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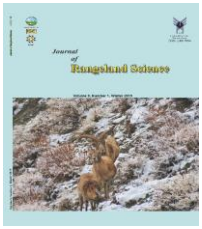

Research and Full Length Article:

Resting Impact on Vegetation Cover of Fescue-Forbs Rangeland in Mongolia

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Abstract. The rangeland in the Khangai mountain region in Mongolia has degraded for the last decades mainly because of overgrazing and climate change. Livestock production is important part of the economy and is based on natural rangeland. In this research we seek to elucidate the influence of five years (2004-2009) of protection from grazing on vegetation cover of different degradation levels of *Fescue-forbs* rangelands in Khangai mountain region of Mongolia. In the beginning of the study grasses dominated within the slightly degraded site, especially *Agropyron cristatum* and *Koeleria macrantha*. Forbs dominated within the moderately degraded site, mainly *Artemisia frigida* and *A. commutata* and within the heavily degraded site sedge species dominated, mainly *Carex duriuscula.* The climate was fluctuated during the study period that affected the plant growth and vegetation cover. When looked at variation of total vegetation cover among years within un-grazed and grazed sites there had been fluctuation among years. The total vegetation cover was significantly different ($P<0.001$) among years at all degradation levels. The total vegetation cover was 18-22% higher in un-grazed site of slightly degraded site, 8-10% in un-grazed site of moderately degraded, 39-58% in un-grazed site of heavily degraded site in 2005 to 2006. The total vegetation cover was higher ($P<0.05$) at un-grazed sites than grazed fir many years. The vegetation cover was lower at all sites in 2007 through 2009. It was depending on drought and accumulation of litter cover. Grasses and forbs had improved in un-grazed site of slightly and heavily degraded sites.

Key words: Rangeland, Resting impact, Vegetation cover, Grazing, Un-grazed area

Introduction

About 80% of the Mongolian total land area can be considered rangeland (Damiran, 2005). Mongolian nomadic animal husbandry is based on natural rangeland and livestock production is an important part of the economy. Today Mongolia is one of the most heavily grazed countries in the world (Archer & Smeins, 1991). From 1990 to 2017, the total number of herding households in Mongolia doubled and livestock number increased 2.5 times and reached over 66.2 million animals (National Statistical Office of Mongolia 1990, 2017). Mongolia has no regulation on maximum number of livestock allowed that makes the rangeland potentially susceptible to overgrazing and degradation (Sankey *et al.,* 2009).

In Mongolia the ownership of land has changed for the past decades. For centuries herders moved between places with their herd so grazing impact was not so intense at each place. Following 1921 when the communist ruled the country, individuals could not own livestock but they herded state-owned animals on state-owned rangelands for a salary. Although nomadic movements were restricted during the Socialist period, collectives allowed seasonal movements and regulated rangeland use (Johnson *et al.,* 2006). Grazing methods changed after 1990 when herding collectives were dismantled and most state-owned livestock was privatized. Rangeland remained state-owned but herders could utilize it. Following privatization number of herding household increased and seasonal movements of herders decreased (Fernandez-Gimenez, 1999).

The effect of grazing is traditionally viewed as negative on the primary production through a series of direct and indirect effects on plant growth (Archer & Smeins, 1991). Although many plant species are well adapted to defoliation, domestic livestock can substantially impact their growth and persistence in numerous ways (Archer & Smeins, 1991). The aboveground parts of plants are destroyed, but in addition plants suffer from trampling (Gunin, 1999). In cases of heavy grazing it is well known that plant composition changes and can result in vegetation and land degradation (Chognii, 1977). The influence of grazing on grass cover has a more complicated character when combined with natural shortages of water.

Climate changes influences the health of rangelands and affects the dynamics of rangeland vegetation (Gunin, 1999). The climate has been getting warmer and slightly drier in Mongolia (Batima *et al.,* 2005). The estimation of water resource in 2007 indicated that water resources had decreased during last two decades (Dagvadorj *et al.,* 2010). Total number of rivers had decreased by 16.6%, springs by 25.4% and lakes by 31.5% (Dagvadorj *et al.,* 2010). Due to this and heavy grazing dust storms are more frequent than before and a total area of 113 million hectares in Mongolia is affected by wind and water damage on soil (Association of Environmental Impact Assessment, 2010).

