Results of Assessment of the Current Status and Degree of Disturbance of the Desert-Steppe Rangelands of Western Mongolia

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Abstract

Concern about the status of Mongolia's rangelands has increased due to dramatic increases in livestock populations of this country during the past 18 years. The objective of this study was to document the current status and degree of disturbance of the desert-steppe rangelands of western Mongolia. A total of 123 rangeland monitoring sites representing 33 million hectares (21 % of total country area) were established and inventoried in July/August 2008. Overall, our study indicated that 82.9% of the dessert-steppe rangelands, consisting of 27.36 million hectares, have been degraded to some extent. The degree of degradation varies; slight 26%, moderate 30.9%, severe 13.8% and very severe 12.2% of total the area. In conclusion, in addition to natural factors several specific human-driven causes, such as animal husbandry have led to widespread disturbance in Mongolian desert-steppe rangelands.

Introduction

Mongolia is a land-locked country located between 87°41″ and 119°56″ east longitude, and 41°35″ and 52°09″ north latitude in the central region of north-east Asia (Tsegmid and Vorobiev, 1999). It has a population of 2.6 million people in an area of 1.56 million km^2, with considerable potential for agricultural production, primarily through extensive livestock pastoral grazing. The territory of Mongolia as a whole is characterized by great diversity and can be separated into several agro-ecological regions and sub-regions with significantly different environments and vegetation cover which provide different agricultural and livestock production potentials (Jigjidsuren and Johnson, 2003). The main ecological regions are: Hangai-Hovsgul, Selenge-Onon, Central and Eastern Steppe, Gobi Desert Region, and Mongolian Altai Region (Johnson et al., 2006). The Altai Region, located in western Mongolia includes two districts. The first includes the Mongolian Altai stretching from the north-west to the south-east for more than 1500 km. The second district comprises the Turgen Mountains and Lake Ureg-Nur. The Altai Region's elevation ranges between 1500 and 4000 m (Tsegmid and Vorobiev, 1990). The mean annual temperature is between -2.5ºC and 5.0ºC with low temperature of -24ºC in January and high temperature of 22ºC in July; between 60-120 frost free days, and precipitation between 400

and 500 mm (Batjargal, 1996). Snow depth ranges between 5 to >15 mm and wind speed can occur between 2 and 6 m/sec (Tsegmid and Vorobiev, 1990). The Mongolian Altai north-eastern slopes have a desert steppe and desert ecosystem (western Mongolian desert steppe) (Gunin, 1999).

Western Mongolian desert-steppe rangelands play an important role in the Mongolian economy. An annual precipitation ranging from less 50 mm in the south to over 150 mm at upper elevations in the west creates an arid to semiarid shrub-dominated environment. This gradient generates correspondingly large differences in plant production. Concern about the status of Mongolia's rangelands has increased due to dramatic increases in livestock populations during the past 18 years. Between 1990 and 2007, the number of domestic animals increased to an estimated 43.3 million head of livestock (Monthly Bulletin of Statistics, 2008.). An overall decline in net primary productivity has been observed with increasing signs of localized degradation, including both plant community changes and increased soil erosion. The aim of this study was to document the current status and degree of disturbance of the western Mongolian desert-steppe rangelands. Our specific research objectives were 1) to document plant communities sampled along gradients of desert-steppe zones of western Mongolia, 2) evaluate current rangeland conditions, 3) to establish permanent monitoring sites. A further objective was to develop reference site descriptions in the desert-steppe rangelands of the western Mongolia.

Materials and Methods

The study area was the desert steppe ecosystem type of western Mongolia, in Khovd and Uvs Aimag (province). This ecosystem is the largest rangeland type in this area (Buyan-Orshih, 1981; Gunin, 1999). Based on the environmental factors of slope, elevation, soil type, or soil moisture content, and vegetation, we stratified the sampling area into 5 habitats: 1) depression, 2) lower slopes of a mountain (lower slopes), 3) river flood plains, 4) mountain steppe and 5) valley. Permanent monitoring sites were established and a survey was conducted from mid July to late August 2008. In total 123 monitoring sites were spread throughout the 5 habitats (Fig. 1). We established and sampled 18, 10, 56, 18, and 21 monitoring sites for depression, lower slopes, river flood plains, mountain steppe, and valley habitat, respectively.

