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The effects of enclosures and land-use contracts on rangeland degradation on the Qinghai–Tibetan plateau

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ABSTRACT

Rangeland degradation on the Qinghai–Tibetan Plateau is a growing concern, often attributed to climate change and overgrazing. A minority of researchers have suggested instead that degradation may be caused by changes in land management, particularly enclosures and the contracting of long-term rangeland use rights to households. However, these claims have been hampered by a lack of empirical evidence. This field experiment is the first to compare rangeland conditions over time in the case of different management regimes on the Qinghai–Tibetan Plateau, specifically single-household versus multi-household management. A survey of vegetation properties in Maqu County, Gansu province in 2009, and repeated in 2011, examined the differences between single- and multi-household management in terms of vegetation biomass, cover, and species richness. In 2009, the biomass of the sedge group under multi-household management was significantly higher than that under single-household management. In 2011, biomass, vegetation cover, and species richness were all significantly higher under multi-household management than single-household management. These data suggest the flaws of the tragedy of the commons assumptions underlying single-household management.

1. Introduction

Rangeland degradation has become an issue of considerable concern for the Chinese government since the economic reforms of 1978 and particularly since the late 1990s, following dust and sandstorms over Beijing, major flooding of the Yangtze River, and the increased incidence of the Yellow River running dry, all of which have been attributed to upstream degradation (Harris, 2010; Ho, 2000a; Yeh, 2009). Claims that 90% of Chinese rangelands are degraded are pervasive and generally accepted in China, despite a lack of credible data and contradictions among and within official reports on degradation (Harris, 2010; YontenNyima, 2012). In addition to technical measures such as aerial sowing, removal of livestock, forage cultivation, and the eradication of small mammals such as pikas, the Chinese government has focused on attempting to halt rangeland degradation through the implementation of policies to privatize use rights to pasture.

These policies have been based on the assumption of the "Tragedy of the Commons" (Hardin, 1968) – the belief that only privatized land-use rights can provide an adequate incentive for households to manage their livestock without causing rangeland degradation, by making herders responsible for matching herd sizes to rangeland resources and for investing in improvements for sustainable management (Harris, 2010; Ho, 2000a; Yan et al., 2005). Rangeland use rights contracts were first implemented in the 1980s with China's 1985 Grassland Law, which stipulated that grazing land could be contracted out both to collectives and to individual households (Ho, 2000b; YontenNyima, 2012). This possibility was reiterated in the Land Administration Laws of 1986, 1998, and 2004, as well as the amended Grassland Law of 2002. However, the Rural Land Contract Law of 2002 and Property Law of 2007 stated that land, including grazing land, should be contracted to individual households (YontenNyima, 2012). Laws and policies have thus been inconsistent with respect to the basic unit of rangeland use rights allocation as well as whether pasture should be used individually or collectively after implementation of land-use rights contracts.

There has been a strong tendency for local and regional governments to interpret the policies as a mandate to limit land-use rights to the scale of individual households. This began in the

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1980s in Inner Mongolia and gradually spread to Xinjiang and the eastern and then western parts of the Qinghai–Tibetan Plateau (QTP) in the 1990s and into the 2000s. This has led to many documented problems, including household inequality, as rich households that can afford to buy barbed wire fences started enclosing more land than allocated, thus increasing grazing pressure on unfenced land; inequitable access to water and increased labor and economic burdens; and an increase in rangeland conflicts (Cao et al., 2011a; Williams, 1996, 2002; Wu and Richard, 1999; Yan and Wu, 2005; Yan et al., 2005; Yeh, 2003).

Though policy-makers and most scientists assume that overgrazing and climate change are the key drivers of degradation on the QTP, some researchers have pointed out that the Tragedy of the Commons assumption-based rangeland contract system and its enclosures may be more important drivers of rangeland degradation (e.g. Banks, 2001, 2003; Miller, 2000; Sheehy et al., 2006; Taylor, 2006; Yang, 2010; Yan et al., 2005; Yan and Wu, 2005). However, the lack of empirical ecological evidence has limited the acceptance of this argument. This study is the first to test this argument through a field experiment that compares rangeland conditions over time in the case of different management regimes in Maqu. By comparing rangeland vegetation quality between single household and multiple household-managed pastures, the study tests the assumption that privatization and individualization of resources leads to environmentally and socially superior outcomes. In doing so, it contributes to the broad literature on the "tragedy of the commons" and rangeland management (Crépin and Lindahl, 2009; Feeny et al., 1990; McKay and Acheson, 1987; Ostrom, 1990; Peters, 1997; St. Martin, 2001).