Because of the heavy grazing and climate changes in Mongolia it is important to gather information about the grazing tolerance of the land but also about methods that can be used to restore degraded land. Such data will serve as basic information needed for the assessment of the carrying capacity of the pastures and for management decisions for a sustainable use of the natural rangeland.

Materials and Methods

Study area

The study area belongs to the Forest steppe belt, Khangai mountain region which is located in Ikhtamir soum, Arkhangai province of Mongolia (47°47'– 47°50'N; 100°56'–100° 54'E) (Gunin, 1999). Altitude of the study area is between 1793-1844 m above sea level.

The climate at the study area is extreme continental (Badarch, 1971). Average wind speed is 2.3 m/sec and maximum speed is 20 m/sec (Institute of Meteorology and Hydrology, 2012). During 2004-2009 annual temperature fluctuated, the highest temperature was in 2007 and lowest was in 2005 (Fig. 1). Within each year annual temperature was usually higher than long-term average except for year 2005.

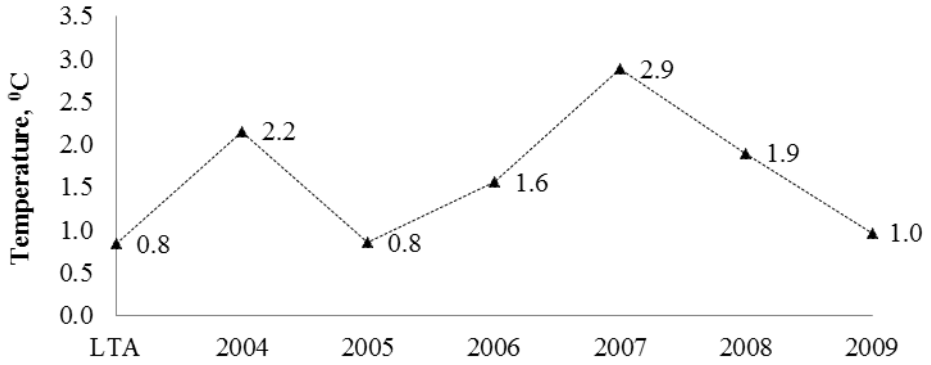

Fig. 1. Annual temperature (°C) of the study periods at the Tsetserleg station in Arkhangai province and long-term average of climate data from 1970-2010 (LTA) (Institute of Meteorology and Hydrology, 2012). Tsetserleg station is 80 km from the study area.

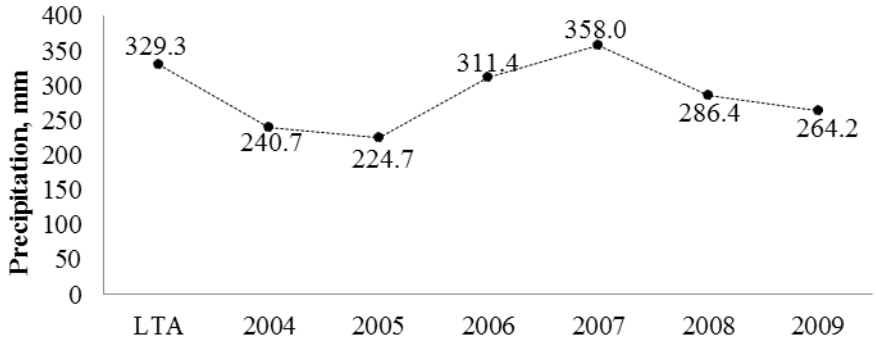

Fig. 2. Annual precipitation (mm) of the study periods at the Tsetserleg station in Arkhangai province and long-term average of climate data from 1970-2010 (LTA) (Institute of Meteorology and Hydrology, 2012). Tsetserleg station is 80 km from the study area.

The average of long-term (1970-2010) precipitation is 329.3 mm (Fig. 2) (Institute of Meteorology and Hydrology, 2012). Annual precipitations were always lower than long term average (LTA) except for 2007 however the summer precipitation (about 190 mm) was mainly after 20th of August when it was too late for plant growth. The long-term average temperature is 0.8°C the monthly minimum temperature is -14.8°C in January and the maximum temperature is 15.4°C in July (Fig. 3). In average more than 80% of precipitation is distributed during growing season of plants, which is in between May to August (Fig. 4).

