Degradation Issue of *Fescue-Forbs* Rangeland in the Mountain Steppe of Mongolia

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The XXIV International Grassland Congress / XI International Rangeland Congress (Sustainable Use of Grassland and Rangeland Resources for Improved Livelihoods) takes place virtually from October 25 through October 29, 2021.

Proceedings edited by the National Organizing Committee of 2021 IGC/IRC Congress

Published by the Kenya Agricultural and Livestock Research Organization

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Keywords: Rangeland degradation; species composition; individual species; plant canopy cover

Abstract

The total area of *Fescue-forbs* rangeland in Mongolia is 10 million hectares, accounting for 8.5% of total rangeland area. The *Fescue-forbs* rangeland is the main type of rangeland in the mountain steppe. The Mongolian rangeland has degraded in the last two decades mainly due to overgrazing and climate change. The main objective of this study was to determine the change of plant community and reduction of frequency and productivity of the dominant species *Festuca lenensis* in different degradation states of rangeland. The dominant species and main plant functional groups have completely changed in *Fescue-forbs* rangeland in all three states of rangelands. The cover of *Festuca lenensis* was decreased by 98.6-99.5% and biomass percentage was decreased by 95.3-100% in three different degradation degrees compared with the reference site. As a result of species composition, the highest number of species was determined in moderately degraded rangeland, the lowest number of species was determined in heavily degraded rangeland. The similarity coefficient of species was 0.45 between the slightly and moderately degraded rangelands. Heavily degraded rangeland was different from other two types of rangeland. Number of individual species increased in moderately and heavily degraded rangelands in comparison to slightly degraded rangeland. This was depended on increaser and tolerant plant species; these are *Arenaria capillaris, Potentilla acaulis, Artemisia frigida, A.commutata, Chamaerodos erecta and Carex duriuscula.* Our study revealed the degradation process of *Fescue-forbs* rangeland in mountain steppe of Mongolia.

Introduction

Natural rangelands are a source of survival for Mongolian nomadic animal husbandry, which takes place in an extreme continental climate. The total amount of natural rangeland of Mongolia is 110.5 M (million) hectare; it is 70% of the total area [7], of which 78.3% is eroded [1]. According to a desertification assessment, 72% is included in slight to very severe class of desertification [9]. The current state is due to global climate change and the negative impact of human activity. The Khangai sub-zone of mountain steppe is 12.9% of the total area [10], of which *Fescue* rangeland is dominant with over 10 Mha area. Over 90% of the Khangai mountain area of *Fescue* rangeland is degraded [4]. In the last two decades, higher animal numbers have degraded grasslands. Mongolia had 25.8 M animals in 1990, but 70.1 M animals in 2019 [6]. Therefore, the rational usage of natural grassland and protection of its natural composition are urgent issues.

Our study goal was to study the vegetation change of *Fescue-forbs* rangeland in the mountain steppe. Our study objectives were:

1. To study the change of frequency, number of individuals, canopy cover and total yield of edible species in *Fescue-forbs* rangeland at different degree of degradation
2. To conduct a comparative study in species composition along with the changes in the total number of individuals at different degrees of degradation.

Methods and study site. Three different degrees of degraded *Fescue-forbs* rangeland, situated in the east valley of the Del in Bort bag[1] of the Ikhtamir soum[2] of the Arkhangai aimag[3], were chosen for the study. This study was conducted in 2005-2006 on slightly degraded grass-forbs, moderately degraded *Artemisia*-forbs, and heavily degraded Sedge-forbs rangeland. Data of normal *Fescue-forbs* rangeland was compared

[1] *An initial administrative unit in countryside of Mongolia*
[2] *A secondary administrative unit in countryside of Mongolia*
[3] *A tertiary administrative unit in countryside of Mongolia*

to Lkhagvajav's study [4] which was conducted between 1986 and 1995 [3]. Species composition of rangeland was determined by determining flora richness in 0.1, 1 and 100 m^2 quadrats [11] as follows:

- The number of individual species was counted in 10 replicates of randomly allocated 20 cm x 50 cm ($0.1m^2$) frames.
- The frequency of edible species was determined randomly by allocating $0.1m^2$ net with 10 replicates [2];
- The bunch diameter of edible species was determined by measuring a line transect with mm accuracy;
- Canopy cover (%) of each plant species was determined in five replicates of 1 m x 1 m nets (100 windows) [8];
- Rangeland yield was determined by cutting plants at ground level in five replicates of $1m^2$ quadrats. After cutting, the plant material was sorted into species and all plant material was air dried at room temperature for 20-25 days before weighing.

