Mongolian Journal of Agricultural Sciences, *Vol.17, No.39 (2023)*
https://doi.org/10.5564/mjas.v17i39.3679

Rangeland degradation in the steppe zone of Mongolia

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Received: 01.05.2023 Revised: 25.10.2023 Accepted:02.11.2023

Abstract
Changes in rangeland management practices and global warming are to blame for the degradation of Mongolia's rangelands. Rangelands might deteriorate as a result of the expected repercussions from grazing disturbances, which is likely to make the situation worse [1] The people of Mongolia are aware of the growing degradation of rangelands, that is linked to the confluence of unsustainable behaviors and drought events. On the other hand, little research has been done on how naturally degraded rangelands recover and if restoration is necessary. In order to evaluate the state of rangelands and determine the effects of management methods across Mongolia, this article explores the application of "recovery class" principles in rangeland management. In order to test the recovery in steppe zone, the 25x25 size fence was set up. Outside of the fence was grazed continuously for year-round and comparative study of vegetation in outside and inside was carried. Because of unproper grazing, the productivity and species diversity declines. Also, decline in total and species cover declined. Du to conservative grazing and resting inside of fence, vegetation had a great recovery.

Keywords: rangeland degradation, vegetation transformation, recovery, land tenure, grazing.

Introduction

Mongolia is one of the world's biggest landlocked countries, with 1,564,000 square kilometers [3]The nation is split up into 21 provinces, which are then subdivided into soums, or county. A mix of both human and natural factors, including as ongoing grazing, unsustainable water use, and the effects of climate change, contribute to the deterioration of Mongolian rangelands. It is noteworthy that the treatment of livestock as private property and the unfettered usage of land contribute to the estimated 70% degradation of grazing areas [1]. The deterioration of pasture is exacerbated by pastoralists' abandonment of conventional and rotational grazing patterns, which results in altered land use practices. Nowadays, a lot of individuals who are not part of the traditional herding group use cattle herding as their main source of income. Between 1940 and 2003, Mongolia's yearly mean temperature raised by 1.8°C, indicating significant changes in the country's climate [4]. Future winter warming rates are expected by climate change to range from 0.9°C to 8.7°C, and summer temperature increases are anticipated to vary from 1.3°C to 8.6°C. More than 80% of the nation's land is thought to be extremely susceptible to catastrophic weather events. With an annual precipitation range of 125–250 mm, the Steppe zone is home to plant species as CARMI and ARFRI (*Caragana micropylla (Pall.) Lam.* and ARFRI (*Artemisia frigida Willd.).* The soil is sandy, free of carbonate, and rich in nutrients.

The Steppe zone, characterized by an annual precipitation range of 125–250 mm, features vegetation species like CARMI and ARFRI (*Caragana microphilla, Artemisia frigida*). The soil is rich of nutrient, sandy no carbonate, and some areas experience huge soil salinity. Dominant plants in the Steppe zones include *Stipa spp., Potentilla spp., and Elymus spp.*

Material and methods

This study focused on areas surrounding by Steppe (n=4) zones. Data collection took place between 2009 and 2010 these sites, which were specifically selected to represent typical pasture types within different ecological groups. The research places comprised pairs of fenced plots, approximately 25 m x 25 m, inside (protection) as well as outside (control) (Fig. 1). Six transects were located within, and three were established outside of fence. Biomass samples from 1 m^2 plots were collected. The selection criteria of locations are following: I. ability to represent the grazing season, II. Ability to represent Steppe Zone III. Follow the management plan IV. Normal grazing outside the fence V, fence at least 200 meters far from the road. At the start of the transect, five replicates of the biomass were measured, which was separated from litter. An electron balance was used to weigh the air-dried biomass (0.000 g). Line point intercept method were used to measure the vegetative cover inside and outside the fence, and Shannon's diversity index (SHDI) was used to quantify the species diversity. Amongst the diversity indices that can be used to assess the diversity of species utilizing categorical information is the SHDI. The data was checked for residual normality and homogeneity prior analysis. One-way ANOVA comparison and Non-Metric Multidimensional Scale (NMS) ordination were employed in the analysis. NMS, that differentiates itself by its unique design and interpretation, uses randomized information as a null model for comparison and works well even when diversity is high or ecosystem gradients have uneven strengths. Stress plots have been developed for the purpose to verify the dimensionality of each ordination (McCune, 2002).

