Do formal, community-based institutions improve rangeland vegetation and soils in Mongolia more than informal, traditional institutions?

Robin S. Reid[1,2,3], Chantsallkham Jamsranjav[4,5], María E. Fernández-Giménez[4,6], Jay Angerer[7], Altanzul Tsevlee[8], Baasandorj Yadambaatar[9], Khishigbayar Jamiyansharav[4,10], Tungalag Ulambayar[4,11]

[1]Dept of Ecosystem Science and Sustainability, Colorado State University
[2]Center for Collaborative Conservation, Colorado State University
[3]<Robin.Reid@colostate.edu>
[4]Dept of Forest and Rangeland Stewardship, Colorado State University
[5]<jchantsaa@yahoo.com>
[6]<Maria.Fernandez-Gimenez@colostate.edu>
[7]Texas A&M University, <jangerer@brc.tamus.edu>
[8]Nutag Action Research Institute, <tse_zulaa@yahoo.com>
[9]Land Use Division, Institute of Geo-Ecology, Mongolian Academy of Science, <baasandorj_ya@yahoo.com>
[10]<jkhishig@gmail.com>
[11]<tungaa@rams.colostate.edu>

ABSTRACT

Since the 1990's, herding communities across Mongolia have established over 2000 community-based rangeland management (CBRM) organizations to improve livestock grazing management and reverse perceived declines in rangeland (grassland) productivity. Here, we compare the vegetation and soils of rangelands managed by these formal community-based herder groups (CBRM) with those managed by informal traditional neighborhoods (non-CBRM) in four ecological zones across Mongolia. A companion study shows CBRM used both traditional and innovative rangeland management practices more often than traditional neighborhoods. We hypothesized that this should then result in better rangeland vegetation and soils in CBRM-managed than non-CBRM managed rangeland. We sampled vegetation and soils in winter pastures around 143 livestock camps or water points in *soum*s (counties) with and without CBRM management. We explicitly controlled for grazing intensity by sampling plots along grazing gradients at 100, 500 and 1000 m from these impact points. At each 50 x 50 m plot (n=428) we sampled standing biomass, plant cover, basal gap, species richness, forage quality, and soil and site characteristics. We also compared paired time series of MODIS NDVI data in counties with and without CBRM organizations from 2000-2014 to quantify changes in length of the growing season, and current and previous season greenness (a proxy for biomass accumulation). We then analyzed all data using general linear models and χ^2 tests.

CBRM had surprisingly few and subtle impacts on vegetation and soils in Mongolia's rangelands, whether measured in the field or by remote sensing, compared with areas managed by more traditional neighborhood groups. Some CBRM pastures supported

more litter biomass, plant connectivity and less soil erosion, and a lower abundance of grazing tolerant or annual plant species than non-CBRM pastures in some ecological zones. CBRM management appears to modestly improve vegetation condition in the steppe than other ecological zones. At the *soum* level, we could see no differences in the length of the growing season, current season greenness or current and previous season greenness of the vegetation over the 15 years from 2000-2014. We did find, however, that herding families that participate in CBRM groups hold more livestock, sometimes twice as many, in 3 of the 4 ecological zones. This suggests that CBRM management may be having more impact on pastures than our data show, since these pastures can support more livestock without losing rangeland vegetation abundance and soil retention capacity.

Keywords: Community-based rangeland management, NDVI, biomass, forage quality

INTRODUCTION

Since the 1990's, herding communities across Mongolia have established over 2000 community-based rangeland management (CBRM) organizations to improve livestock grazing management and reverse perceived declines in rangeland productivity (Mau and Chantsallkham, 2006; Fernandez-Gimenez et al., 2014). Here, our objectives were to compare the vegetation and soils of rangelands managed by formal community-based herder groups (CBRM) with those without such formal management (non-CBRM) across Mongolia. Our other work (Ulambayar, 2015) suggests that CBRM groups used both traditional and innovative rangeland management practices more often than traditional neighborhoods. We hypothesized that this should then result in more vegetation abundance and soil retention capacity in CBRM-managed than non-CBRM managed rangeland.