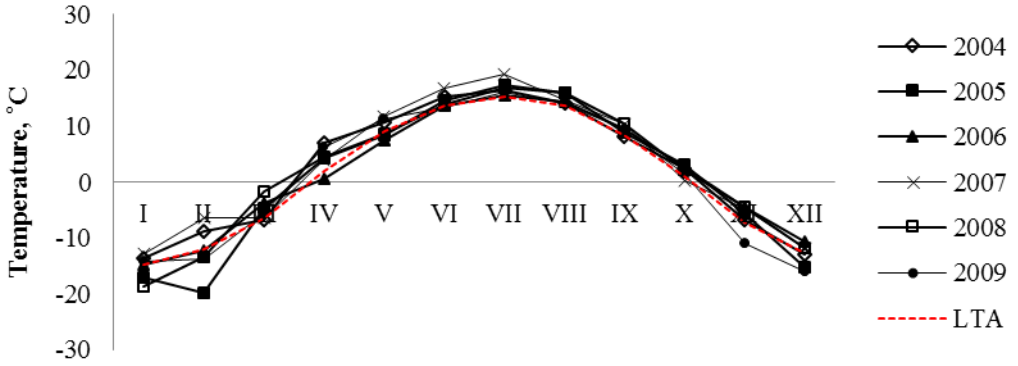

Fig. 3. Average air temperature (°C) by months at the Tsetserleg station in Arkhangai province and long-term average of climate data from 1970-2010 (LTA). (Institute of Meteorology and Hydrology, 2012).

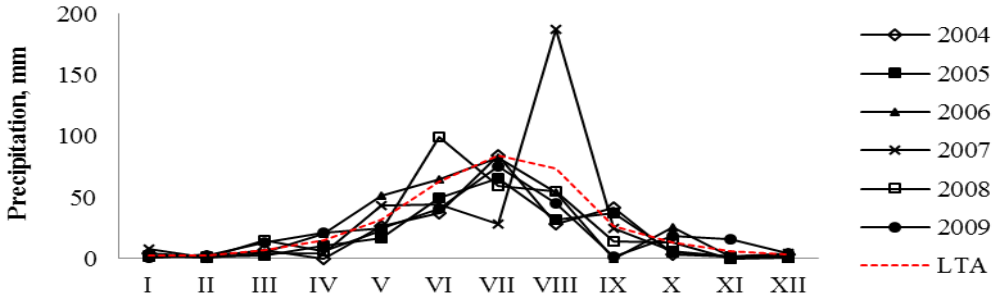

Fig. 4. Precipitation (mm) by months from 2004-2009 at the Tsetserleg station in Arkhangai province and long-term average of climate data from 1970-2010 (Institute of Meteorology and Hydrology, 2012).

The vegetation at the study area is *Fescue-forbs* community which is common vegetation type in mountain forest steppe (Lkhagvajav, 2000). The grass *Festuca lenensis* was a dominant species in the community and is considered as one of the main indicator species for healthy rangeland. Coverage of *Festuca lenensis* was about 21.5% of total cover and 25-30% of total biomass in earlier researchers (Tserendash, 1978; Lkhagvajav, 2000). Studies in 2002 have shown that more than 90% of *Festuca lenensis* cover and abundance has decreased since 1986 (Lkhagvajav, 2000; Lkhagvajav & Otgontuya, 2008).

Research Method

Within the study areas are three experimental sites (Table 1). Within each site a 1 ha area was fenced off in 2004 with as homogeneous vegetation as possible and it has been un-grazed since 2004. At the time of fencing the three experimental sites were at three different degradation levels of *Fescue-forbs* rangeland and were estimated to be slightly, moderately and heavily degraded. In the beginning of the study grasses dominated within the slightly degraded site, especially *Agropyron cristatum* and *Koeleria macrantha* (Table 1). Forbs dominated within the moderately degraded site, mainly *Artemisia frigida* and *A. commutata* and within the heavily degraded site sedge species dominated, mainly *Carex duriuscula*.

Table 1. The three experimental sites with different degradation level and different vegetation type of *Fescue-forbs* community in year 2004.