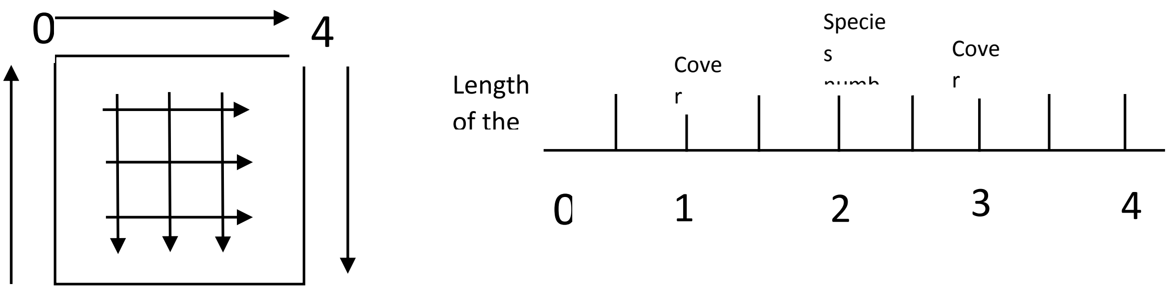

Figure 1. Study design[1]

Results

The data indicate a substantial decrease in biomass by 23.1% ($p<0.001$) and a significant fall in vegetative cover by 9.1% ($p<0.001$). The conditions in the inside and outside fence were similar, demonstrated by the lack of substantial variations in species variety and abundance between the grazing and resting areas (Fig. 2). The effect of total biomass, average number of species, and total vegetative cover inside is illustrated graphically in Figure 2. The overall number of species in the fence remained unchanged, despite significant rises in total cover and total biomass. The impact of grazing on functional groups is depicted in Figure 3. Protection from grazing resulted increase of more grass, legume, and forb cover. On the other hand, under grazing situations, the percentage of forb cover decreased by 31% ($p<0.002$), the quantity of grass cover decreased by 28% ($p<0.005$), and legumes were completely absent in outside of the fence. The lack of more palatable species under grazing, like legumes, indicates that this group may be more negatively impacted. In addition, the area of bare land increased as a result of grazing at all sites ($p<0.05$).

[1] Arrangement of sampling plots and their positioning on the transect involved three control transects measuring 0–40 m in length, with an internal 0–20 m transects and 6 replications each. However, the enclosure transects were shorter than the control transects due to insufficient space within the fenced area to accommodate 0–40 m transects. Data collection was conducted on each transect. It’s important to note that the diagram is not drawn to scale. The transect length was 20 m if located inside, but otherwise, it was 40 m

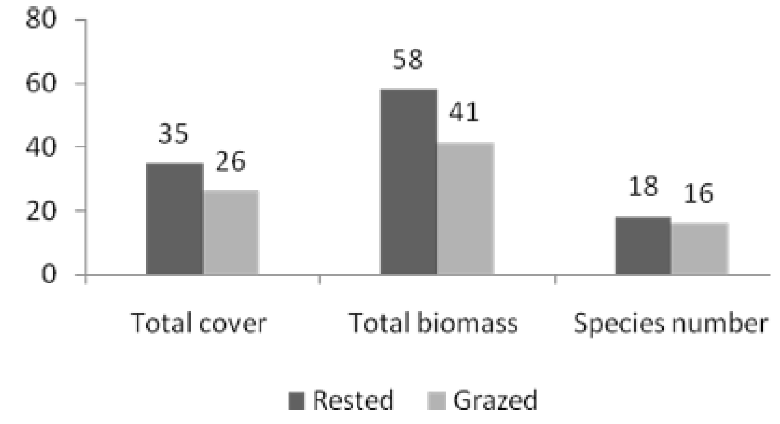

Figure 2. The vegetation transformation

It's important to observe that the y-axis show several units. Figure 2 displays the average species numbers, revealing a greater species diversity within the enclosures compared to the outside. The impact of grazing is evident in a 78% reduction in species composition, as depicted in Figure 2.