Results

Study of edificatory species: According to study result, the edible species *Festuca lenensis* in the *Fescue-forbs* rangeland of mountainous species had some change (Table 1). However, frequency of *Festuca lenensis* at the moderately degraded rangeland with grass-forbs was 95%, number of alive individuals was lower by 98.3% compare to normal *Fescue*-forbs rangeland [4]; bunch diameter was decreased by 1.3 times. Percentage in total canopy cover and total yield was lower by 95.3-98.6% compare to normal *Fescue*-forbs rangeland. Frequency of *Festuca lenensis* at the moderately degraded *Artemisia*-forbs was 70%, the number of individuals at the unit area was decreased by 99.7% compare to normal *Fescue*-forbs rangeland, bunch diameter was decreased by 2.4 times.

Table 1. Change in some characters of edible species in *Fescue-forbs* rangeland

Rangeland	Degradation degree	Frequency (%)	Number of individuals (1 m^2)		Bunch diameter (sm)	Percentage in total coverage, %	Percentage in total yield, %
			alive	dead			
Fescue-forbs	Normal	100	302	-	3.1	21.5	29.8
Grass-forbs	Slight	95	5	54	2.3	0.3	1.4
Artemisia-forbs	Moderate	70	1	12	1.3	0.2	0.1
Sedge-forbs	Heavy	30	0.4	-	0.9	0.1	0

The role of the *Festuca lenensis* in the yield and canopy cover of total vegetation has declined considerably with grazing this specieshas become. Frequency of *Festuca lenensis* at the heavily degraded Sedge-forbs rangeland was decreased by 70%, number of individuals was decreased by 99.9% and bunch diameter was decreased by 3.4 times; this shows that this rangeland has lost its natural basic type (Table 1).

Change in species composition: In average, seven plant species were found within the 0.1 m^2 quadrat area; 13 plant species at the 1 m^2 scale; and 35 plant species at the 100 m^2 scale on the slightly degraded grass-forbs rangeland, respectively. The total vegetation canopy cover was 50-55% on this class of rangeland and the significant grass species were *Koeleria macrantha* and *Agropyron cristatum* for animal feed. On moderately degraded *Artemisia*-forbs rangeland, 10 plant species were found on the $0.1m^2$ area; 19 plant species at 1 m^2 and 40 plant species at 100 m^2. The canopy cover was 50-53% on average. The forbs *Artemisia frigida* and *A.commutata,* were important in this type of rangeland. On the heavily degraded Sedge-forbs rangeland, an average of 4 plant species were grown on 0.1 m^2 areas; 9 plant species at 1 m^2 and 22 plant species at 100 m^2 respectively. *Carex duriuscula* was the dominant species and canopy cover was 70-80% at this type of rangeland (Figure 1).

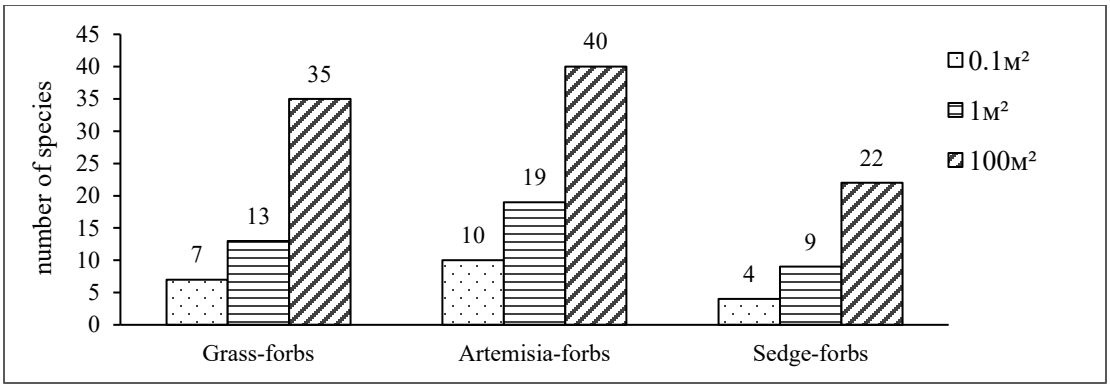

Figure 1. Change in species composition *Fescue-forbs* rangeland

According to our study result, the number of species was increased as well, species number was initially increased with degradation but species number decreased with heavy degradation. This is explained by growth of increaser species in the empty spaces left after the death of the edifible species *Festuca lenensis. Carex duriuscula* grew in the empty spaces of dead plants in the heavily degraded rangeland. According to a comparison of species dissimilarity (Table 2), the species composition of the rangeland states become progressively different from each other a consequence of overgrazing.

