Describing ecological potential and ecological states of rangeland to support livestock management in Mongolia

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Abstract. Perception of rangeland degradation in Mongolia and its causes are well known but herders and policy makers lack clear messages on how much rangeland is degraded, whether is it reversible, and what management changes should be implemented. This paper illustrates a portion of our ongoing efforts to develop ESDs that can be used at the grass roots level as management tools. At the Undurshireet soum study site, which is split mainly into Gravelly, Loamy, Sandy, and Deep sandy ecological sites, rangeland community shifts in Gravelly and Loamy ecological sites are interpreted as reversible shifts in species composition or species proportion within the states, indicating that a change to grazing management may be effective for restoration of desired conditions. Sandy and Deep sandy ecological sites in this area are at high risk of erosion and may be more difficult to restore.

Keywords: Rangeland degradation, ecological potential, ecological site description, state and transition model

Introduction

Statistics show that one-third of all Mongolian's lives are directly dependent on pastureland, indicating that rangeland has high value from the ecological, economic and social perspectives of this country. Drastic changes in Mongolian nomadic lifestyles in the past two decades require that evidence-based policies and management tools be implemented at the grass roots level. Some estimates report that as much as 70% of Mongolian rangeland is degraded. Herders are waiting for tools to enable them to say how much rangeland is degraded, whether is it reversible, and what management changes should be implemented.

Concurrently, the Government needs an appropriate tool for linking rangeland monitoring to sound management and decision making. Ecological site descriptions (ESDs) and the state and transition models are synthetic concepts that communicate the ecological potential of a distinct land area (the ecological site) and the alternative states or plant community variants within states, and the causes of shifts among them, observed on an ecological site (the state and transition model). Rangeland use agreements made between pasture users groups and the local government can include information on the reference state/ ecological potential of their grazing area, the current state or conditions at the time agreement is established, the consequent recommendations for grazing management, and expectations for subsequent change (*e.g.*, what rangeland attributes should improve or be sustained). Importantly, this approach provides local government with vital information to design enforcement mechanisms to improve rangeland functions and support and reward those who sustain desired rangeland condition. As yet, however, there are few examples of ESD development in Mongolia. In this paper, we describe a portion of our ongoing efforts to develop ESDs that can be used in the development of pasture use agreements. Specifically, we use multivariate analysis of soil profile properties to suggest conceptual divisions for ecological sites and then develop concepts and management interpretations for those site classes.

Site description

Undurshireet soum of Tuv aimag is located in the centre of Mongolia (Fig. 1). The northern areas of this steppe region, representing 34% of the total area of Mongolia, have relatively low annual precipitation (220 mm), are dominated by perennial grasses and shrubs and are generally referred to as dry steppe. Temperatures show a high variability, with the average temperature in the coldest month (January) being -17.1^{o}C and in the warmest month (July) being 20.3^{o}C. Due to livestock privatization and also the geographical location being closer to market, the livestock number in sheep units has doubled and the number of animals per ha has increased from 0.56 to 1.20 in past 5 years.

Plots sampled in the Undurshireet soum area were predominantly Loamy, Gravelly, and Sandy/Deep sandy ecological sites and their relationship to the ordination is shown in Figure 2. Based on vegetation survey from sites, expert workshops, questionnaires from herders and a literature review we used the ESD concept for this region

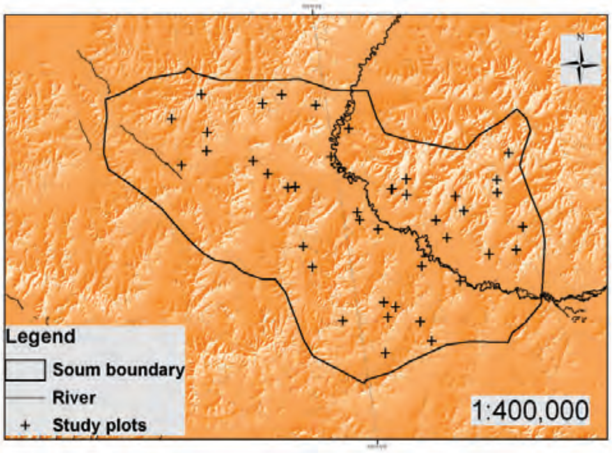

Figure 1. Sampling sites in Undurshireet

Table 1. Component matrix of PCA with factor loadings of 1 environmental variables

Variable	Eigenvector	
	1	2
Slope	-0.2336	0.8378
Clay B	0.5452	0.1543
Rock A&B	-0.2910	0.8077
Sand_A	-0.8736	-0.3138
Silt_A	0.6785	0.3205
Sand_B	-0.9271	0.0206
Silt_B	0.8597	-0.1465

as a roadmap for defining or assessing the existing states of soum rangelands having different ecological potential. For example, whether these areas are degraded, if so to what extent, whether degradation is reversible and what management should be recommended. As a part of the ESD concept we drafted the state and transition models for these three common ecological sites based on data, experts and herders knowledge on community changes.