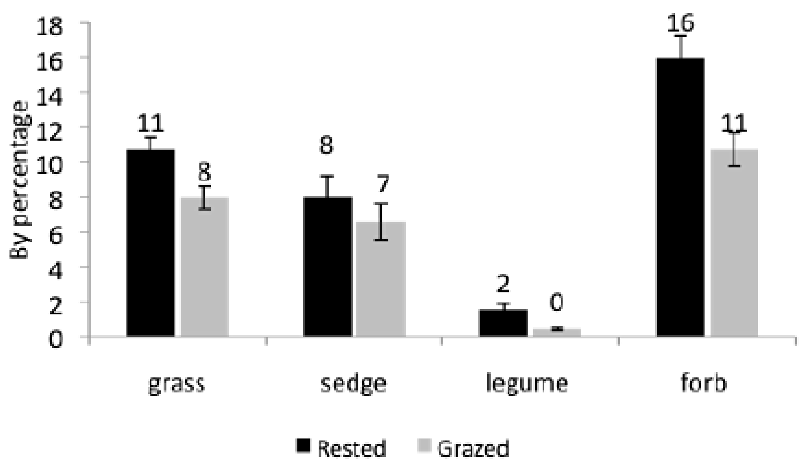

Figure 3. The functional groups transformation[2]

Further insights into this effect are provided by the ordination in Figures 4. To assess the proportional impact of grazing on species numbers, one can compare in and outside, with the other two (outside, inside). Approximately ¼ of the species, or 50 out of 192, are influenced by grazing (Fig 3 illustrates the results of ordination for the grazing data, where the NMS ordination indicated a three-dimensional solution after iterations. While trends shown were not immediately apparent, the identification of 41 species exclusive to the enclosures and nine species found solely outside highlights the grazing effect.

[2] Grazing impact on cover (%) categorized by functional group. Inside areas within outside fence are denoted by dark gray, while grazed areas outside fences are indicated in light gray. The numbers presented above the columns signify treatment averages, and the error bars (I-bars) represent the standard error of the mean

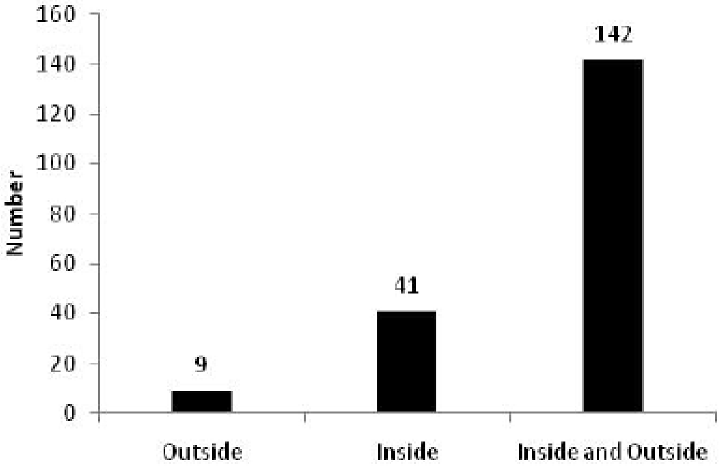

Figure 4. The average counts of species that exclusively occurred within the fenced areas, solely outside the fenced areas, and those found in both inside and outside locations

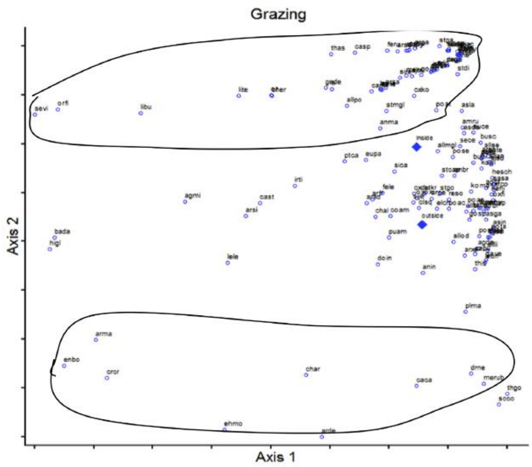

Figure 5. The spatial distribution of species, categorized as either inside or outside the enclosures[3]

