raise their animals alone and are too poor to marry; thus, they must leave their villages. This “young bachelor” problem is gradually becoming common in Inner Mongolian pasture regions.

The remaining 34% of the lessors (9/26) still live in the pasture regions. Two are solitary elderly people who rent out grasslands to supplement their pensions. The other seven families have rented out large parts of their grasslands to pay debts and live on the remaining small proportion of their contracted grassland. If they can pay off their debts, they wish to recover their rented grasslands. The STPR reform can protect them from losing their grassland forever; thus, the policy benefits these poor herders.

4.5.2. Tenants

Only 16% (4/26) of the tenants are native to the county. According to local regulations, only local native herders have the legal right to rent grassland from lessors. However, the majority of tenants may be “non-native herders of this county,” according to the national household registration system. Therefore, based on the local regulation, these non-native herders are renting grasslands illegally. Some are urban people of the county, but others do not even reside in the county. Most are only financial investors who do not manage the livestock and grassland themselves but employ farmhands to do so. Most of the farmhands are poor herders from adjacent counties of this region. Only two outsiders, who migrated into this county because their own grasslands had degraded completely, manage their rented grassland themselves. The area of rented grasslands varies from 400 to 600 ha, and lease terms usually vary from 1 to 4 years.

4.5.3. Cooperatives

All nine cooperatives accepted the startup funding from the local government, which is 200,000 yuan for each cooperative. The chiefs of all the cooperatives are current or former village officials. However, the cooperatives contain only very few ordinary members, all of whom are blood relatives of the chief, because China rural cooperative law stipulates that cooperatives cannot have fewer than five members. Most of the cooperatives have only five members and do not want to accept more. The cooperatives manage all the grasslands and animals together and share profits at the end of the financial year. Moreover, all the cooperatives refuse to consolidate grasslands by accepting nonrelated members in the future because they would have to share rights with these new members under the “one member, one vote” principle. Many chiefs reported that they preferred to rent grasslands rather than persevere in the cooperative approach.

4.5.4. PES policy subsidies

The grassland lessors receive the same PES subsidies as the family managers, while the tenants receive no subsidy. All members of cooperatives receive the basic PES policy subsidies and can also obtain other subsidies from competitive government projects. For example, a cooperative obtained funding from a national livestock and poultry genetic resources protection project supported by the Ministry of Agriculture. This cooperative obtained 400,000 yuan from the project merely by raising 280 pure native male sheep. Our survey indicated that applying for projects and obtaining extra subsidies depends on the social networks and personal abilities of the cooperatives’ chiefs. Of course, the cooperative chiefs usually receive the lion’s share of these extra subsidies. Compared to these knowledgeable chiefs, ordinary herders and tenants are less likely to know how to apply for and implement these competitive projects.

4.5.5. Grassland use

Grassland use differs significantly among the three groups. As mentioned above, grazing intensity is highest in rented grasslands. The families and cooperatives graze their grasslands in a seasonal rotation, while tenants do not. That is, families and cooperatives mow only 25% of their grasslands each year and then fence the mowed parts to allow them to recover over the following year or two. In contrast, tenants usually mow all the rented grasslands and then graze on these mowed grasslands immediately, repeating the process in the following years. Therefore, rented grasslands have no time to recover. In addition, many local herders and government officials describe the mowing style of tenants as “predatory mowing” because it strips all the standing grass, litter and even some surface root. In contrast, families and cooperatives often adjust their mowing behaviors based on their perceptions of the climate and vegetation. For instance, 81% of the families and 56% of the cooperatives bought hay in 2015 instead of mowing their own grasslands in this dry year. Although all the tenants were also aware of the drought in 2015, they all still mowed their rented grasslands.

