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EFFECT OF UTILIZATION ON BIOMASS AND VEGETATION IN MONGOLIAN RANGELAND

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ABSTRACT

The rangeland in the mountain forest steppe in Mongolia has degraded for the last decades, mainly because of overgrazing. This has challenged the government to improve the land and gather information about the tolerance of the rangeland. Livestock production is an important part of the economy and is based on the natural rangeland. The aim of this research was to test the effect of cutting frequency (four, three, two and one), cutting height (0 and 3 cm) and duration of cutting on aboveground biomass and also to test the effect of grazing exclusion on vegetation cover at different degradation levels of *Fescue-forbs* rangeland. Three sites were selected with different degradation levels; slightly, moderately and heavily degraded. The cutting experiment was a randomized complete block design with five replications. Sampling was carried out in 2006, 2007 and 2008. In 2009 all the plots were cut at the same time in August and at 0 cm height and the results were analysed. The results showed that total biomass was influenced by cutting frequency, cutting height and duration of cutting. The biomass decreased considerably with increasing cutting frequency, in most cases when cutting height was 0 cm, but small changes were noticed when the cutting height was 3 cm. The biomass decreased by 30-54% when cut four times per year at 0 cm in slightly and moderately degraded sites. Years of duration influenced biomass significantly at slightly and heavily degraded sites. The total vegetation cover was higher in ungrazed sites compared with grazed sites within all three degradation levels. Grasses and forbs had improved on ungrazed slightly and heavily degraded sites. This study showed that the intensity of grazing readily influences biomass production but also that recovery of rangeland can be slow when weather conditions are unfavourable.

Key words: rangeland, degradation level, cutting frequency, cutting height, resting impact

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1. INTRODUCTION

Many parts of the world are degraded due to overgrazing and severe climatic conditions (Gunin 1999; Liang et al. 2009). Because of increasing activity of humans less land cover has become available for grazing, which makes it ever more important to manage the land properly (Briske & Heitschmidt 1991). This situation has challenged range managers throughout the world to repair rangelands during the last few decades. To accomplish this, herders and range managers must have a good understanding of the tolerance of rangelands and plants as well as of the ecosystem structure.

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 2011, the total number of herding households in Mongolia doubled and livestock numbers increased by 28.7% and reached over 36.3 million animals (National Statistical Office of Mongolia 1990, 2011). Mongolia has no regulation on the maximum number of livestock allowed, which makes the rangelands potentially susceptible to overgrazing and degradation (Sankey et al. 2009).

In Mongolia the ownership of land has changed in the past decades. For centuries herders moved between places with their herds so the grazing impact was not so intense at each site. Following 1921, when the country came under communists rule, 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 the number of herding households 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 influence the health of rangelands and affect the dynamics of rangeland vegetation (Gunin 1999). The climate has been getting warmer and slightly drier in Mongolia (Batima et al. 2005). An estimation of water resources in 2007 indicated that water resources had decreased during the preceding two decades (Dagvadorj et al. 2010). The 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 erosion (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. In this research I seek to test a) the effect of different grazing management intensities (cutting frequencies and cutting heights) on the aboveground biomass of rangelands with different degradation levels following three years (2006-2008) of utilization and to b) elucidate the influence of five years (2004-2009) of protection from grazing on vegetation cover of different degradation levels. To approach these objectives the research was applied on *Fescue-forbs* rangelands in mountain forest steppe of Mongolia.

2. MATERIALS AND METHODS

2.1 Study area

The study area belongs to the forest steppe belt in the 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). The altitude of the study area ranges from 1793 to 1844 m above sea level.

The climate in 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). 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. 1). During 2004-2009 the annual temperature fluctuated; the highest temperature was in 2007 and the lowest was in 2005 (Fig 2a). Within each of these years annual temperature was usually higher than the long-term average except in 2005.