Study area	Degradation level	Vegetation type
Fescue-forbs	Slightly degraded	Grass-forbs
	Moderately degraded	Artemisia-forbs
	Heavily degraded	Sedge-forbs

The slightly and moderately degraded sites were historically utilized between October to May and the heavily degraded site was utilized year around by sheep, goats, cattle and horses. Furthermore, that site was a main path of livestock moving between grazing areas until 2000 and therefore heavily utilized. Area outside of each fence has been grazed during the study.

The slope is 2.5% in slightly and moderately degraded sites and 1% in heavily degraded site. Aspects are 254° and 245° in slightly and moderately degraded sites and 315° in heavily degraded site.

To study the effect of resting on vegetation composition, the measurements were applied inside the fence were un-grazed and outside of the fence were grazing continued after 2004. Five plots (1x1 m) were randomly selected for measurement of vegetation cover inside the fence and five outside the fence. We followed methodology of Ramenskii (1971) which is 1 m^2 set. Each 1 m^2 set is divided to 100 parts and each part equals 1%. We measured vegetation cover by each individual species in 20th of July since 2004 to 2009.

Data Analysis

In order to obtain information on vegetation cover of un-grazed and grazed areas mean and standard errors of total vegetation cover and main plant functional groups were calculated. A two-way ANOVA were applied to test if there was a difference of total vegetation cover between years and between un-grazed and grazed area. Statistical analysis was performed using SAS (Enterprise Guide 4.2) for Windows.

Results

Results of two-way ANOVA for resting impact on vegetation cover changes of different degradation level of *Fescue-forbs* rangeland is presented in Table 2. Result showed significant effect of year and resting impact on vegetation cover in all of three sits. The Year × Resting intraction effect were siginficant in slightly and heavily degraded sits ($P<0.01$) (Table 2).

Table 2. Results of two-way ANOVA for resting impact on vegetation cover changes of different degradation level of *Fescue-forbs* rangeland.

Source of variation	DF	F Values		
		Slightly degraded	Moderately degraded	Heavily degraded
Year	5	33.2**	30.3**	16.7**
Resting impact	1	27.6**	6.7*	35.6**
Year × Resting impact	4	4.9**	2.3^{ns}	13.4**

* and ** indicate significant differences at $p<0.05$ and $p<0.01$.

Total vegetation cover was similar (52-55%) within fenced areas in each experimental site during the first year (2004) of the study (Table 3). However, dominant plant functional groups were different. Grasses were dominant within the slightly degraded site, forbs within the moderately degraded site and sedge within the heavily degraded site (Fig. 5). In year 2009 the pattern of dominant species groups was similar as in 2004 (Figs. 5 and 6). However, in general total vegetation cover and cover of plant functional groups were lower than in the beginning of the study.

When un-grazed and grazed sites are compared, total vegetation cover and cover of plant functional groups in all cases were lower at grazed areas (Fig. 6). Exception from this was in moderately degraded site where cover of grasses was higher within grazed area, forbs where higher within grazed area in heavily degraded site and cover of sedges was

higher in grazed at all degradation levels (Fig. 6). Vegetation cover of grasses was much lower within grazed site at heavily degraded site.

Table 3. Total vegetation covers (%) of *Fescue-forbs* rangeland in within slightly degraded (SD), moderately degraded (MD) and Heavily degraded (HD) sites over 6 years.

Treatments (sits)	Vegetation covers %			
	Total (2004)	Un-grazed (2009)	Grazed (2009)	Total (2009)
Slightly degraded	52.4±1.78 a	38.2±1.16 a	31.4± 2.69 b	69.60 ab
Moderately degraded	52.6±2.11 a	35.6±2.23 b	30.2±4.07 b	65.80 b
Heavily degraded	54.8±3.25 a	34.2±1.17 b	41.4±3.08 a	75.60 a