Cooperatives do not depend on raising more livestock to gain more profit but focus on maximizing their return on investment. Cooperatives use very profitable management models, such as raising more cattle, which need more investment and have long payback periods. Most of the family herders cannot use the same model because of the limitations of investment and labor. Tenants do not prefer such models because they desire a quicker cash return. In addition, cooperatives also keep the livestock intensity low to maintain high vegetation biomass and wait for good commercial opportunities. For example, they buy livestock at very low prices from unfortunate herders who run out of forage and cash during droughts or harsh winters. Cooperatives have enough forage to fatten these thin animals and then sell them at a good price. This fattening business is very profitable, and the same strategy is used by a few rich families. However, tenants cannot copy this strategy because they cannot hold the grassland with no cost and risk, as can cooperatives and families.

4.5.6. Income

In 2015, families earned an average of 104,000 yuan from selling livestock and received 15,000–20,000 yuan in subsidies from PES policies. The average gross income of tenants who rented grassland in this year was 142,000 yuan from selling animals, which is higher than the income for families. Grassland lessors received an average of 52,000 yuan in rent and received the same amount of PES subsidies as the families. The tenants received an average of 90,000 yuan after paying rent. The rate of return on investment is approximately 20% for tenants, which is profitable from the perspective of financial investment. Cooperatives earned less from selling animals in this year but received more income through extra subsidies. The ordinary members of the cooperatives earned an income similar to that of the families, while the average income of the chiefs was 281,000 yuan.

This study also estimated the income per SU, which may indicate

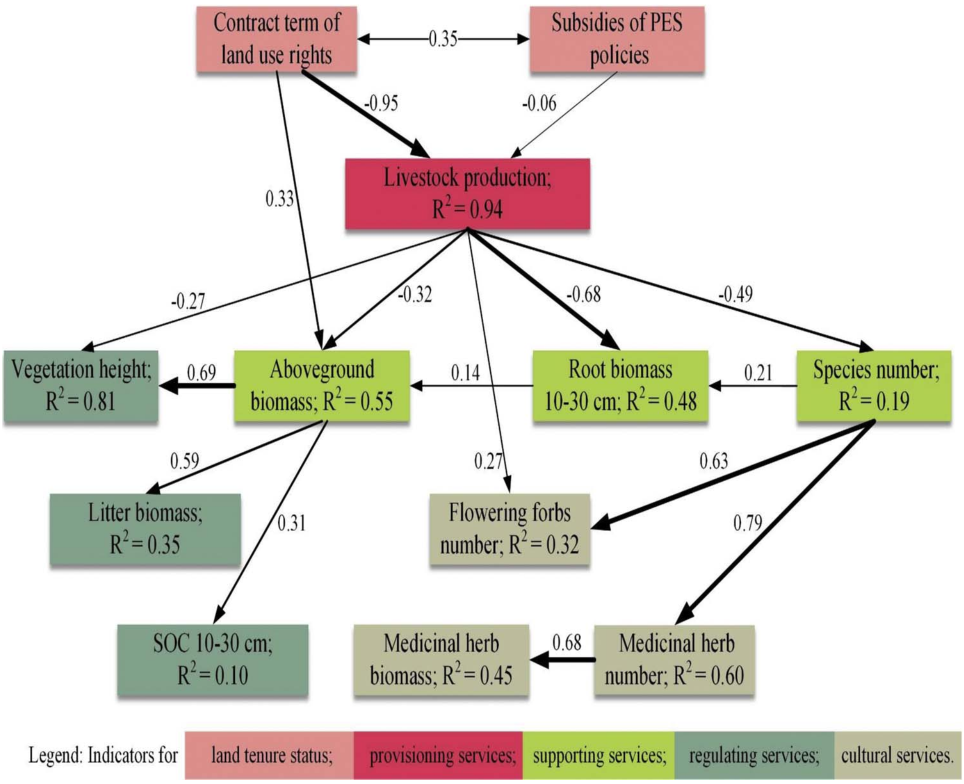

Fig. 7. Brief results for the structural equation model regarding the influences of grassland use rights trades on ecosystem services. Goodness-of-fit statistics are $\chi^2 = 52.21$, df = 39, $p = 0.07$; adjusted goodness-of-fit index (AGFI) = 0.94; comparative fit index (CFI) = 0.99; root mean square error of approximation (RMSEA) = 0.03. All paths between variables are statistically significant ($p < 0.05$), and the coefficients of single arrow paths are standardized partial regression coefficients. Part of the variances (R^2) explained by the model are labeled by the variable names. Note that "contract term of land use rights" and "subsidies of PES policies" are two correlated exogenous variables that are connected by a path with a double arrow. In addition, no R^2 of the two exogenous variables is reported by the SEM model.