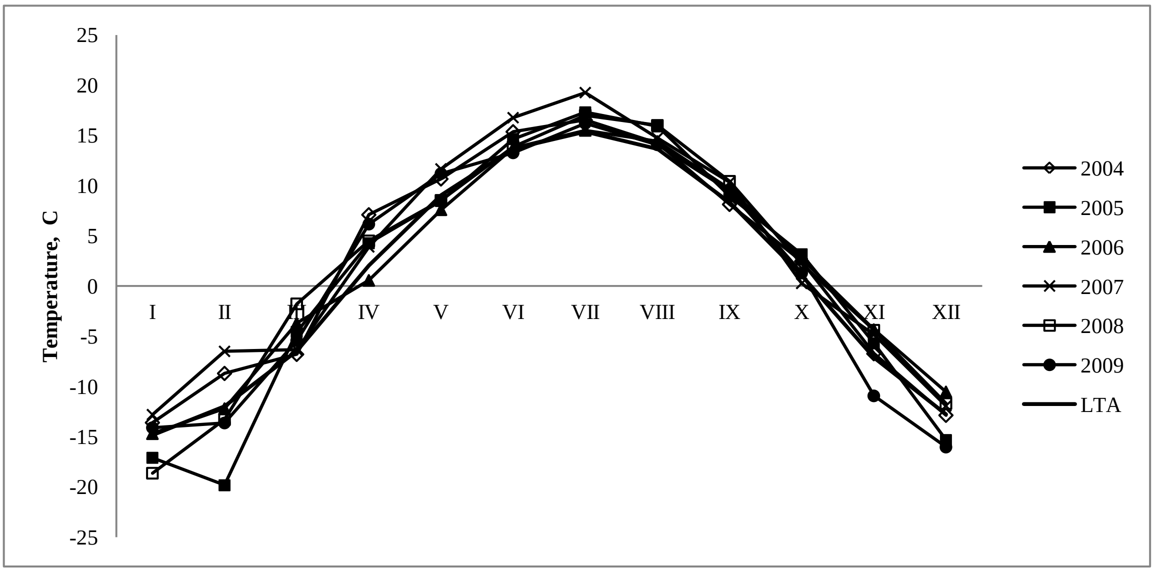

Fig. 1. *Average air temperature (°C) by months at the Tsetserleg station in Arkhangai province and long-term average of climate data from 1970-2010 (LTA). (Institute of Meteorology and Hydrology 2012).*

The average long-term (1970-2010) precipitation is 329.3 mm (Fig 2b) (Institute of Meteorology and Hydrology 2012). During the study period the annual precipitation was always lower than the long-term average except for 2007; however, the summer precipitation (about 190 mm) was mainly after the 20th of August when it was too late for plant growth. On average more than 80% of the precipitation is distributed during the growing season of plants, which is from May to August (Fig 3).