Table 2. Dissimilarity of plant species at degraded *Fescue-forbs* rangeland

	Variants		
	1&2	1&3	2&3
Dissimilarity coefficient	0.55	0.66	0.65

Explanation: Dissimilarity coefficient by *Czekanowskii* 1909, 1913 [5]: 1&2 compares slightly and moderately degraded rangeland, 1&3 slightly and heavily degraded rangeland and 2&3 moderately and heavily degraded rangeland

Change in number of individuals: 26.8 individual plants of six species were counted in a unit area of slightly degraded rangeland, 1.5 times higher in moderately degraded rangeland and 4.7 times higher at heavily degraded rangeland at *Fescue-forbs* rangeland. The increase in species on degraded rangeland is explained by the growth of the forbs *Arenaria capillaris, Potentilla acaulis, Artemisia frigida, A.commutata, Chamaerhodes erecta, Carex duriuscula,* which occupied former bunch grass space (Figure 2). Percentage of sedge was high in all three types of degraded rangeland – 95.2% was *Carex duriuscula* in heavily degraded rangeland. The number of grass individuals was 31.3% int slightly degraded grass-forb rangeland; *Artemisia* was about 20% and forbs were 35.7% in moderately degraded rangeland. At the slightly degraded rangeland, palatable species such as *Agropyron cristatum, Koeleria macrantha, Festuca lenensis* and *Poa attenuata* grasses were grown; grass individuals were very few at the moderately and heavily degraded rangeland.

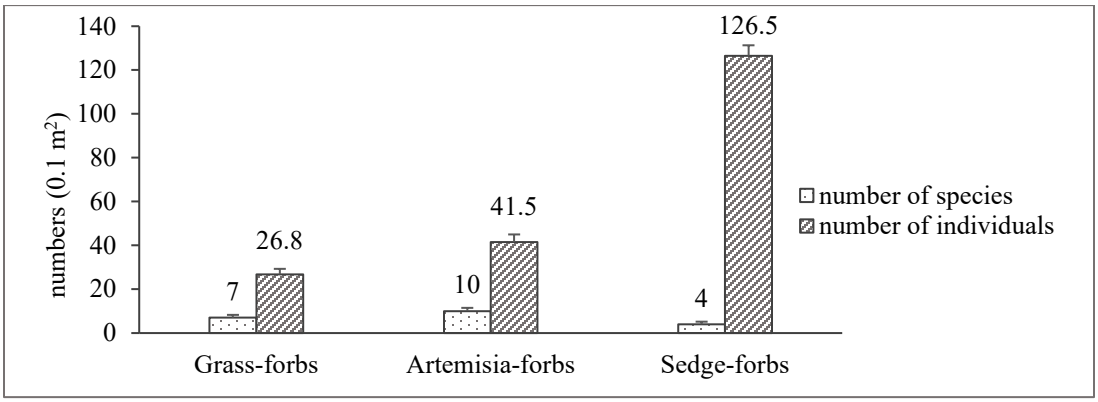

Figure 2. Change of individuals in unit area of *Fescue-forbs* rangeland of mountain steppe

Degradation indicator species such as *Artemisia commutate, A.frigida, Arenaria capillaris, Potentilla acaulis, Heteropappus altaicus, Chamaerodos erecta* were grown at the moderately degraded *Artemisia*-forbs rangeland. *Carex duriuscula* was dominant at heavily degraded Sedge-forbs rangeland sites, as recorded by Yunatov [12].

Conclusion

Following changes occurred in the degraded *Fescue-forbs* rangeland of mountain steppe:

1. The frequency of *Festuca lenensis* was decreased by 5-70%, number of individuals was decreased by 98.3-99.9 and bunch diameter was decreased 1.3-3.4 times at three different degraded rangelands compare to normal rangeland. The percentage of *Festuca lenensis* in canopy cover and yield of total plants was decreased and its role as an edible species was lost.
2. A change in species composition of *Fescue-forbs* rangeland was observed, with a plant species dissimilarity of 0.55 between slightly and moderately degraded rangeland, and the heavily degraded rangeland became dissimilar from other two types.
3. With increasing degradation of the original *Fescue-forbs* rangeland, the number of species in unit area was initially increased but sedge species dominated heavily degraded rangeland.

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