the differences in management strategy among the three groups. The average income per SU is higher for the cooperative grasslands than for the family and rented grasslands ($p = 0.0075$, $F = 5.37_{2,53}$): 424 yuan/SU, 195 yuan/SU, and 155 yuan/SU, respectively. This finding indicates that cooperatives focus on maximizing profit, while the other groups focus on maximizing the number of livestock.

4.5.7. Security of grassland use rights

As noted above, the local government stipulates that only local native herders can legitimately rent grassland use rights; therefore, the bulk of the tenants, who are urban people or come from outside the county, rent grasslands illegally. The local government also provides an official standardized contract with stipulations to control grassland trade. For example, grazing intensity should be lower than the official carrying capacity, and the mowing area should be less than 15% of the total rented grassland. These two items are too strict; thus, even family managers do not obey them in practice. Tenants always violate these stipulations, who know they may be banished from the pasture regions for their illegal grassland use behaviors. The official standardized contract also stipulates that the lease term cannot exceed 3 years, which is much less than the 30-year term of grassland contracted rights. Therefore, it is no wonder that most of the tenants reported that they believe their grassland use rights are insecure.

4.6. SEM results

The goodness-of-fit statistics indicated the reported model was acceptable ($\chi^2 = 52.21$, df = 39, $p = 0.07$; AGFI = 0.94; CFI = 0.99; RMSEA = 0.03, Fig. 7). All paths in this model were statistically significant ($p < 0.05$). Because the three stocking rate indicators for provisioning services highly correlated with each other, this model retained only the livestock production to represent provisioning services. The model explained 94% of livestock production variances ($R^2 = 0.94$). The standardized partial regression coefficient was −0.95 from the contract term of grassland use rights to livestock production but was only −0.06 from subsidies of PES policies to livestock production.

These results suggested that improving the contract term of grassland use rights was the main path to reducing the provisioning services. Increasing the subsidies of PES policies may also reduce the provisioning services, but this effect may be slight. In addition, the model showed the direct impacts of the contract term on aboveground biomass: the standardized partial regression coefficient was 0.33. Because grassland mowing could not be accurately quantified, this factor was not included in the model for this study. In practice, long-term and secure contracts did reduce the intensity of grassland mowing, thus improving the aboveground biomass. As a result, the model generated a direct positive path from the contract term of grassland use rights to the aboveground biomass.

Most of the paths among the indicators of the four ecosystem services coincided with previous knowledge. Livestock production significantly reduced all the indicators of supporting services, such as aboveground biomass, root biomass at the 10–30-cm depth, and number of species per 1 m^2. Livestock production also sharply reduced the vegetation height, which was an indicator of regulating services. In contrast, the indicators of supporting services had positive influences on the indicators of regulating and cultural services. However, some of the variances explained by the model were low for the species number per 1 m^2 ($R^2 = 0.19$) and the SOC of soil at the 10–30-cm depth ($R^2 = 0.10$). The reason was that species composition and soil SOC usually changed more slowly than biomass indicators.

5. Discussion

5.1. Severe grassland degradation has occurred under the STPR policy

Our results show that the STPR policy, although well intentioned, has led to trading of grassland use rights, which in turn has resulted in severe grassland degradation and consequent dramatic decreases in multiple ecosystem services in the Inner Mongolian grasslands. Although rented grasslands substantially increased provisioning services in the short term, their supporting, regulating, and cultural services have been seriously undermined compared to those of family grasslands. Cooperative grasslands, in contrast, have maintained levels of ecosystem services similar to those of family grasslands.