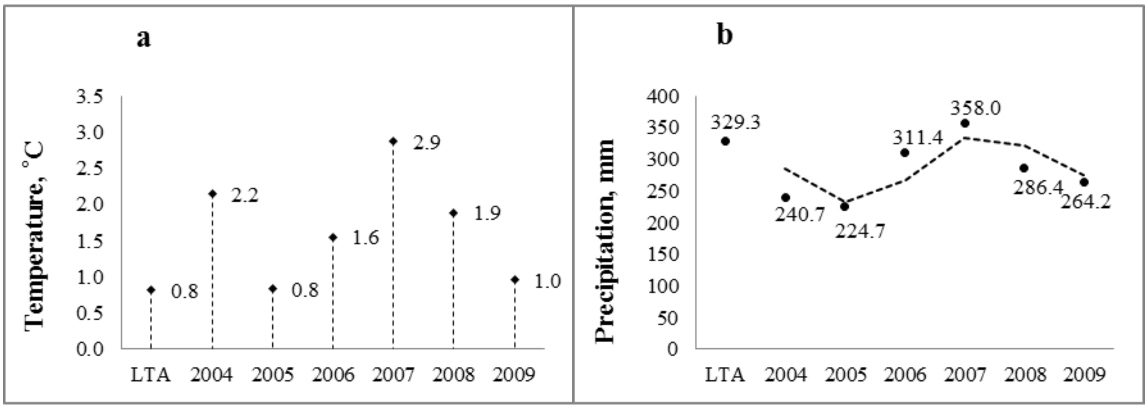

Fig. 2. a) *Annual temperature (°C) and* ***b)*** *precipitation (mm) at the Tsetserleg station in Arkhangai province and long-term average of climate data from 1970-2010 (LTA) (Institute of Meteorology and Hydrology 2012). Tsetserleg station is 80 km from the study area.*

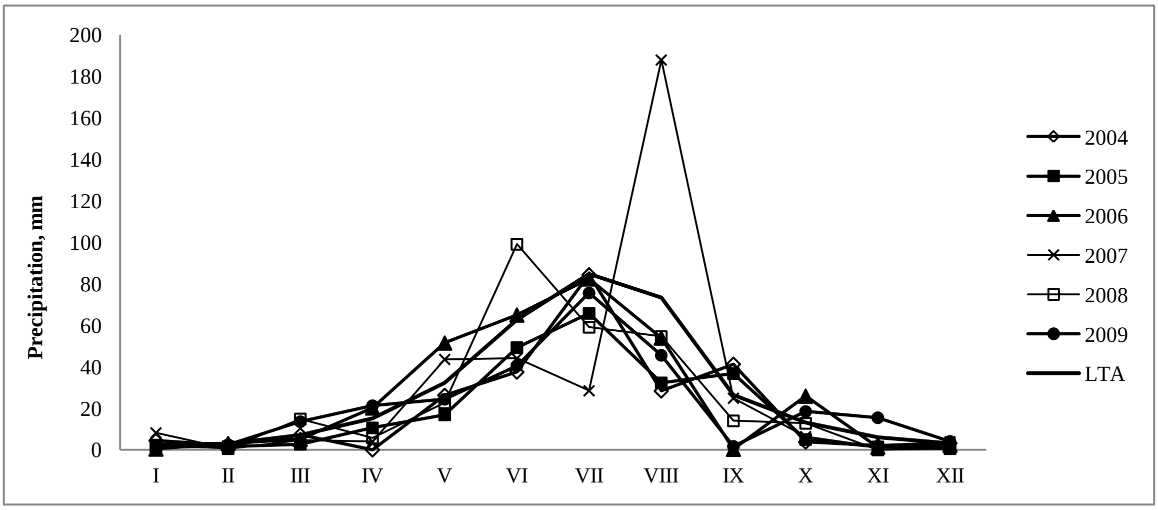

Fig. 3. *Precipitation (mm) by months from 2004-2009 at the Tsetserleg station in Arkhangai province and long-term average of climate data from 1970-2010 (Institute of Meteorology and Hydrology 2012).*

The vegetation in the study area is *Fescue-forbs* community, which is a common vegetation type in mountain forest steppe (Lkhagvajav 2000). The grass *Festuca lenensis* used to be 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 studies (Tserendash 1978; Lkhagvajav 2000). Studies in 2002 have shown that more than 90% of the *Festuca lenensis* cover and abundance has decreased since 1986 (Lkhagvajav 2000; Lkhagvajav & Otgontuya 2008).

2.2 Experimental design and methods

Within the study areas are three experimental sites (Table 1). Within each site a 1 ha area with as homogeneous vegetation as possible was fenced off in 2004 and they have been ungrazed since. 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 levels and different types of Fescue-forbs communities in 2004.*

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

The slightly and moderately degraded sites were utilized between October and May and the heavily degraded site from May to the end of September by four types of livestock (Fig 4). Furthermore, that site was a main path of livestock moving between grazing areas until 2000 and therefore heavily utilized. The area outside of each fence was grazed during the study.