2. Materials and methods

2.1. Study area

Maqu County, Gansu province (101°–102 °E, 33°–34°N) is located on the boundary of Sichuan and Qinghai provinces, in the eastern Qinghai–Tibetan plateau (Fig. 1). The altitude ranges from 2900 to 4000 m with an annual rainfall of 450–780 mm. The annual average temperature is 1.8 °C, with a low of −10.7 °C in January and a high of 11.7 °C in July. The maximum air temperature during the growing season can reach 29 °C, and there are on average 270 frost days annually. The rangeland area covers about 87×10^4 ha, and 59% is classified as alpine meadow, dominated by sedges such as *Kobresia capillifolia* and *Scirpus pumilus*; grasses such as *Festuca ovina*, *Poa poophagorum* and *Elymus nutans*; poisonous weeds such as *Ligularia virgaurea, Stellera chamaejasme*, *Anemone rivularis*, *Trollius farreri Stapf* and *Anemone obtusiloba;* and legumes such as *Astragalus polycladus* and *Gueldenstaedtia Verna*.

Historically, herders of Maqu engaged in transhumant pastoralism of yak and Tibetan sheep based on collective rangeland rights, an apparently environmentally sustainable land use (Cao et al., 2011b; Yan et al., 2005). In 1996, a policy of enclosure and land-use contract grazing was implemented in Maqu County and the local government decided that winter pasture use rights should be contracted to single households (SH), while summer pasture rights could be contracted to units of up to three households (multiple households: MH). Average household size is 4.7 herders in Maqu, and each herder received roughly 15 ha when use rights were contracted. Based on this, we can infer the size of rangeland of the two different household types. In both cases, enclosures were used. For MH grazing, an enclosed area of rangeland proportional to the number of people in the families is jointly managed with no internal boundaries between pastures, while for SH, a smaller rangeland area is fenced off and managed by one household. However, the MH system was in practice implemented on winter pasture in some cases as well, including units larger than 3 households. Local officials were flexible in allowing herders to choose the management regime they preferred.

There are 7406 households in Maqu County, for a total of roughly 35,000 herders. In 2008, a survey of 4752 of those households was conducted to examine management and scope of multi-household units (Cao, 2010). Of those surveyed, 82% managed their winter pastures in multi-household units. Among these households, about 50% did so in units of 3 households, 30% managed in units of around 10 households, and 20% managed in even larger-scale units. On summer pasture, 86% (4103 households) engaged in MH management with around 15 households or more. Generally, those who managed their winter pastures in MH units also did so in summer pasture. On the other hand, some of those who managed their winter pastures in SH units found they needed to organize into MH units on the relatively remote summer pastures due to its limited water sources and for the greater security possible with multiple households, important in the more sparsely populated landscape. Our previous research found that those who managed their

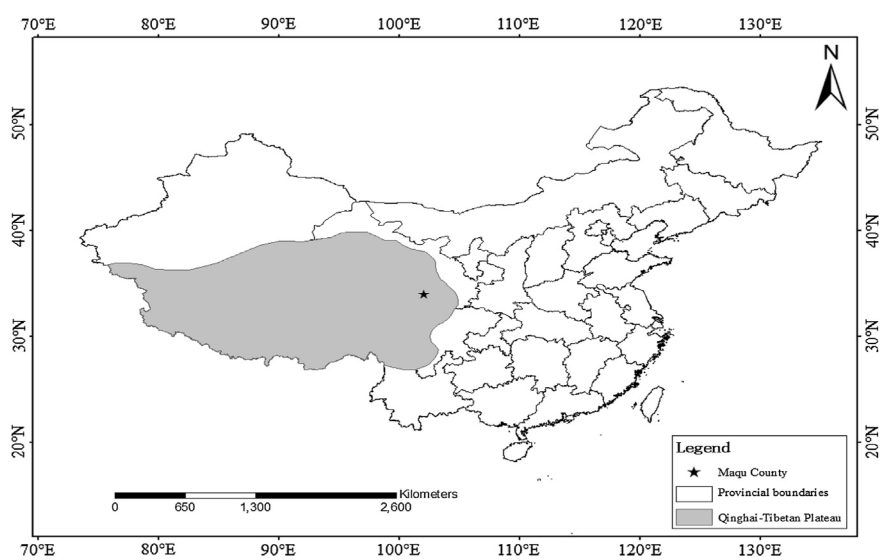

Fig. 1. The location of Maqu on Qinghai–Tibetan plateau.