In this study, ecosystem services indicators were surveyed for only a single growing year. Some ecosystem services indicators, such as biomass indicators and plant community height, are fast variables, that degenerate immediately after overexploitation in a growing season. Therefore, the single sampling period was not a problem for establishing causal links between land use intensity and these fast variables, as reflected in their significant correlations in the SEM results. However, some slow variables, such as plant community species number and SOCs, also exist among the ecosystem services indicators surveyed in this study. When exposed to overgrazing and predatory mowing, these slow variables need a relatively long time to show significant changes. The SEM explained the relatively low variance of these slow variables within the one year of data sampled in this study. These low correlations raise a doubt regarding whether one year of sampled data can prove causal links between overexploitation and slow variables?

Fortunately, it has been well documented that overexploitation of grassland resources, such as overgrazing and over-mowing, can cause serious degradation of all long-term ecosystem services in grassland ecosystems (Ford et al., 2012; Power, 2010). Overexploitation first weakens supporting services by removing a large proportion of biomass and reducing species diversity. In particular, the biomass and richness of dominant and leguminous species decline sharply, while r-strategy species usually increase in abundance but make little contribution to the overall ecosystem services. This change in turn leads to a decline in both the quantity and quality of litter (Yu et al., 2010), slows nutrient cycling (Liu et al., 2009), decreases carbon sequestration and aesthetic values, and causes the spiraling of a series of grassland degradation processes (Lal, 2009). In addition, grassland that has degenerated due to low biomass and short vegetation is extremely vulnerable to drought and snow disasters. Grassland degradation in our study areas appears to be consistent with the general mechanisms reported elsewhere. With these well-established causal links, this study can attribute the differences in slow variables to the different grassland use intensity among the three land tenure groups.

The SEM reported two paths from livestock production to number of forbs with showy flowers. One was positive and direct but less important; the other was negative and indirect but the main path. The reason for the positive path was that biomass harvest by grazing and mowing can reduce the light competition of dominant species and then increase the number of forbs (Niu et al., 2016). The negative path suggested that this effect was hidden by the grassland overexploitation. However, both the root biomass and SOC in topsoil (0–10 cm depth) were excluded by the SEM. Many previous studies reported that livestock grazing not only removes biomass but also increases the organic matter content in the topsoil by accelerated fragmentation and decomposition of litter by animal trampling (Mancilla-Leyton et al., 2013) and animal excreta (Gusewell et al., 2005). Because of the mixed responses of root biomass and SOC in topsoil, the SEM did not establish the deterministic relations between grazing intensities and the two indicators in the soil layer at a depth of 0–10 cm.

Although overgrazing has long been recognized as a primary reason for land degradation in Inner Mongolia (Jiang et al., 2006), the magnitude and ecological influences of overgrazing that are currently being observed in rented grasslands are unprecedented. The GMSC reported that the average grazing intensity was 126% of the officially recommended carrying capacity during the PES subsidies period from 2011 to 2015 (GMSC, 2016), which was similar to the level we found in the family-managed grasslands in this study. However, the average grazing intensity of rented grasslands was 200% of the officially recommended carrying capacity. Although scholars have different opinions about whether the officially recommended carrying capacity is the optimal and sustainable grazing intensity in arid grasslands (Vetter, 2005; Nyima, 2015). Apparently, the high overgrazing rate suggests the extremely heavy grazing intensity in rented grasslands. On the other hand, excessive mowing, which was particularly serious in rented grasslands, is another reason for grassland degradation. A control experiment in which the only treatment factor was grazing indicated a loss of 70% of the original aboveground biomass after four years of grazing at an intensity of 9 SUs/ha in this region (Schönbach et al., 2011). However, rented grasslands lost 70% of aboveground biomass in four years with an average grazing intensity of only 2.14 SUs/ha. This much larger loss of biomass from rented grasslands was due to excessive mowing by the tenants in addition to overgrazing.