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

2.3 Cutting experiment

The cutting experiment included three factors (Table 2). 1) Cutting height: aboveground biomass was cut at two different heights above ground level. At 0 cm the vegetation was cut at surface level and the other height was 3 cm above the surface. 2) Cutting frequency: aboveground biomass was cut at four different frequencies within the same growing season. The cutting was applied monthly; four times (May, June, July and August), three times (June, July and August) and two times (July and August) and once (August). 3) Duration: the duration of the cutting treatments was different; for three years (2006-2008), two years (2007-2008) and one year (2008).

In total, 360 plots with different degradation levels were randomly chosen for the cutting experiment within the three fenced areas. Within each fence a total of 120 (1x1 m) plots were randomly chosen and plots were separated from each other by 0.5 m buffer strips. During the first year of the study (2006) five plots were randomly chosen for each cutting frequency and cutting height, in total 40 plots (Table 2). The duration of cutting treatments for those plots was three years; they were cut the same way in 2006, 2007 and 2008. In 2007 and 2008 two other sets of plots were selected following the same setup. Plots established in 2007 were cut for two years and those established in 2008 for one year. In 2009 all 360 plots were cut once in August at 0 cm. Each treatment was randomly assigned to five blocks, or replicates, and the design of the experiment was fully factorial.

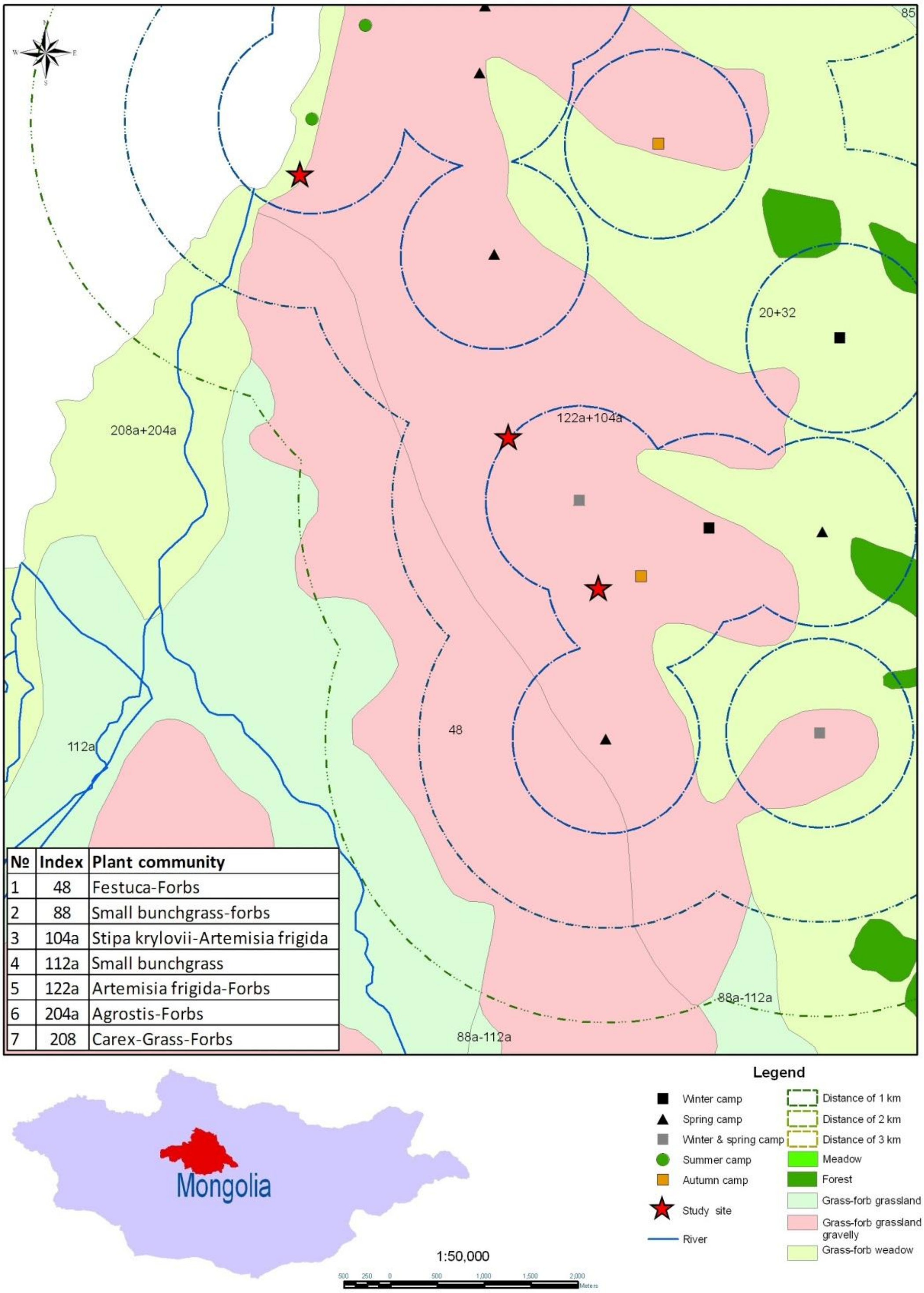

Fig. 4. *Location of experimental sites at the study area in Ikhtamir soum, Arkhangai province, Mongolia. The heavily degraded site is to the left, moderately degraded in the middle and slightly degraded site to the right.*

The measurements were carried out during the growing season, from May to August (Table 2). Biomass was obtained from the plots on the 20th of every month and cutting was done by hand. All plant material was air dried at room temperature for 20-25 days and then weighed.

In the beginning of April each year, before the growing season, dead biomass from the previous year was removed.