Methods

Staff from the National Agency for Meteorology and Environmental Monitoring were trained to carry out standardised, repeatable measurements of rangeland and soil sampling to update existing monitoring procedures and a National Rangeland Monitoring Database was initiated to house data from 1550 monitoring plots that had been established. A sampling campaign was undertaken in 2009-2011 to record data at existing monitoring sites using new procedures as well as at additional inventory sites, totaling 600 samples across different ecological zones of Mongolia.

Line-point intercept, gap intercept, and soil profile and landscape characterizations were performed at each site following Herrick *et al.* (2005) and Bestelmeyer *et al.* (2009). Recorded soil, vegetation and geomorphological data from different ecological sites and states within the target soums followed the ESD methodology of NRCS, USDA are entered in DIMA program (Data base for Inventory, Monitoring and Assessment).

Based on data from the last three years, plus knowledge and experience from local representatives, we

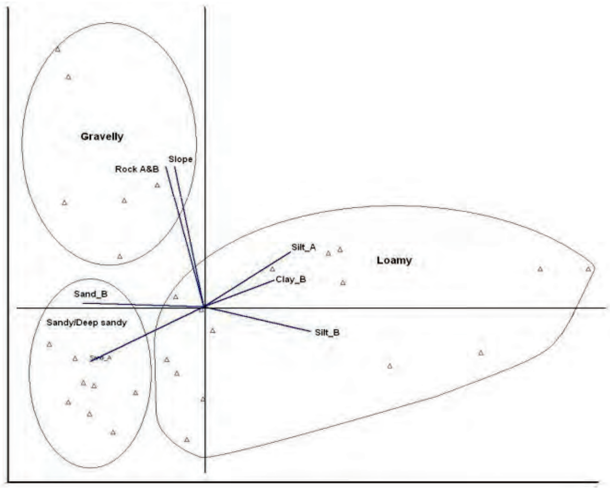

Figure 2. Ordination graph of ecological sites of dry steppe along PCA factor scores (N=29).

developed ecological site concepts for the main ecological zones and state-and-transition models for the most common rangeland communities within those zones.

As an example, we present exploratory analysis of a data set featuring 29 plots in Undurshireet soum. Ordination analysis (Principal Component Analysis (PCA); PCORD 6; Peck 2010) was used to examine the relationships between soil variables (Table 1).

Results and discussion

The PCA extracted three axes that explained 85% of total variance of the environmental data set. Increasing values along the first axis (46% of variance) represent an increase of clay and silt in both the A and B horizons that should be related to increasing soil water holding capacity. The second axis (23%) was related to an increase of gravel and slope percent. Increased gravel and cobble content and slope in the steppe zone are associated with hilly areas resulting in higher rates of water capture. High water availability in rocky areas where runoff is slowed may promote grass community resilience on hills (Zemmrich 2005) but if erosion occurs it can be irreversible.

Plots sampled in the Undurshireet soum area were predominantly Loamy, Gravelly, and Sandy/Deep sandy ecological sites and their relationship to the ordination is shown in Figure 2. Based on vegetation survey from sites, expert workshops, questionnaires from herders and a literature review we used the ESD concept for this region as a roadmap for defining or assessing the existing states of soum rangelands having different ecological potential. For example, whether these areas are degraded, if so to what extent, whether degradation is reversible and what management should be recommended. As a part of the ESD concept we drafted the state and transition models for these three common ecological sites based on data, experts and herders knowledge on community changes.