STUDY SITES

Our goal was to sample vegetation and soils across Mongolia and compare CBRM effects in four ecological zones: mountain and forest steppe (MFS), eastern steppe (ES), steppe (S), and desert steppe (DS). We sampled vegetation and soils at 143 winter camps or water points in 36 paired *soum*s (or counties), 18 *soum*s with formal CBRM organizations and 18 with informal, traditional neighborhoods across these 4 ecological zones.

METHODS

Our design explicitly controlled for grazing intensity and production potential by sampling plots along grazing gradients at 100, 500 and 1000 m from livestock winter camps or water points and by placing these grazing gradients on similar landforms and soils (or ecological sites). At each 50 x 50 m plot (n=428) we sampled standing biomass, plant cover, basal gap, species richness, plant gap sizes, plant palatability, forage quality, connectivity of plant patches, evidence of surficial soil movement and site characteristics in 2011 and 2012. We also compared paired time series of MODIS NDVI data (vegetative greenness) at a 250 m spatial resolution (MOD13A1) in *soums* with and without CBRM organizations from 2000-2014 to quantify changes in vegetation greenness and seasonality. We used TIMESAT software (Eklundh and Jonsson, 2009) to calculate green-up and brown-down dates (and thus growing season length), current season NDVI, and current and previous season NDVI. We then analyzed all data using model type III ANOVA in SAS 9.3 software using both log and arcsine transformations to correct for non-normality of data. We use conservative p-value interpretation ('significant' = $p<0.01$,

'near significant' (NRS*)= p□0.01 and <0.05 and not significant (NS) = p≥0.05) in our results, because of our large number of dependent variables.

RESULTS AND COMMENTS

Overall, both grazing and ecological site, measured at the scale of each winter camp, had more impact on vegetation and soils than did community-based management. This is expected since we purposely measured along a strong grazing gradient and soils often have strong effects on vegetation productivity.

CBRM had surprisingly few and subtle impacts on vegetation and soils of Mongolia's rangelands, whether measured in the field or by remote sensing, compared with areas managed by more traditional neighborhood groups (Table 1; Chantsallkham, 2015). There were no fully significant ($p<0.01$) differences in total standing biomass, total cover and functional group biomass, species richness, forage quality, growing season length, or current (or previous) season greenness comparing between CBRM vs non-CBRM-managed pastures. Generally, CBRM pastures were had slightly more litter biomass (ES only), more plant connectivity (MFS, S, Figure 1) and less soil erosion (MFS) in some ecological zones, and lower abundance of a grazing tolerant grass (MFS), a grazing tolerant sedge (ES) and an annual grass species (DS). We included plant connectivity since it is probably directly related to soil erosion and showed some of our most significant effects. In the desert steppe, our results are contradictory, where CBRM pastures had smaller open gaps between perennial plants, but less connected plant patches and more soil erosion (Table 1). If we include near significant effects, the largest impacts occurred in the steppe, where pastures managed by CBRM groups supported more shrub, litter and standing dead vegetation biomass and litter cover than pastures managed by traditional neighborhoods.

There were few significant interactions among our three main effects of CBRM, grazing and ecological site (grazing effects are covered in another paper at this conference). In general, CBRM pastures sometimes had stronger and declining grazing gradients than non-CBRM pastures. And, some plant species responded differently to the two management types on clayey compared to rocky soils.

At the *soum* level, CBRM *soums* were not different from non-CBRM based on remote sensing data. Hence, there was no difference in the length of the growing season, current season vegetative greenness or current plus previous season greenness.

DISCUSSION AND IMPLICATIONS

This is the first study, to our knowledge, to assess the effectiveness of CBRM across all of Mongolia's major ecological zones. Our results suggest that traditional neighborhood groups are almost as able to maintain the vegetation and soils of Mongolian rangelands as formal community-based rangeland groups, ranging from the southern desert steppe (Gobi) to the northern forest steppe. Our field and remote sensing results consistently show few differences in the two management types. For the desert steppe, our results support another Gobi field study (Addison et al., 2013), which showed little impact of CBRM groups, but they contradict a Gobi remote sensing study, which showed 11% greater full season NDVI in pastures managed by CBRM groups (Leisher et al., 2012).