Table 2. *Treatments repeated within fenced area of each experimental site. The treatments included different cutting heights (0 and 3 cm), different cutting frequencies (4=May, June, July and August, 3=June, July and August, 2=July and August and 1=August). Numbers indicate number of plots for each cutting height and cutting frequency. Treatments started in 2006 and duration of treatments varied (one year=2008, two years=2007-2008 and thre years=2006-2008). Each treatment was replicated five times. In 2009 all plots were cut at 0 cm during the peak yield period (in August).*

Year	Cutting height-cutting frequency				Cutting height-cutting frequency			
2006	0-4	0-3	0-2	0-1	3-4	3-3	3-2	3-1
2007	0-4	0-3	0-2	0-1	3-4	3-3	3-2	3-1
2008	0-4	0-3	0-2	0-1	3-4	3-3	3-2	3-1
2009	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1

2.4 Vegetation cover measurements

To study the effect of resting on vegetation composition, measurements were applied inside the fence where vegetation was ungrazed and outside the fence where grazing continued after 2004. Five plots (1x1 m) were randomly selected for measurement of vegetation cover inside the fence and five outside the fence. The design followed the methodology of Ramenskii (1971) which is 1 m^2 sets. Each 1 m^2 set is divided into 100 parts and one part equals 1%. Vegetation cover of each individual species was measured on the 20th of July from 2004 to 2009.

2.5 Analysis

To estimate the effect on total biomass of different cutting heights and cutting frequencies during the years 2006-2008 two-way ANOVA for block design was run on data from 2009 (Fowler et al. 2010). Each treatment was replicated five times. Each different degradation level was analysed separately. With two-way ANOVA you get differences between cutting frequencies and different cutting heights and this indicated whether there was interaction between cutting frequency and height. Two-way ANOVA was also used to estimate the effect on total biomass of duration and cutting frequencies and indicated interaction between duration and cutting frequency by two different cutting heights separately.

In order to obtain information on the vegetation cover of ungrazed and grazed areas the mean and standard errors of the total cover and the main plant functional groups were calculated. I ran two-way ANOVA to test if there was a difference in total vegetation cover between years and between ungrazed and grazed areas. All statistical analysis was performed using SAS (Enterprise Guide 4.2) for Windows.