Loamy ecological site

Vegetation was dominated by *Stipa* communities having Sandy loam surface texture, argillic horizon with >10% clay content in B horizons and calcium carbonate present in

Figure 3. Soil profile in Sandy/Deep sandy ecological site

Figure 4. Grassland with shrub rangeland

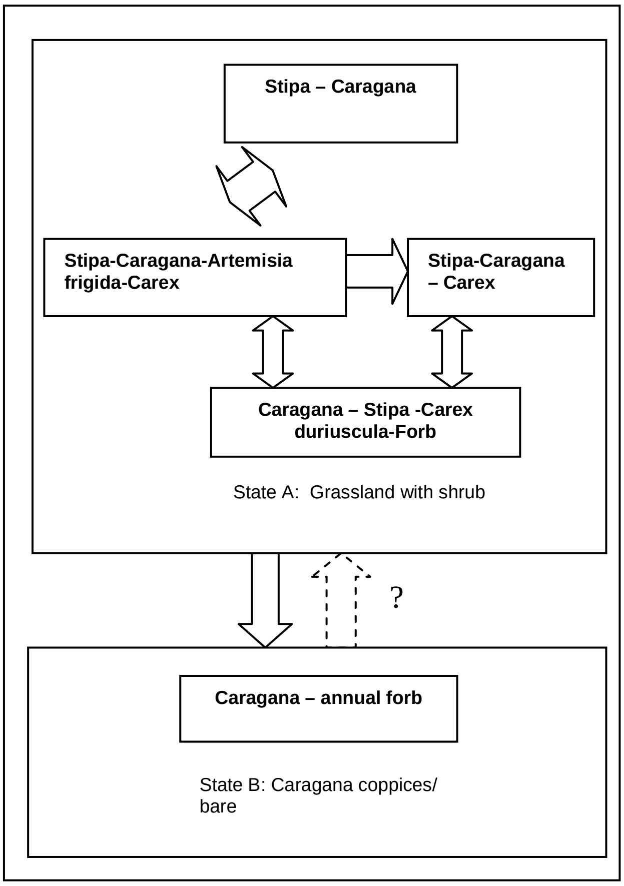

Figure 5. State and transition model for Sandy/ Deep sandy ecological site proposed based on our rangeland inventory data and experts workshop.

the B horizon. Loamy ecological sites occur mainly in upland areas and are usually used for winter and spring pasture in the Undurshireet case where the productivity and species richness is relatively high. According to expert knowledge and our data, livestock grazing can increase *Artemisia frigida* and *Artemisia adamsii* especially near to water points and camps. Recorded vegetation changes are mostly community phase shifts (Bestelmeyer *et al.* 2009) indicating the potential of reversibility through improved management practices.

Gravelly ecological site

Gravelly ecological sites were located on hills higher than 1200 m with slopes greater than 7%. Soil profiles featured >25% rock fragments by volume from 0-50 cm depth, no argillic horizon, and infrequent calcic horizons. *Stipa* dominated communities were common and *Artemisia frigida* and other grass species were subdominants. Very little or no Caragana spp. were observed and xerophytic species such as *Arenaria capillaries* and *Ptilotrichum canescens* were present. This ecological site had the highest species diversity (>8 perennial species) and was grazed mostly in the winter, spring and autumn. Compared to the other two ecological sites the plant communities exhibited less species variability. Like the Loamy ecological site, plant community shifts in Gravelly sites where the key perennial grass species are present in good proportion are interpreted as reversible shifts in species composition or species proportion within the states, indicating that a change to grazing management may be effective for restoration of desired conditions.

Sandy/Deep sandy ecological site

This site type is generally located in the bottom of mountain valleys and flood plains along rivers. Usually no argillic horizon is present or argillic horizons have low clay content (<8%). Calcic horizons are absent (Fig. 3). Vegetation may shift from grassland with shrubs to a shrubland dominated by Caragana coppices (Fig. 4 and 5). In the grassland with shrub state, open spaces between Caragana shrubs are covered by grass and forbs. In the shrubland states, annual forbs are common between coppices and species richness is very low (2-7 perennial species). Being close to rivers, Sandy/Deep sandy ecological sites are commonly summer pastures with the highest grazing pressure for whole growing season. Sandy/Deep sandy ecological sites in this area have a high risk of erosion and undesired plant community change. The reversibility of shifts to coppice dunes is not well understood but community changes are believed to be persistent. Because open spaces between Caragana shrubs are covered by annual forbs in rainy years that leaves a very unstable, erodible sand surface having 4c score of Soil Redistribution Class and “So” Pedoderm Class Indicator in dry years.

Conclusion

Ecological site classifications, state and transition models, and documents to communicate science information to herders and government decision makers may provide a useful tool to prevent persistent degradation and to prioritise and target management actions in Mongolia. In the coming years we will be expanding this work at the community and government level and tailor the approach to the Mongolian setting.

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