The magnitude of overgrazing and excessive mowing in rented grasslands seems to have much greater impacts than climate changes on this grassland region. For example, after reducing annual rainfall by 60% for four years, a control experiment in ungrazed grassland of this region found that aboveground biomass decreased by 27% and root biomass declined by 23% (Zhang et al., 2017). In contrast, the rented grasslands lost 70% of aboveground biomass and 60% of root biomass in four years. A climate warming experiment suggested that SOC in the 0–30-cm soil layer of ungrazed grassland would decrease by 2–3% in this region when the soil temperature consistently increased by 1.39 °C for six years (He et al., 2012a). However, our study found that the SOC of topsoil at a depth of 30 cm decreased by 13% in rented grassland in only four years.

5.2. Grassland use rights trade is a present-day market-oriented behavior

Although grassland renting behavior emerged at the beginning of the HRS policy, the current land use rights trade is completely different from the former grassland renting behavior. The HRS policy reform caused resource mismatches between livestock and grassland (Li et al., 2007). For example, some fortunate families might gain much livestock from a bumper harvest, while others might lose many animals to a disaster. To cope with resource mismatch problems, many herders spontaneously rented grassland from neighbors who had less livestock but more unused grassland. These renting behaviors usually occurred between members of the same communities and were supervised by the local community. In addition, grassland lessors always preferred to accept live livestock as rental. In this way, they could easily recover their livestock population after a natural hazard or an epidemic disease. Therefore, grassland renting behaviors between local herders in the early HRS period can be considered a form of cooperation in a local community.

In contrast, the current grassland use rights trade is market oriented. Most of the tenants are financial investors who rent grassland for profit rather than to solve the resource mismatch problem. Many lessors rent grassland out for cash to support their life in town or to pay debts. In addition, rented grasslands are no longer supervised by the local community. Therefore, the grassland use rights trade has become a business.

5.3. The STPR policy may lead to predatory land use and grassland degradation

Our study documented unintended but severe grassland degradation as a result of China's STPR rural reform policy. The "predatory" land use of tenants is the direct reason for degradation in rented grasslands, but it cannot be attributed simply to moral issues among the tenants. Herders know that raising more livestock can increase not only gross income but also costs and thus cannot ensure an increase in net profit (Briske et al., 2015; Kemp et al., 2013). However, the insecurity of grassland use rights is the root reason for degradation in rented grasslands. Without long-term security of grassland use rights, tenants will naturally tend to overuse the grassland to maximize their short-term gains. The insecurity of grassland use rights is a combined result of the local government's control policies and interactions among multiple groups of stakeholders, including the central and local governments, lessors, and tenants.

As mentioned earlier, local government is authorized to make detailed rules to implement the STPR reform on the ground. However, the key interests of local governments in relation to the reform are quite different from the goals of the central government. According to the public choice theory (Blumm, 1994), local governments are more motivated by self-interest than pure public service. Local governments currently have little interest in public affairs related to pasture regions because they have no legitimate power to adjust grassland tenure (Ma et al., 2015), to tax herders (Wang & Shen, 2014), or to withhold any PES subsidies. For local government, grassland management therefore means only much expenditure with no income. In addition, because local government revenues are generally less than their spending responsibilities under the current national tax sharing system (Lam & Wingender, 2015), local officials have neither the initiative nor adequate money to advance the STPR reform.

However, local government officials are extremely concerned that they are held accountable for environmental degradation under the current cadre evaluation system (Wang, 2013). In Inner Mongolia, serious human-induced grassland degradation can prevent the promotion of many local officials, including the chief executive of the local government and the officials in charge of grassland management. Thus, implementing the STPR reform is an uncertain adventure for local officials. If they approve a grassland use rights trade, they must protect the land in question from degradation. Otherwise, the grassland degradation will be blamed on them, and they will receive bad performance evaluations and lose potential chances for promotion (Chang & Wang, 2016). In contrast, if they do not approve the trade, the degradation of the rented grassland will be blamed on those who traded it illegally. Approving trades in grassland use rights thus means greater expenditure and more risk than denying them. Therefore, the environmental cadre evaluation drives local officials to restrain such trade in practice. This consequence deviates from the original intention of the evaluation.