pastures, both winter and summer, in SH units were households that made few contacts with others, and were conveniently located to be able to rent their pastures to outsiders without others intervening. By contrast, those who managed in MH units were less conveniently located for renting to outsiders, and had more community networks. In the context of a long history of collective pastoralism, they were also reluctant to switch to SH management due to concerns about fairness in the equitable use of patchy rangeland and water sources (Cao et al., 2009; Yeh and Gaerrang, 2011).

Traditionally, pastures for each of the four seasons were distinct, with frequent movement among and within them. However, with the implementation of land-use contracts, the scope and space of available rangeland has been reduced. Currently, most MH households only have summer and winter pastures, and often move livestock in June from winter to summer pasture, and return to winter pasture in August. They spend another month at summer pasture in September and then return to winter pasture in October, spending a total of about 9 months per year at winter pasture (Cao et al., 2011b). Some SH households have only one pasture for year-round use. In addition to the differences in the cost of production, social capital and grazing patterns between MH and SH (see Cao et al., 2011b for more details), access to water sources also being different. Water sources in Maqu are diverse, with some coming from the Yellow River, and others from seasonal rivers or groundwater (Fig. 2). Generally, MH units have access to several sources of water, while SH units tend to have one or even none. In the latter case, households must buy water from others for livestock, or travel long distances to water sources.

2.2. Methods

Thirty SH and thirty MH areas of winter pasture, all alpine meadow, within an area of 36 km^2 were selected for study. All of the units sampled had been under either SH or MH management since the implementation of land-use contracts in 1996. The MH and SH units had the same type of livestock – all yaks – as well as the same stocking rate. According to the Animal Husbandry Bureau of Maqu County, this stocking rate is two sheep equivalent units per hectare (Animal Husbandry Bureau of Maqu County, 2005). None of the units chosen for the study rented their land to or were renting land from other units. Among the 30 MH households, 20 were units of 3–15 households and 10 had more than 15 households, with the largest having 30 households.

A randomly selected 50 m $\times$ 50 m plot was used for quadrat sampling in each area. Rangeland quality was characterized using common indicators of degradation: total biomass (g), vegetation functional group biomass (g), vegetation cover (%), and plant species richness (Reed et al., 2007). All samples were taken on winter pasture during a week of dry weather from 4 to 9 July in 2009 and