Means of column followed with the same letters are not significantly different

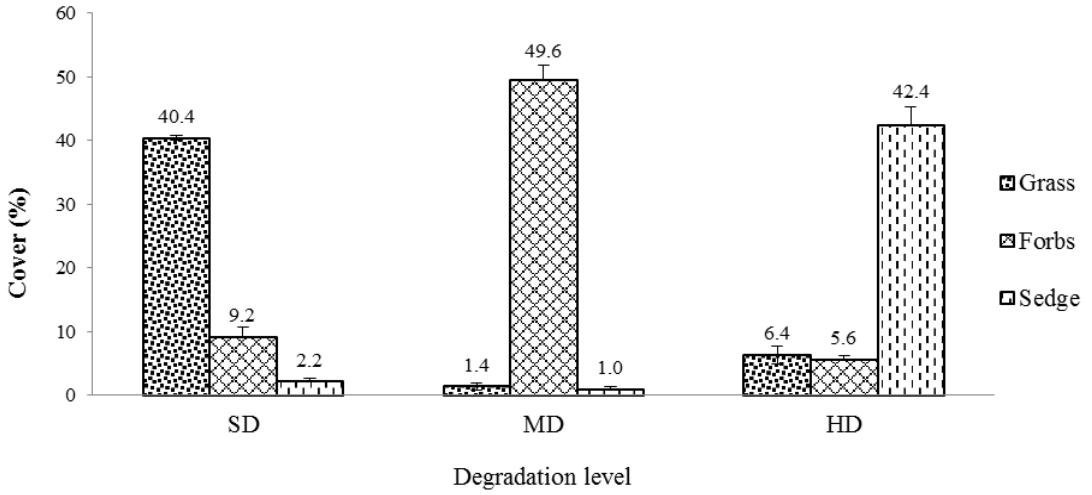

Fig. 5. Vegetation cover of grasses, forbs and sedges (%) of *Fescue-forbs* rangeland in 2004 within slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites.

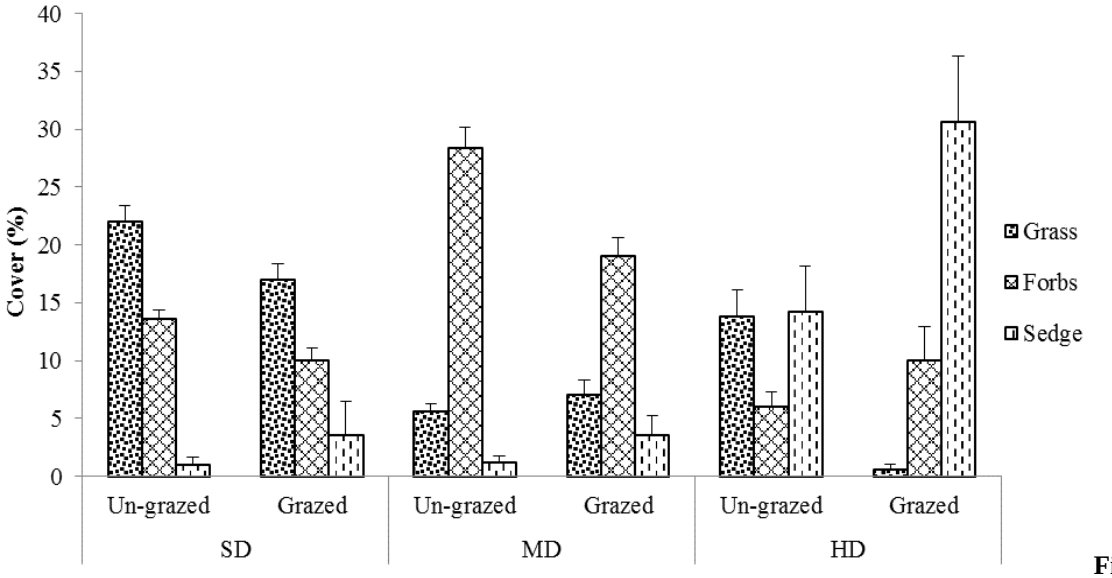

Fig. 6. Vegetation cover of grasses, forbs and sedges (%) of *Fescue-forbs* rangeland in 2009 for un-grazed area and grazed area of slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites.

When looked at variation of total vegetation cover among years within un-grazed and grazed sites there had been fluctuation among years (Fig. 7). The total vegetation cover was significantly different ($P<0.01$) among years at all degradation levels (Table 2). The total vegetation cover was 18-22% higher in

un-grazed site of slightly degraded site, 8-10% in un-grazed site of moderately degraded, 39-58% in un-grazed site of heavily degraded site in 2005 to 2006 (Fig. 7). In most of years total vegetation cover was higher ($P<0.05$) at un-grazed sites than grazed (Table 2). The vegetation cover was lower at all sites in 2007 through 2009 (Fig. 7). It was depending on drought and accumulation of litter cover.