Local herders generally support the controlling policies of local officials. Because rural land legislation, which aims to protect the grassland contracted rights of herders, forbade village collectives to adjust contracted land after 2002 (Ma et al., 2015), many young local herders born after 2002 still have not received their contracted grassland from village collectives. Many local herders believe that it is not fair under such conditions to rent grassland to outsiders. This public opinion is particularly strong in the Mongolian community. According to the public choice theory, local interest groups can exert a powerful influence on policy making (Blumm, 1994). In China, local interest groups can express their dissatisfaction by appealing to higher authorities, which also has a negative effect on local officials' performance evaluations. Therefore, local officials usually comply with public opinion to pacify disaffected local herders, which is another reason that they tend to limit grassland use rights trade.

The top priority of grassland lessors is to receive their rent in one lump sum to meet financial demands or establish an urban life. The total rent usually ranges from 200,000 to 300,000 yuan, which is an astronomical number for ordinary local herders, whose disposable income was only 20,000 yuan per capita in 2015. Many lessors therefore seek to lease their land to illegal tenants who are able to pay all the rent in one lump sum. They make private agreements without governmental approval or in some cases use a false identity to obtain governmental approval. Of course, all such agreements are illegal.

Renting grassland is a profitable business. The net profit rate of this business is approximately five times the three-year deposit rate in China. Therefore, illegal tenants are motivated to rent grassland use rights and cannot be expelled from the markets by the controlling regulations. As seen, tenants generally believe that they take great risks to buy grassland use rights that are insecure. Given the high risks of the trade, they also wish to avoid long-term contracts. Under these conditions, it is meaningless for tenants to abide by the strict and sustainable rules for mowing and stocking rate. They can obtain neither legal use rights nor long-term profit by obeying these rules. Moreover, local officials frequently improve their political popularity among disaffected local herders by banishing a few illegal tenants and "seeking rent" from other illegal tenants. Hence, tenants usually adopt a predatory strategy to earn their money back as soon as possible.

Therefore, local officials do not uphold their responsibility to achieve both economic efficiency and social justice in the grassland STPR reform, the goal set for the reform by the central government. Instead, to seek benefits for themselves, local officials may implement a range of policies to control the trade in grassland use rights. With certain controlling policies, they can reduce the financial expenditure and responsibility of the local government and improve their political popularity among local herders, but they cannot restrain the development of the grassland use rights trade market. These controlling policies lead to massive illegal trades in grassland use rights and predatory overexploitation of rented grasslands.

5.4. Advantages and limitations of rural cooperatives

This study confirmed the advantages of cooperative groups in grassland consolidation, primarily because cooperative grasslands did not degrade as badly as rented grasslands and showed no significant differences from family grasslands for most of the ecosystem services in this region. These advantages of cooperatives in our study were not as great as those found in many previous studies that suggested that cooperative grasslands were managed significantly better than family grasslands (Cao & Du, 2011; Tang & Gavin, 2015). The reason for this difference may be that both families and cooperatives in this study had enough grassland to adopt rotation grazing, while families in previous studies did not have enough grassland to do so, as cooperatives did.

We found no evidence of contributions from grassroots democracy or community governance, as reported by Tang and Gavin (2015). Herder cooperatives are composed mainly of family members, which seems to help ensure the security of grassland use rights and promote sustainable grassland use. This phenomenon can be seen in agricultural regions in China as well. For example, tenant farmers in Guangdong Province invested more resources in farmlands rented from their relatives than in other rented farmlands (Gao et al., 2012). In addition, chiefs' personal ability to obtain governmental subsidies may contribute to the advantages of cooperatives.