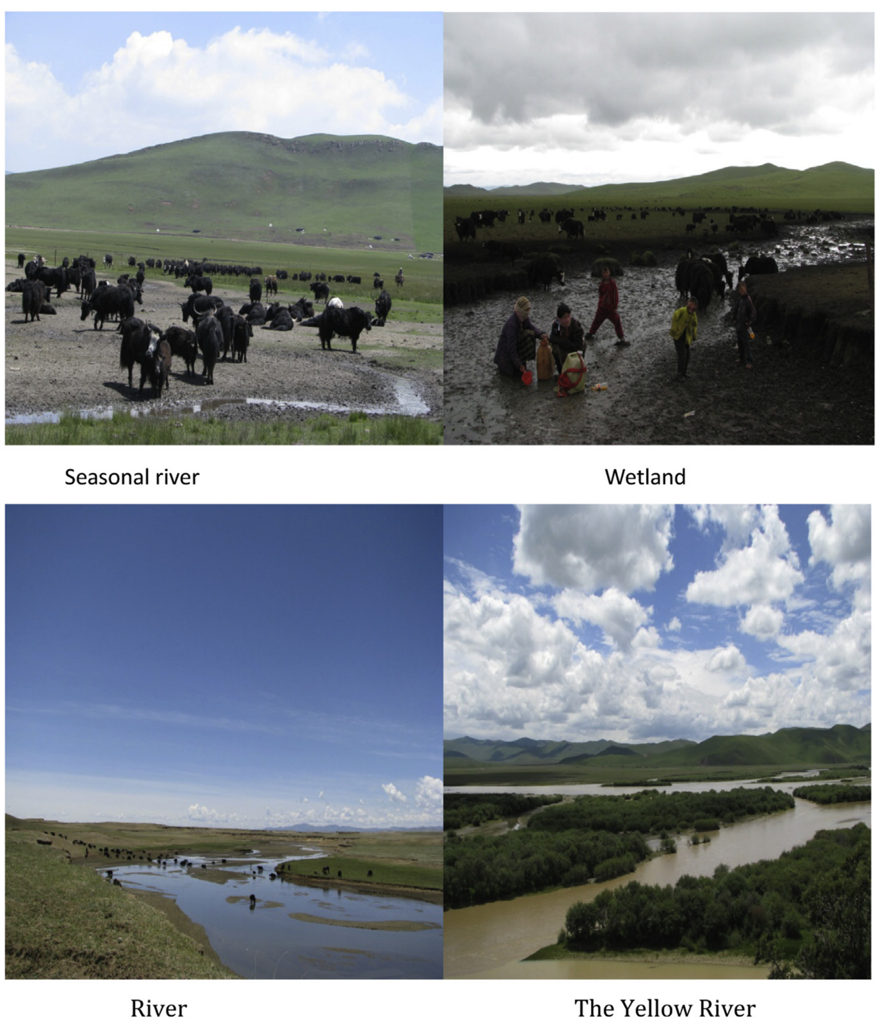

Fig. 2. Diverse water sources in Maqu County.

again from 19 to 24 July in 2011 (Yang, 2012), after the herders had moved to summer pasture in both cases. Within each plot three quadrats (50 cm × 50 cm) were laid out at random locations and orientations and data recorded for plant functional groups including sedge, grass, poisonous weed and legume biomass. Cover was estimated using the Braun–Blanquet scale (Westhoff and Van Der Maarel, 1978). Fresh samples were oven dried at 80 °C to a constant weight (48 h) and each biomass type was expressed by dry weight. Biomass was recorded as zero if weight of the functional group was <0.01 g. The species richness was expressed as the mean species count for each plot. The number of households grazing each MH site was also recorded. The data were analyzed using SPSS 15.0, and $p < 0.05$ was used as the critical threshold for significance to determine differences in the parameters.

3. Results

There was no significant difference in total biomass, coverage, and plant species richness between SH and MH in 2009, but by 2011 significant differences had emerged (Table 1). Only the sedge group had significantly greater biomass in MH than in SH in 2009 (Table 2), while by 2011 MH had significantly greater biomass in all functional groups except grass. The overall species richness declined in both SH and MH from 2009 to 2011.

4. Discussion

There were differences in biomass between 2009 and 2011 (Table 1), but it should be noted that these could have been due to the 2011 sampling being 15 days later in the year than in 2009. July is the peak of the summer growing season in Maqu County (Cao, 2010). In alpine habitat, the growing season is short so the biomass changes quickly.

Precipitation in Maqu was similar in 2009 and 2011, at about 600 mm, which is adequate for the needs of plant growth (Wang et al., 2008). Assuming that the higher biomass of both SH and MH units in 2011 relative to 2009 was due to the differences in sampling time, we would expect that if there were no degradation, the cover and species richness would also be higher in 2011. However, this is not the case. Instead, the results show that cover and species richness of both MH and SH units decreased between 2009 and 2011; the species richness decrease was significant ($p < 0.01$) for both SH and MH units, while the decrease in cover was not significant.

The cause of decrease in species richness in SH units was most likely the ongoing effects of the transition from collective rangeland management to SH management, the imposition of fencing, and the resulting reduction in flexibility and mobility compared with historical management (Fernandez-Gimenez, 2002; Yan et al., 2005; Yeh and Gaerrang, 2011), which leads to intensified trampling (Ao et al., 2008; Klein et al., 2011; Li and Zhang, 2009; YontenNyima, 2012). According to Yang (2010) the damage caused by trampling is twice that of grazing. Furthermore, trampling damage often interacts with other degrading factors, such as soil disturbance activities of small herbivores, exposure to wind scouring, low regeneration capacity of alpine turf communities, and the decline in vegetative reproductive capacity of some rhizomatous alpine turf species, which ultimately causes loss of the alpine turf and decreases the quality of rangeland. Given the increase in trampling due to the smaller, limited grazing area, the soil quality under SH managed plots was probably decreasing, in an ongoing process since the imposition of SH units in 1996, leading to decreased capacity for plant regeneration and seed propagation, and thus species richness decline (Briske et al., 2008; Liu et al., 2003). This view is supported by Cao et al. (2011a), who found that SH management caused a decrease in plant diversity by focusing continuous and higher grazing pressure on smaller areas of rangeland. A loss of grass species reduces the functional diversity of the grass layer and decreases the resilience of the system in terms of its ability to keep functioning ecologically in the face of external shocks (Carpenter and Turner, 2000; Carpenter et al., 2001).