Establishing Monitoring Sites

In the selection of monitoring sites, local (soum and bag) governors and herders were consulted to determine the most appropriate resource management area for the survey. We also considered herders' mobility and camp locations in the research area. We were able to cover the pastures for all seasons, including winter, transitional or spring/autumn, and summer ranges. These permanent monitoring sites were spread between 91°18'23.1" and 93°21'49.0" of eastern longitude, and 45°06'49.0" and 50°46'41.8" of the northern latitude. All monitoring sites were marked with the geographical positions enabling investigators to use them as long term permanent monitoring sites, as well as for short and mid term research purposes. Each monitoring site was permanently marked using stakes and documented with photographs.

Rangeland Survey

At each monitoring site, three sampling plots were oriented along cardinal directions from the center of the monitoring point (25 meter paces each direction). The vegetation was surveyed using the Braun-Blanquet cover scale: (+) a limited number of individuals; (1) vegetation cover

< 5 %; (2) vegetation cover between 5 and 25 %; (3) vegetation cover between 25 and 50 %; (4) vegetation cover between 50 and 75 %; and (5)vegetation cover > 75 % (Braun-Blanquet, 1932). The plot size was 1 m^2.

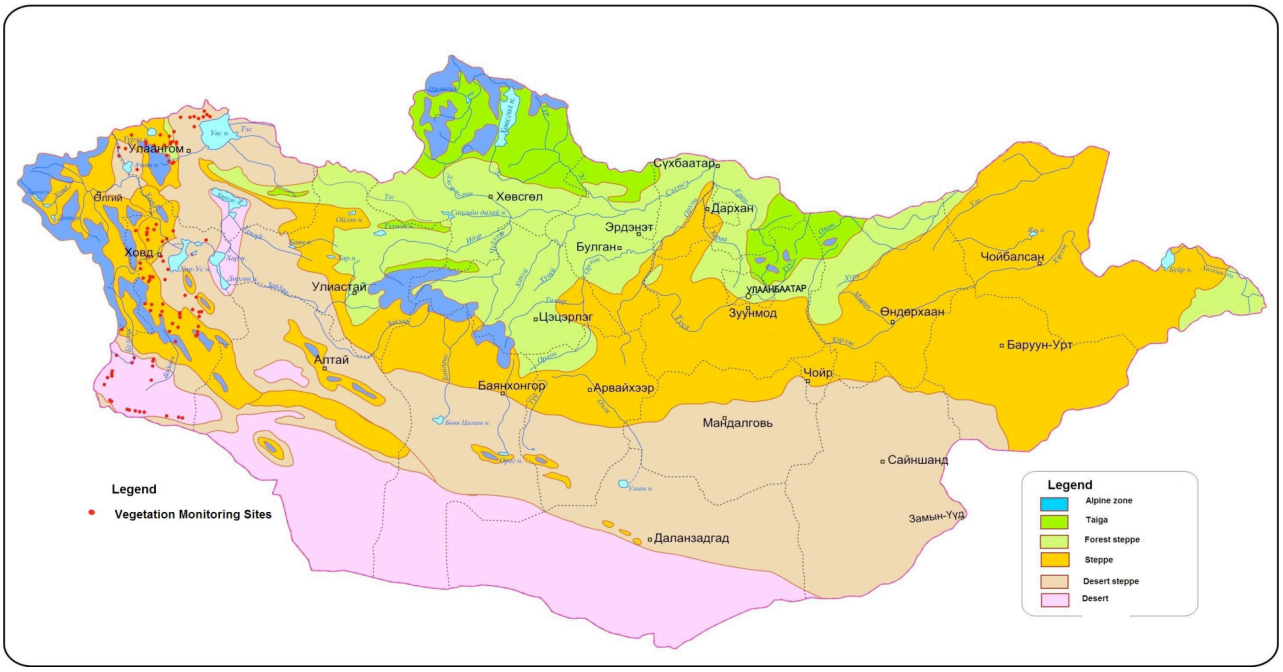

Figure 1: Map of Mongolia showing survey sites

Standing Crop

After the canopy cover survey, all vegetation within the rectangular frame (1 m^2) was clipped at ground level. All clipped samples were separated by live and dead materials, the latter of which was discarded. Live material (standing crop) was further separated by growth form, oven dried at 60°C for 48 h, weighed, and expressed in kg/ha. Total standing crop of a monitoring site was determined by summing the above ground biomass of all growth forms removed from each plot. Nomenclature of plant species follows Ulziikhutag (1984).