However, in our study area, cooperatives have limited their group size and refused to accept new members once the number of members reached the statutory registration standards. Concern with the free-rider problem seems to be the major reason that limits the growth of these cooperatives. According to China's farm cooperative law, cooperatives must follow the "one member, one vote" principle in decision making and profit sharing, regardless of differences in level of investment and individual contributions. Although this approach is fair in some ways, it ignores the fact that chiefs contribute more than ordinary members in practice, particularly in applying for extra subsidies. A larger cooperative group size means that chiefs must share the subsidies with more members, who contribute much less to obtaining government projects. In a study of cooperative behavior, Wang et al. (2013) demonstrated that two ways for chiefs to solve the free-rider problem are cooperating only with relatives and ensuring the majority vote by limiting group size. Our study seems to corroborate this theoretical result. Our findings also support an academic opinion that although governments can create rural cooperatives with good intentions and generous investments, these cooperatives can hardly achieve real and durable cooperation among rural people (Yan & Chen, 2013; Ichinkhorloo & Yeh, 2016). This study suggested that current cooperatives cannot become the primary channels of grassland consolidation without any improvement. In 2015, the Inner Mongolia Development and Reform Commission (IMDRC) also reported that cooperatives had consolidated only 11.5% of the total transferred rural land in Inner Mongolia, which confirmed our judgment (IMDRC, 2015).

5.5. PES policies are no longer effective for rented grassland

The current PES policies are too simple for the situation of Chinese grasslands (Yeh, 2009) because the central government is the only buyer. The central government distributes PES subsidies directly to herders' accounts based on their grassland contracted right; this method can prevent local government from intercepting these subsidies and thus reduce corruption. However, the subsidies are technically tied to grassland contracted right and thus become the social welfare of the contractor. Even after the STPR reform, subsidies for rented grasslands are still distributed to grassland lessors, who do not manage the grassland. Therefore, the PES subsidies, which are designed to secure grassland conservation, are ineffective because they do not address the real managers of the rented grasslands.

6. Conclusions

This case study suggests that the current STPR reform of grassland casts a shadow on grassland conservation in China's pasture regions. The reform balances economic efficiency and social justice principles, maintains grassland food production, and provides social welfare to rural migrant workers. However, it has also caused serious degradation of grasslands in our study region. These undesired consequences are due primarily to local governments' control policies for grassland use rights trades, which have led to the insecurity of grassland use rights and the subsequent overexploitation of rented grasslands. In addition, the STPR reform has counteracted the efforts of PES policies because the PES subsidies have become a type of social welfare for grassland lessors and cannot secure conservation in rented grasslands. Moreover, rented grasslands in general are presently used only to provide food, and other ecosystem services are ignored. This study also suggests that cooperatives have achieved a level of sustainable management of these consolidated grasslands; however, these cooperatives are open only to the kinship of their chiefs, and the free-rider problem impedes them from becoming a primary channel of grassland consolidation. Therefore, the Chinese government, at the national and local levels, should pay attention to the problematic environmental effects of this reform in grassland regions.

There are many potential solutions for these problems. The government could design some policy innovations to achieve the sustainable use of rented grasslands. Government officials and local people can combine the merits of market-oriented methods and community co-management of the grassland use rights trade; for example, a Tibetan pasture community embedded grassland use rights trade within local customary institutions and thereby achieved sustainable management of grassland and livestock (Gongbuzeren et al., 2016). At the same time, the government should help cooperatives solve the free-rider problem and encourage them to accept additional herder members and their grasslands through legislation and financial tools. The PES policies should also be improved. The government may induce more buyers to pay for multiple ecosystem services beyond provisioning food, which is more in accord with the original intention of the PES policy (Engel et al., 2008). However, Chinese grasslands are vast and diverse, and grassland management problems are also complex and heterogeneous. Future studies should carefully evaluate the effectiveness of these potential solutions and find sustainable approaches to managing rented grasslands.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.landusepol.2017.11.052.

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