The species richness decline between 2009 and 2011 on MH-managed areas can be explained as the result of the scale of the MH plots not being large enough to offer enough mobility to offset the effects of grazing pressure. Plant species richness was positively related to the scale of households in MH in both 2009 ($r = 0.51$, $p < 0.001$) and 2011 ($r = 0.49$, $p < 0.01$) (Cao et al., 2011a; Yang, 2012). Most MH units had 3 to 10 households, suggesting that this scale of MH households is too small to support plant diversity and should be enlarged in number of households and thus grazing area.

Our study found that species richness of both MH units and SH units declined significantly between 2009 and 2011, but due to the lack of previous data, we do not know when this significant difference was first established. That is to say, we know that between 1996, when these smaller-scale units were first established, and 2011, species richness was reduced on both SH-managed units and MH-managed units, but we cannot say whether these differences became significant only in 2009, or earlier.

The fact that the difference in species richness between SH and MH was insignificant in 2009 but became significant in 2011 requires further study. We speculate here that although the rangeland quality of both MH and SH declined, the SH-managed rangeland was more easily degraded because its trampling pressure is generally heavier than that of MH. In addition to the fact that the smaller spatial scale of SH management leads to more concentrated areas of trampling as discussed above, the lack of water sources for SH households also contributes to the concentration of grazing and trampling. By contrast, MH units have more opportunities to move during community growth and development, shortening the grazing duration on certain areas of rangeland, leading to less grazing as well as trampling pressure on rangeland than SH. In addition, financial expenditures also differed between MH and SH units. Generally, SH units need to spend more money on fencing material and other infrastructure than MH households (Cao et al., 2011b). In Maqu County, 90% of herders' income comes from the

Table 1
Biomass, coverage and species richness of SH and MH.

	2009		2011	
	SH	MH	SH	MH
Biomass (g)	24.16 ± 3.30	32.44 ± 5.12-	34.47 ± 2.26	42.34 ± 2.38**
Cover (%)	89.2 ± 0.09	92.5 ± 0.13-	87 ± 0.01	91 ± 0.01*
Species richness	21.0 ± 0.70	22.3 ± 0.65-	15.0 ± 0.58	18.35 ± 0.53***

Note: "-","*", "**", "***" means not significant, and significant at $p < 0.05$, $p < 0.01$, and $p < 0.001$ respectively.

Table 2
Biomass of the four functional groups (g).

	2009		2011	
	SH	MH	SH	MH
Sedge	8.27 ± 0.81	11.84 ± 1.03*	15.23 ± 0.98	22.12 ± 1.48***
Grass	2.71 ± 0.56	3.08 ± 0.53-	4.37 ± 0.89	4.09 ± 0.97-
Poisonous weed	12.49 ± 0.87	16.42 ± 1.77-	13.07 ± 1.60	15.35 ± 1.48**
Legume	0.67 ± 0.16	1.09 ± 0.37-	0.48 ± 0.10	1.49 ± 0.42*

Note: "-","*", "**", "***" means not significant, and significant at $p < 0.05$, $p < 0.01$, and $p < 0.001$ respectively.

sale of livestock and livestock products such as milk (Cao, 2010). With increased expenditures, forage needs also increase, and thus cause trampling to be further intensified. In sum, owing to the limited spatial scale of grazing areas and greater financial pressures, the rangelands with SH units are subject to more trampling than MH units. The former, direct cause of trampling is the main trigger of rangeland degradation, while the latter indirect pressure further exacerbates degradation.