Discussion

According to [5] grazing animals have an impact on plants through both direct and indirect ways. Degradation and trampling have a direct impact on plant morphology, while changes in the microclimate, the features of the soil, and competition between plants has indirect results. It can be hard to distinguish between these main elements that contribute and the way they interact. Species unique to the enclosures included *Setaria viridis (L)P.B, Oxytropis filiformus DC., Linaria buriatica Turcz., Bassia dasyphylla (Ficsh. Et Mey.) Ktze., Hierochloe glabra Trin., Agropyron Michnoi Roshev., Leontopodium leontopodioides (Willd.) Beauvd., Artemisia scoparia Waldst. et Kit., Caragana stenophylla Pojark., Limonium tenellum (Turcz.) Ktze.,*. Outside the enclosures, 10 species were identified, while ordination figures revealed 11 species, namely *Artemisia macrantha Ldb., Enneapogon borealis (greseb.)*

[3] A diagram of ordination representing the spatial distribution of species, categorized as either inside or outside the enclosures. The upper section denotes the inside domain, while the lower section represents the outside domain, as labeled by diamonds. Circles are used to cluster the most prevalent species for each respective domain. Further details, including species codes and explanations of species abbreviations

Honda, Crepis crocea (Lam.) Babc., Chenopodium aristatum L., Carum carvi L., showcasing their resilience to continuous grazing. With a 23.1% decrease in biomass and a 9.1% decrease in vegetation cover, continuous grazing had an important effect on the vegetation. Meaningful ecological shifts indicated potential issues over time, even though there were not any statistically significant modifications in diversity of species and numbers among rest and pastures. For instance, the Shannon's biodiversity index (SHDI) was 1.401 inside that were rested as opposed to 1.286 in areas that were grazed, probably since grazing areas contained fewer species. This demonstrates how species variety and richness are impacted by grazing pressure, with overall biomass and cover indicating a greater sensitivity. Han et al [6] published similar findings to those presented here. According to their results, the amount of ground vegetation cover decreased and bare soil increased in the grazed areas. Furthermore, total biomass decreased with grazing intensity after four years. Also, my results corresponded to those of Li et al. [7], who found that litter cover, plant cover, aboveground and primary production decreased with increasing grazing pressure. Grazing research has been conducted in Inner Mongolia for a long time. One study focused on the influences of continuous grazing and livestock exclusion on soil properties in degraded sandy grassland [8]. According to their results, live vegetation and litter were highest in areas that had had no grazing for 10 years, intermediate in areas where grazing had been excluded for 5 years, and lowest in the areas with continuous grazing. In fact, biomass could increase up to 16 times in ungrazed compared to grazed areas. Similarly, Ringrose et al [9] found a 1.5-fold biomass increase after six years of exclusion, and a 56% ground cover increase. The results presented in this paper indicate that total cover and total biomass in Mongolia have decreased significantly due to overgrazing. It appears however, that livestock exclusion is sufficient to reverse the negative degrading trend, indicating that the ecosystem has not yet passed a non-reversible ecological threshold. This finding is in accordance with previous research, including [10] and [11] which concluded that increasing grazing intensity was linked to decreasing total biomass, increasing empty space, and reduced ground plant cover. The findings are supported by previous research on the Mongolian plateau, such as [12] and [13] which shows that the exclusion of cattle can enhance ground cover and increase biomass. The facts show that decline has substantially lowered Mongolia's total cover and biomass. It is encouraging to note that the exclusion of cattle seems to be working to reverse this downward trend, indicating that the ecosystem is not yet at an irreversible ecological threshold.

Conclusion

Year around grazing in the Mongolian steppe rangelands shown resulted in a significant decrease in overall vegetation cover, biomass, and a reduction in species diversity and is particularly noticeable in the vulnerability of biomass and vegetative cover. Specific vegetation, for instance legumes and forbs, witness a decline in cover under grazing pressure, while groups better adapted to grazing, such as grasses, experience a milder reduction. Grazed areas exhibit an increase in bare ground, and there is a shift in species composition towards less palatable species. An examination of species distribution reveals unique vegetation patterns in the Steppe. These findings underscore the varied vegetation patterns existing in the Steppe zone.

Conflict of interests

The authors declare no conflict of interests.

Authors' Contribution

Bur.Dash and Bul. Den. designed and performed the study; Bul. Den. supervised the experiment; Bur.Dash analyzed data.

Acknowledgment

This research has been carried out with a financial support from the Mongolian National Federation of Pasture User Groups.

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