Evaluation of Current Status and Disturbance Level

Numerous physical, chemical and biological indicators of the current desert steppe rangeland status can be measured in various compartments and at various spatial and temporal scales of the ecosystem. Among them, plant species composition is the key indicator of rangeland health (Adams et al., 2005). Therefore, in order to make inferences on the health/condition of rangelands it is increasingly common to pay more attention to the dominant plant species of a surveyed area. As a rapid assessment, we compared the similarity of 6 dominant plant species for each monitoring site to 6 dominant plant species of their reference/healthy counterpart using Kulcyznski's similarity index (Oosting, 1956). For each indicator species, abundance was estimated using a two-tiered qualitative classification scheme (presence/absence). If the similarity index was 100-80, 80-67, 67-50, 50-29, 29.0-0.0, current status of sites were considered as normal, slight, moderate, severe, and very severely disturbed.

Key Indicator Species by Ecotypes

In the area, where this study was conducted, established reference sites or detailed description of reference sites were lacking. Therefore published materials (Gubanov, 1996; Gunin et al., 1999; Jigjidsuren and Johnson, 2003; Tserendash and Altanzul, 2006) of related studies were the main references to develop reference sites or indicator species from healthy ecotypes, as well as our observations from previous and current studies (Damiran, 2005; Ariunsuren, 2006). Indicator plant species for healthy ranges were selected as follows:

Depression: Selected species or key species for six functional groups included *Eurotia ceratoides* (L.) C. A. Mey., *Suaeda kossinskyi* Iljin. or *Suaeda heterophylla* (Kar. et Kir.) Bge., *Reaumuria soongorica* (Pall.) Maxim. or *Salsola spp*., *Agrophyron cristatum* (L.) P. B., *Nanophyton grubovii* Pratov., *Cleistogenes squarrosa* (Trin.) Keng. and *Caragana spp*. Healthy sites vegetation canopy cover ranges from 41-50%.

Lower slopes: Healthy site key species are: *Stipa Krylovii* Roshev., *Agrophyron cristatum* (L.) P. B.or *Koeleria cristata* (L.) Pers., *Artemisia frigida* Willd., *Potentilla spp., Ephedra* spp. *Heteropappus altaicus* (Wiild.) Novopokr. and *Convolvulus Ammanii* Desr. dominated. Canopy coverage is 41-50%.

River flood plains: In the river flood plains of desertified steppes, the fine succession series are dominated by *Carex duruiscula* C. A. Mey., *Halerpestes salsuginosa* (Pall ex Georgi.) Greene., *Glaux maritima* L., *Saussurea amara* (L.) DC., *Plantago salsa* Pall., *Oxytropis salina* Vass., *Iris lacteal* Pall., and *Suaeda corniculata* (C. A. Mey.) Bge.. Rangeland sites vegetation canopy cover could range between 81 to 100%.

Mountain steppe: The mountain steppe is dominated by crested wheatgrass (*Agrophyron cristatum* (L.) P. B.), *Stipa Krylovii* Roshev., *Festuca lenensis* Drob., *Poa attenuata* Trin., Junegrass (*Koeleria cristata* (L.) Pers.) and *Carex pediformis* C.A. Mey. (Bedunah, Schmidt, 2000). Further, forb-sedge (*Carex duriuscula* C. A. Mey. and *C. stenophylloides* V. Krecz.), grass-forb (*Agrophyron cristatum* (L.) P. B., *Stipa Krylovii* Roshev., *Poa attenuata* Trin., *Poa altaica* Trin., *Koeleria cristata* (L.) Pers., *Koeleria altaica* (Domin.) Kryl.), and fescue mountain steppe (*Festuca lenensis* Drob.) are the dominant communities in this habitat. In the mountain steppe, the expected level of canopy cover would be in the range of 81 to 100%.

Valley: In the valley of western Mongolian desert steppe *Anabasis brevifolia* C.A.Mey, *Allium polyrrhyzum* Turcz. ex Rgl., *Stipa gobica Roshev*., *Salsola passerina* Bge., *Reaumuria soongorica* (Pall.) Maxim., and *Ajania fruticulosa* (Ledeb.) Poljak. are key plant species. Vegetation cover of healthy rangelands should be in the range 21-25%.