From Tables 1 and 2, we can see that the rangeland quality of MH is better than that of SH in both 2009 and 2011, and the discrepancy of rangeland quality between MH and SH became larger in 2011. In 2009, though only the difference of the biomass of the sedge group between MH and SH is significant, this strongly suggests that the rangeland quality of MH is better than SH because alpine meadow are dominated by sedge species on the QTP (Niu et al., 2010). In 2011, by contrast, the differences between the biomass, cover and species richness between MH and SH were all significant. This appears to indicate that MH will be better than SH in terms of protecting rangeland, but may not be as good as traditional transhumant grazing because livestock cannot graze over a large enough area in the current configuration of MH units.

There are no completely traditional grazing systems still in place on the QTP, and thus this cannot be determined by empirical observation. However, interview data support this idea. Cao et al. (2011b) found that 60% of herders interviewed in Maqu preferred traditional transhumant grazing on a large scale because of better and more flexible access to water and grass, allowing livestock access to greater varieties of feed, and to greater mobility through migration in all four seasons. Generally, by grazing over a larger area, livestock can use abundant low-quality food with little disturbance, and spatially heterogeneous urine and dung deposition across the landscape then aids in plant recruitment. The livestock may also be efficient seed dispersers by transporting soil and undamaged seeds over larger distances. Spatially-heterogeneous urine deposition could also increase regeneration sites and soil heterogeneity (Olff and Ritchie, 1998).

The results of an earlier study indicate that 8–15 household units would be suitable for cooperative management of grazing and could be socially acceptable with suitable policy support in the current social and political context (Cao, 2010). Despite both the herders' stated preferences for larger-area MH grazing and the results of the field observations reported here that strongly indicate MH is more suitable for grazing management than SH in terms of species richness and biomass, the actual trend across Maqu in the absence of policy support for larger MH groups has been one of large MH groups breaking into smaller groups, including a trend toward SH management.

There are two main reasons for the trend toward smaller MH and SH management in Maqu County. Like some areas of the QTP, such as Naqu County (Wu and Richard, 1999; YontenNyima, 2012), there is also a system in place in Maqu County for households with more livestock to compensate those with fewer when pastures are managed in common by MH. However, conflicts have emerged over refusals or delays in paying compensation, and in the course of our survey in 2009 we encountered several larger MH groups that had divided into smaller ones as a result of non-receipt of compensation money (Cao, 2010). In addition to perceived inequality within MH groupings, if pastoralist households decide to settle in towns, which is an increasingly common phenomenon across the QTP (Yeh and Gaerrang, 2011), the household first separates from the MH group into SH management to facilitate the rental of grazing rights. This has also led directly to a decrease in the size of MH groups, and according to those interviewed during the field study, rangelands that are rented tend not to be grazed according to theoretical rangeland carrying capacity (perhaps because the herder no longer has a personal investment in the land), and overgrazing leading to trampling damage becomes more common. The disconnection between the holder of land use rights, the herder, and the land thus leads to rangeland degradation.

5. Conclusions

Providing results of the first field experiment on the QTP that compares rangeland conditions over time under different management regimes, this ecological study demonstrated that MH-management was superior to SH-management in terms of key indicators of rangeland quality, particularly plant biodiversity, cover, and biomass. This finding suggests that Chinese policies leading either directly or indirectly to individual household enclosures and management of rangeland on the QTP should be carefully reconsidered. More generally, the evidence from this study strongly suggests, in line with studies of other pastoral areas around the world, that basing policy on the "tragedy of the commons" assumption that undermines common property management is detrimental (Behnke and Scoones, 1992; Little, 2003; McCabe, 1990; Peters, 1997; Turner, 1993; Williams, 1996). Instead, common ownership and management can be environmentally beneficial, particularly in the context of pastoralism, which has been traditionally characterized by mobility and flexibility.

The study provides evidence that management regimes play an important role in determining rangeland condition on the QTP, and that deteriorating conditions cannot be attributed to climate change alone. Moreover "overgrazing" cannot be understood simply in terms of individual herders' irrationality, nor can it be thought of only in terms of numbers of livestock, but must also consider the distribution of livestock on the landscape and how this is conditioned by policies of enclosure and land tenure. If policy can't tolerate a return to traditional nomadic pastoralism over large spatial scales (Harris, 2010), the rangeland policy of Chinese government should consider MH with a larger number of households per group. Finally, given other structural pressures that are encouraging the breakup of MH households to SH management, even when herders recognize and clearly articulate the benefit of the former, this will require careful planning and further research that takes into account a whole suite of socio-cultural, political-economic, and ecological factors.