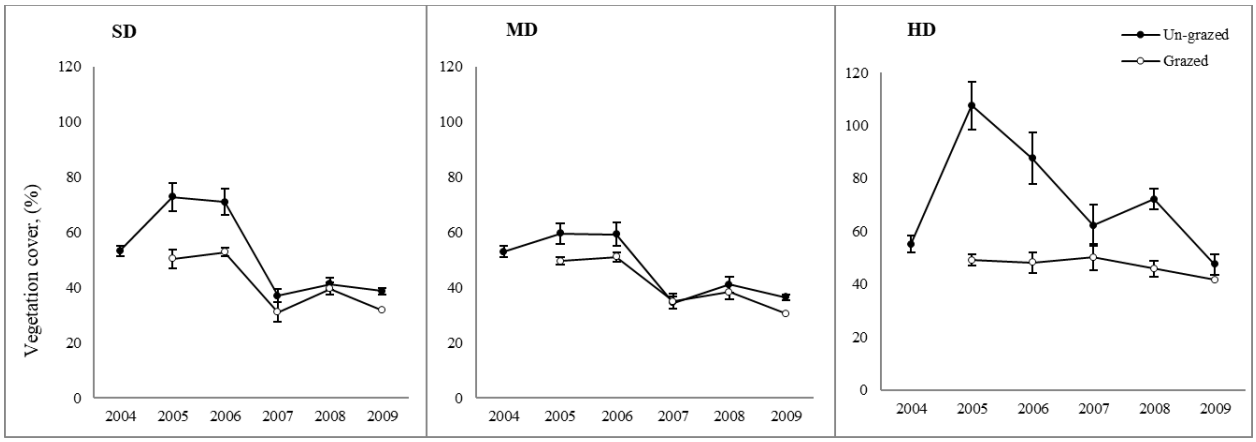

Fig. 7. Total vegetation cover by year within un-grazed and grazed area of slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites.

Discussion

It is well known that intensity of grazing matters when it comes to health and sustainability of rangelands (Liang *et al.*, 2009). The total vegetation cover and cover of plant groups during the first year of this study give indication of vegetation changes that can be observed in *Fescue-forbs* rangeland following different degradation levels (Fig. 56). However, it has to be kept in mind that the three sites vary to some extent and for example is the heavily degraded site about 500 m from the Khanui river, moderately degraded site 4.5 km and, slightly degraded site 6.5 km from it.

In study in the northern Flint Region of Kansas three palatable forbs species from un-grazed, low, moderate and high grazed area was studied (Hickman & Hartnett, 2002). The results showed that when the grazing intensity increases, the total shoot biomass and percentage of reproductive stems of *Ruellia humilis* decreased. Also stem height reduced and total shoot biomass of *Aster ericoides* significantly decreased due to increases of grazing intensity.

Resting is well known method to restore rangeland´s health. The predominant plant groups or plant traits which appear under different grazing intensities, for example seem to depend strongly on a combination of climate and evolutionary history of herbivore (Díaz *et al.*, 2002). Different plant traits can predominate in areas with the same annual precipitation and livestock density, depending on whether grazing has been a strong selective pressure over evolutionary time or not. Heavy grazing is associated with high abundance of annual species in many regions (Díaz *et al.*, 2002). The association of palatable species with less palatable species may also influence the frequency and intensity of plant defoliation (Briske, 1991). Groups of plant species which respond to the abiotic and biotic environment in similar ways can be defined as response plant functional types. Widely used response plant functional type classifications are the distinction between "increaser" and "decreaser" based on their response to grazing (Díaz *et al.*, 2002). Grazing impact, it the factor that change the most the species abundance

on the steppe rangeland in Mongolia (Chognii, 1977). The cover and biomass of dominant species decreased but cover and biomass of grazing tolerance species increased when heavily grazed. The vegetation type of the site changed following heavy grazing (Chognii, 1977). In present study the grazing tolerance species *Carex duriuscula* was dominant within the heavily degraded site and *Artemisia frigida* within the moderately degraded site and within the slightly degraded site grasses are dominant (Fig. 56).