Results and Discussion

During the 2008 survey, a total of 110 species which belong to 60 genera, and 22 families were identified among the monitoring sites. In total, 41 plant community types were distinguished. The standing biomass range was 2.4-33.8 $kg \cdot ha^{-1}$, 3.6-34.1 $kg \cdot ha^{-1}$, 57-93 $kg \cdot ha^{-1}$, 2.4-14.3 $kg \cdot ha^{-1}$, and 2-38.0 $kg \cdot ha^{-1}$ for the depression, lower slopes, river flood plains, mountain steppe, and valley habitat respectively. An average number of plant species were 6, 5, 4, 5, and 4 for the

depression, lower slopes, river flood plains, mountain steppe, and valley habitat respectively. Based on the current study, a range of vegetation canopy coverage by rangeland health category and by habitat in desert steppe of western Mongolia is reported (Table 1). This study also found that 16 monitoring sites were in a healthy condition. Whereas 40, 35, 21, and 11 monitoring sites are slight, moderate, severe, and very severely disturbed, respectively. Habitats differed in vegetation canopy cover between sites for different rangeland health categories.

Table 1. Vegetation Canopy Coverage (%) by 6 Habitats of the Desert-steppe Rangelands of Western Mongolia

Rangeland Health Categories	Habitats					
	Depression	Flood Plains		Valley	Lower Slope	Mountain Steppe
		river plain	salt-marsh			
Healthy	41-50	81-100	41-50	21-25	41-50	81-100
Disturbed						
Slight	31-40	60-80	31-40	16-20	31-40	61-80
Moderate	21-30	40-59	21-30	11-15	21-30	41-60
Severe	11-20	20-39	11-20	6-10	11-20	21-40
Very severe	0-10	0-19	0-10	0-5	0-10	0-20

Variation in the rangeland disturbance level was found between habitats (Table 2). The most pronounced degrading of vegetation succession in the flood plains of western Mongolia are caused by excessive grazing. Hydromorphic vegetation succession changes can be observed in the desert steppe when small ponds are drying up and turning into meadow saline soil depressions. In the most hydrophilous reed stands (*Achnatherum splendens* + *Phragmites austalis*), the shore developed a halohydromorphic community with *Achnatherum splendens* (Trin.) Nevski., *Phragmites austalis* (Cav.) Trin ex Steud., *Hordeum Bogdanii* Wilensky., *Puccinella Hauptiana* V. (Krecz.) Kitag., *Halerpestes salsuginosa* (Pall. ex Georgi.) Greene., *Oxytropis salina* Vass. and *Potentilla* spp. This survey revealed that the most pronounced degrading of vegetation succession in the flood plains of western Mongolia is caused by excessive grazing.

Table 2. Rangeland Disturbance Level in Six Habitats of the Desert-steppe Rangelands of Western Mongolia

Rangeland Health Categories[1]	Habitats					
	Depression	Flood Plains		Valley	Lower Slope	Mountain Steppe
		river plain	salt-marsh			
Healthy	1	2	2	5	2	4
Disturbed						
Slight	8	1	1	13	7	10
Moderate	6	2	0	18	3	6
Severe	1	1	1	12	5	1
Very severe	2	-	-	8	1	-
n	18	6	4	56	18	21

[1]Rangeland health categories based on similarity index (Oosting, 1956) of dominant species to reference site indicator species and vegetation inventories surveyed by Braun-Blanquet, (1932) methodology. If similarity index was 100-80, 80-67, 67-50, 50-29, 29.0-0.0, current status of sites were considered as normal, slight, moderate, severe, and very severely disturbed.

Conclusions and Implications

In conclusion, a combination of natural factors and several specific human-driven factors, including vehicular traffic and especially animal husbandry, are the driving forces for widespread disturbance in dessert-steppe rangelands of western Mongolia. Established permanent monitoring sites will provide reference material and a benchmark of the desert-steppe rangeland of western Mongolia for future investigators and managers. Revisiting past studies for comparative analysis will provide information useful for establishing pastureland ecological conditions and trends. This is especially important in the desert steppe of western Mongolia where significant changes are happening and may soon accelerate due to the development of mineral resources.

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