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References

Ao, M., Ito, M., Ito, K., 2008. Floristic compositions of Inner Mongolian grasslands under different land-use conditions. Grassland Science 54, 173–178.
Banks, T.J., 2001. Property rights and the environment in pastoral China: evidence from the field. Development and Change 32, 717–740.
Banks, T.J., 2003. Property rights reform in rangeland China: dilemmas on the road to the household ranch. World Development 31, 2129–2142.
Behnke, R., Scoones, I., 1992. Rethinking range ecology: implications for rangeland management in Africa. In: Behnke, R., Scoones, I., Kerven, C. (Eds.), Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaptation in African Savannas. ODI, London, pp. 1–30.
Briske, D.D., Bestelmeyer, B.T., Stringham, T.K., Shaver, P.L., 2008. Recommendations for development of resilience-based state-and-transition models. Rangeland Ecology and Management 61, 359–367.
Cao, J.J., 2010. Research on Grassland Management on Qinghai Tibetan Plateau. Lanzhou University Press (in Chinese).

Cao, J.J., Du, G.Z., Wei, H.L., Wang, H., 2009. SWOT analysis on multi-household grassland management in Maqu and strategies for further development. Pratacultural Science 26 (10), 146–149 (in Chinese).
Cao, J.J., Holden, N.M., Lv, X.T., Guo, Z.D., 2011a. The effect of grazing on plant species richness on the Qinghai Plateau, Tibet. Grass and Forage Science 3 (66), 333–336.
Cao, J.J., Xiong, Y.C., Sun, J., Xiong, W.F., Guo, Z.D., 2011b. Differential benefits of multi- and single-household grassland management patterns in the Qinghai-Tibetan Plateau of China. Human Ecology 2 (39), 217–227.
Carpenter, S., Walker, B., Anderies, J.M., Abel, N., 2001. From metaphor to measurement: resilience of what to what? Ecosystems 4, 765–781.
Carpenter, S.R., Turner, M., 2000. Hares and tortoises: interactions of fast and slow variables in ecosystems. Ecosystems 3 (6), 495–497.
Crépin, A.S., Lindahl, T., 2009. Grazing games: sharing common property resources with complex dynamics. Environmental and Resource Economics 1 (44), 29–46.
Feeny, D., Berkes, F., McCay, B., Acheson, J., 1990. The tragedy of the commons: twenty-two years later. Human Ecology 18 (1), 1–19.
Fernandez-Gimenez, M.F., 2002. Spatial and social boundaries and the paradox of pastoral land tenure: a case study from post-socialist Mongolia. Human Ecology 30 (1), 49–78.
Hardin, G., 1968. The tragedy of the commons. Science 62, 1243–1248.
Harris, R.B., 2010. Rangeland degradation on the Qinghai-Tibetan plateau: a review of the evidence of its magnitude and causes. Journal of Arid Environments 74, 1–12.
Ho, P., 2000a. China's rangelands under stress: a comparative study of pasture commons in the Ningxia Hui autonomous region. Development and Change 31, 385–412.
Ho, P., 2000b. The clash over state and collective property: the making of the rangeland law. The China Quarterly 161, 240–263.
Klein, J., Yeh, E.T., Bump, J., Nyima, Y., Hopping, K., 2011. Coordinating environmental protection and climate change adaptation policy in resource-dependent communities: a case study from the Tibetan Plateau. In: Ford, J., Ford, L.B. (Eds.), Climate Change Adaptation in Developed Nations: From Theory to Practice. Springer, pp. 423–438.
Li, W., Zhang, Q., 2009. Comprehending Rangeland Dilemmas: Understanding Several Issues in Arid and Semi-arid Rangeland Utilization Management. Economic Science Publishing House, Beijing (in Chinese).
Little, P., 2003. Rethinking interdisciplinary paradigms & the political ecology of pastoralism in East Africa. In: Bassett, T.J., Crummey, D. (Eds.), African Savannas: Global Narratives and Local Knowledge of Environmental Change. Heineman, Portsmouth, NH, pp. 161–177.
Liu, L.M., Zhao, Y.W., Xie, H., 2003. Study on regional characteristics of rangeland degradation of China and its control strategies for sustainable use and management. China Population. Resources and Environment 4, 46–50 (in Chinese).