We temper these conclusions with two caveats. First, in 3 of our 4 zones (MFS, ES, and S), we recorded livestock herd sizes at each of our sampled winter camps in a companion study (Ulambayar, 2015). There were more livestock (all species, measured as sheep forage units) at CBRM than non-CBRM winter camps in the MFS (54% more), eastern steppe (13% more) and steppe (135% more); but there were 30% fewer livestock in the desert steppe at CBRM camps (Chantsallkham, 2015). Thus, it is remarkable that CBRM pastures near the camps in all zones but the desert steppe had similar vegetation

and soils to winter camps with smaller livestock herds managed by families in traditional neighborhoods. We cannot be sure that CBRM families always hold larger livestock herds than non-CBRM families over the long term at these winter camps, but they did in 2011 and 2012 when our team conducted livestock surveys.

While the families hold larger livestock herds at CBRM winter camps, their families were also larger, meaning that per capita livestock holdings were not different comparing the two management types (Ulambayar, 2015). This tells us that CBRM families are not wealthier than non-CBRM families (Ulambayar, 2015).

Second, our data suggest some subtle improvements in pastures under CBRM compared with non-CBRM management, particularly through different litter amounts, indicator species abundances, plant patch connectivity and surficial soil erosion. This may suggest that CBRM groups need to improve their management to significantly affect rangeland vegetation abundance and soil retention capacity and that the effects of CBRM management may take a long time to affect Mongolian rangelands.

ACKNOWLEDGEMENTS

We thank the many herder families who welcomed us into their *gers* and out onto their pastures during this research. We also thank our kind co-researchers in the Mongolia and the US, who contributed many hours in the field and thoughtful comments about this research.

This material is based upon work supported by the National Science Foundation under CNH Program Grant No. award BCS-1011 *Does Community-based Rangeland Ecosystem Management Increase the Resilience of Coupled Systems to Climate Change in Mongolia?* Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

REFERENCES

Addison J, Davies J, Friedel M, Brown C. (2013). Do pasture user groups lead to improved rangeland condition in the Mongolian Gobi Desert? *Journal of Arid Environments,* 94, 37-46.

Chantsallkham J. (2015). *How and why are Mongolian rangelands changing?* Ph.D. dissertation, Department of Forest and Rangeland Stewardship, Colorado State University.

Eklundh L, Jonsson P. (2009). *Timesat 3.0 Software Manual*. Lund University, Sweden.

Fernandez-Gimenez ME, Batkhishig B, Batbuyan B, Ulambayar T. (2014). Lessons from the dzud: Community-based rangeland management increases adaptive capacity of Mongolian herders to winter disasters. *World Development*, 68, 48-65.

Leisher C, Hess S, Boucher TM, van Beukering P, Sanjayan M. (2012). Measuring the impacts of community-based grasslands management in Mongolia's Gobi. *PloS ONE*, 7, e30991 [doi:30910.31371/journal.pone.0030991].

Mau G, Chantsallkham J. (2006). *Herder Group Evaluation UN Development Program*. Ulaanbaatar, Mongolia.

Ulambayar T. (2015). *Social outcomes of community-based rangeland management in post-socialist Mongolia: Causal factors and favorable institutional designs*. Ph.D. dissertation, Department of Forest and Rangeland Stewardship, Colorado State University.

Table 1. Significance and direction of ANOVA tests comparing vegetation (ANOVA) and soils (χ^2) characteristics in winter pastures in CBRM and non-CBRM *soum*s in each ecological zone. NS = p≥ 0.05; NRS* = p≥ 0.01 and <0.05 (near significant). Non = winter pastures with informal, traditional management but no formal CBRM management.