In the most cases in present study total vegetation cover was higher within un-grazed than grazed areas (Table 3). Total vegetation cover was the highest in un-grazed sites after one and two years of resting at all three degradation levels (Fig. 7). The lowest vegetation cover was obtained in 2007 in both un-grazed and grazed sites (Fig. 7), and could be related with drought during June and July that year and high annual air temperature (Fig. 1 and 2). We believed that accumulation of litter at the study sites negatively affected grass tiller and plant growth within un-grazed site. Therefore, we removed the litter by hand from un-grazed site in April 2007 to 2009. In year 2009 vegetation cover of grasses and forbs was higher within un-grazed area compared with grazed area in slightly degraded site, cover of forbs was higher in moderately degraded site and cover of grasses was higher in heavily degraded site (Fig. 6). Similiarly, a study in the forest steppe zone in Mongolia showed that total plant cover was higher within fenced area (Fujita *et al.,* 2009).

Conclusions

The total vegetation cover was similar with three degradation levels but dominant plant functional groups were different in the first year of protection from grazing condition. Grass cover was increased in un-grazed area of slightly and heavily degraded sites after 5 years. The total vegetation cover was influenced by climate condition in slightly and moderately degraded sites. But total vegetation cover was not influenced by climate condition in grazed area of heavily degraded site. It was depending on dominant plant functional group which is sedge. This study showed that rangeland production or livestock forage are easily disturbed due to utilization but rangeland recovery is slowly in Mongolian dry condition. Therefore, It was recommended that Mongolian herders and range managers adjust their grazing intensity in coherence with the rangeland health and weather conditions.

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تاثیر استراحت روی پوشش گیاهی مراتع پهن‌برگ-فستوکا در مغولستان

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چکیده. مراتع ناحیه کوه خنگی مغولستان در چند دهه اخیر در اثر چرای بیش از حد و تغییرات آب و هوایی تخریب شده است. پرورش دام بخش مهمی از اقتصاد است که پایه و اساس آن مراتع می‌باشد. هدف این پژوهش مشخص کردن تاثیر ۵ سال(۱۳۸۸-۱۳۸۳) قرق(حفاظت از چرا شدن) روی کاهش سطوح مختلف پوشش گیاهی *Fescue-forbs* مراتع در ناحیه کوه خنگی مغولستان می‌باشد. در ابتدای مطالعه گیاهان غالب در مناطق کمتر تخریب شده، *Agropyron cristatum* و *Koeleria macrantha* بودند. گیاهان غالب در مناطق نسبتا تخریب شده، بطور عمده گونه *Artemisia frigida* و *A. commutata* و در مناطق بسیار تخریب شده عمدتاً گونه‌های *Carex duriuscula* غالب بودند. در طول دوره مطالعه آب و هوا تغییر کرد که رشد پوشش گیاهی را تحت تاثیر قرار داد. هنگامی که تغییر پوشش گیاهی در سال‌هایی که مناطق قرق شده بود مورد مطالعه قرار گرفت، تغییرات در طی سال‌ها مشاهده شد.نتایج نشان دادند که کل پوشش گیاهی بطور قابل ملاحظه‌ای در طول سال‌های با سطوح تخریب مختلف، بطور معنی‌داری متفاوت بود($P<0.001$). مجموع پوشش گیاهی طی سال‌های ۱۳۸۵-۱۳۸۴ در مناطق قرق شده ٪۲۲-۱۸ بیشتر از مناطق کمی تخریب شده، ٪۱۰-۸ بیشتر از مناطق نسبتا تخریب شده و ٪۵۸-۳۹ بیشتر از مناطق شدیداً تخریب شده بود. همچنین نتایج بیان می‌کند که مجموع پوشش گیاهی در سال‌های نه چندان دور در مناطق قرق شده بیشتر از مناطق به شدت چرا شده بود($P<0.05$) . در سال‌های ۸۶ تا ۸۸ پوشش گیاهی کمی در تمام نقاط منطقه مورد بدلیل خشکسالی بود و بیشتر انباشت پوشش در بسترها بودند. در مجموع می‌توان نتیجه گرفت که در بخش‌های قرق شده مناطق به شدت تخریب یافته، گیاهان بهبود یافتند.

کلمات کلیدی: مراتع، اثر استراحت، پوشش گیاهی، چرانیدن، منطقه چرا نشده