McCabe, J.T., 1990. Turkana pastoralism: a case against the tragedy of the commons. Human Ecology 18, 81–103.
McKay, B., Acheson, J., 1987. The Question of the Commons: the Culture and Ecology of Communal Resources. University of Arizona Press, Tuscon.
Miller, D., 2000. Tough times for nomads in western China: snowstorms, settling down, Fences and the demise of traditional nomadic pastoralism. Nomadic Peoples 4 (1), 83–109.
Niu, K.C., Zhang, S.T., Fan, B.B., Du, G.Z., 2010. Linking grazing response of species abundance to functional traits in the Tibetan alpine meadow. Plant Soil 330, 215–223.
Olff, H., Ritchie, M.E., 1998. Effects of herbivores on grassland plant diversity. Trends in Ecology and Evolution 13, 261–265.
Ostrom, E., 1990. Governing the Commons: the Evolution of Institutions for Collective Action. Cambridge University Press.
Peters, Pauline, 1997. Dividing the Commons: Politics, Policy and Culture in Botswana. University of Virginia Press.
Reed, M.S., Dougill, A.J., Baker, T.R., 2007. Participatory indicator development: what can ecologists and local communities learn from each other? Ecological Application 18 (5), 1253–1269.
Sheehy, D.P., Miller, D., Johnson, D.A., 2006. Transformation of traditional pastoral livestock systems on the Tibetan steppe. Secheresse 17 (1–2), 142–151.
St. Martin, K., 2001. Making space for community resource management in fisheries. Annals of the Association of American Geographers 91 (1), 122–142.
Taylor, J.L., 2006. Negotiating the grassland: the policy of pasture enclosures and contested resource use in Inner Mongolia. Human Organization 4 (65), 374–386.
Turner, M., 1993. Overstocking the range: a critical analysis of the environmental science of Sahelian pastoralism. Economic Geography 69 (4), 402–421.
Wang, J.B., Wang, Z.G., Lu, H., 2008. Climate background analysis of grassland degradation in the Yellow River important water source supply area. Pratacultural Science 25 (4), 23–27 (in Chinese).
Westhoff, V., Van Der Maarel, E., 1978. The Braun Blanquet approach. In: Whittaker, R.H. (Ed.), Classification of Plant Communities. Junk, The Hague, pp. 297–399.
Williams, D.M., 1996. Grassland enclosures: catalyst of land degradation in Inner Mongolia. Human Organization 55 (3), 307–312.
Williams, D.M., 2002. Beyond Great Walls: Environment, Identity and Development on the Chinese Grasslands of Inner Mongolia. Stanford University Press, Stanford.
Wu, N., Richard, 1999. The privatization process of rangeland and its impacts on pastoral dynamics in the Hindu-Kush Himalaya: the case of Western Sichuan, China. In: Eldridge, D., Freudenberger, D. (Eds.), People and Rangelands: Building the Future. Proceedings of the VI International Rangeland Congress, pp. 14–21.
Yan, Z.L., Wu, N., 2005. Rangeland privatization and its impacts on the Zoige wetland on the Eastern Tibetan Plateau. Journal of Mountain Science 2 (2), 105–115.
Yan, Z.L., Wu, N., Dorij, Y., Jia, R., 2005. A review of rangeland and privatization and its implication in the Tibetan Plateau, China. Nomadic Peoples 9 (1–2), 31–51.
Yang, S.Y., 2010. From Grassland Contraction to Integration (in Chinese). http://www.wyzxsx.com/index.php?m=content&c=index&a=show&catid=60&id=5310.
Yang, Y.Y., 2012. The Effects of Different Grazing Modes on Grassland of Degradation on the Qinghai Tibetan Plateau—a Case Study From Maqu County. Unpublished Master's thesis. Lanzhou University (in Chinese).
Yeh, E.T., 2003. Tibetan range wars: spatial politics and authority on the grasslands of Amdo. Development and Change 34 (3), 499–523.
Yeh, E.T., 2009. Greening western China: a critical view. Geoforum 40, 884–894.
Yeh, E.T., Gaerrang, 2011. Tibetan pastoralism in neoliberalising China: continuity and change in Gouli. Area 43 (2), 165–172.
YontenNyima, 2012. From 'Retire Livestock, Restore Rangeland' to the Compensation for Ecological Services: State Interventions into Rangeland Ecosystems and Pastoralism in Tibet. Unpublished PhD dissertation. Department of Geography, CU Boulder.