Variable	Mountain and forest steppe	Eastern steppe	Steppe	Desert steppe
Total green biomass	NS	NS	NS	NS
Grass biomass	NS	NS	NS	NS
Forb biomass	NS	NS	NS	NS
Sedge biomass	NS	NS	NS	NS
Shrub biomass	NS	NS	**NRS***	NS
Litter biomass	NS	**CBRM>Non**	**NRS***	NS
Standing dead biomass	NS	NS	**NRS***	NS
Total foliar cover	NS	NS	NS	NS
Grass cover	NS	NS	NS	NS
Forb cover	NS	NS	NS	NS
Sedge cover	NS	NS	NS	NS
Shrub cover	NS	NS	NS	NS
Litter cover	NS	NS	**NRS***	NS
Standing dead cover	NS	NS	NS	NS
Perennial grass cover	NS	NS	NS	NS
Annual grass cover	NS	NS	NS	**Non>CBRM**
Dominant species cover	***Cleistogenes squarrosa,*** **Non>CBRM**	***NRS*, Carex duriuscula,*** **Non>CBRM**	***Kochia prostrata,*** **CBRM>Non**	***Eragrostis minor,*** **Non>CBRM**
Gap size	NS	NS	NS	***NRS*, Non>CBRM***
Species richness	NS	NS	NS	NS
Crude protein	NS	NS	NS	NS
Acid detergent fiber	NS	NS	NS	NS
Plant patch connectivity	**CBRM>Non**	NS	**NRS*, CBRM>Non**	**Non>CBRM**
Soil erosion	**Non>CBRM**	NS	NS	**CBRM>Non**
Total current season NDVI (*soum* level)	NS	NS	NS	NS
Total season-to-season NDVI (*soum* level)	NS	NS	NS	NS
Length of growing season (*soum* level)	NS	NS	NS	NS

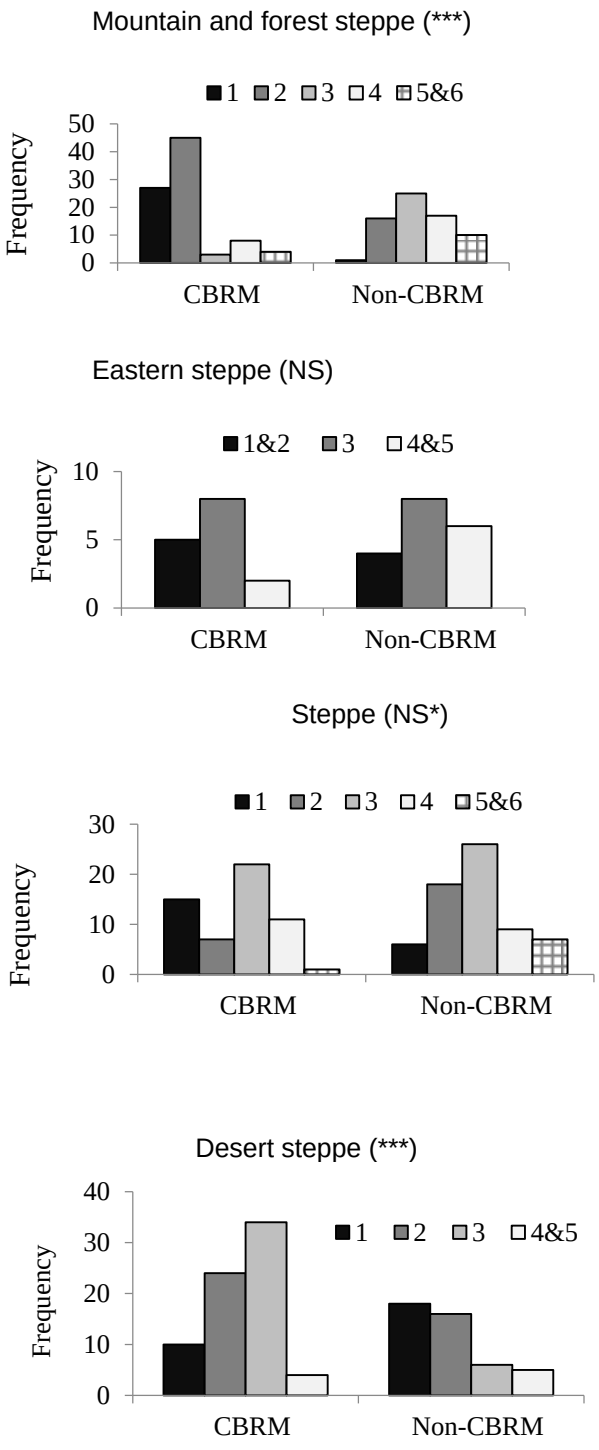

Figure 1. Frequency distribution of the connectivity of plant patches at a plot scale in the mountain and forest steppe, eastern steppe, steppe and desert steppe. Low values are highly connected patches, while high values indicate low connectivity. Zone results are significantly different with NS* = p<.05, ** = p<.01, and *** = p<.001, based on a χ^2 test. NS=Not significant.