3. RESULTS

3.1 Effect of cutting on biomass

Overall the ANOVA analyses showed that cutting height and cutting frequency had a significant effect on biomass in both slightly and moderately degraded sites, regardless of duration of cutting (Table 3). In the heavily degraded site cutting frequency and cutting height were not significant, except for cutting height for two and three years of cutting (Table 3). Furthermore, treatment duration had different effects depending on cutting height (Table 4).

Table 3. *Results of two-way ANOVA for aboveground biomass in plots harvested in 2009 in slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites. CF=different cutting frequencies, CH=cutting height, Duration=duration of treatments. Bold figures indicate significant differences (P<0.05).*

Treatment	Source	*DF*	Duration					
			One year		Two years		Three years	
			F	***Pr > F***	***F***	***Pr > F***	***F***	***Pr > F***
Slightly degraded	Replicate	4	2.99	**0.0359**	1.14	0.3575	0.25	0.9102
	CF	3	4.23	**0.0138**	9.28	**0.0002**	3.97	**0.0178**
	CH	1	13.06	**0.0012**	35.57	**<.0001**	43.46	**<.0001**
	CF*CH	3	3.23	**0.0375**	2.08	0.1257	2.33	0.0961
Moderately degraded	Replicate	4	1.72	0.1743	1.24	0.3149	1.38	0.2661
	CF	3	3.33	**0.0337**	6.24	**0.0022**	5.41	**0.0046**
	CH	1	13.39	**0.001**	30.7	**<.0001**	7.06	**0.0129**
	CF*CH	3	1.42	0.2574	2.24	0.1053	1.83	0.1647
Heavily degraded	Replicate	4	0.32	0.8615	3.92	**0.0119**	4.13	**0.0093**
	CF	3	2.5	0.0798	2.09	0.1248	2.62	0.0706
	CH	1	2.19	0.1502	12.38	**0.0015**	30.23	**<.0001**
	CF*CH	3	0.34	0.7953	1.16	0.3411	0.71	0.5555

Table 4. *Results of two-way ANOVA for aboveground biomass in plots harvested in 2009 in slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites. YD= year duration, CF=different cutting frequencies. Bold figures indicate significant differences (P<0.05).*

Treatment	Source	*DF*	Cutting height			
			3 cm		0 cm	
			F	***Pr > F***	***F***	***Pr > F***
Slightly degraded	Replicate	4	2.92	**0.0314**	1.17	0.3367
	YD	2	1.84	0.171	12.76	**<.0001**
	CF	3	2.07	0.1176	20.34	**<.0001**
	YD*CF	6	0.94	0.4739	1.25	0.2985
Moderately degraded	Replicate	4	1.7	0.166	1.46	0.2319
	YD	2	0.15	0.8577	0.4	0.6707
	CF	3	1.84	0.1538	13.28	**<.0001**
	YF*CF	6	0.29	0.9369	1.18	0.3324
Heavily degraded	Replicate	4	3.69	**0.0113**	2.24	0.0802
	YD	2	0.79	0.4581	6.38	**0.0037**
	CF	3	3.92	**0.0146**	2.63	**0.062**
	YD*CF	6	1.24	0.3064	0.21	0.971

Within the slightly degraded site the cutting frequency had no significant effect (P<0.1176) on biomass when the cutting height was 3 cm (Table 4; Fig. 5). The biomass decreased considerably with increased cutting frequency when the cutting height was 0 cm. During the first year the biomass decreased by 34% when cut four times compared to one cutting. During the second and third years the biomass decreased by 53-54% when the vegetation was cut four times compared with a single cutting at 0 cm (Fig. 5). Interaction between cutting frequency and cutting height was significant (P<0.0375) at year one but not significant (P>0.05) for years two and three (Table 3). Duration of treatments significantly affected biomass when the cutting height was 0 cm (Table 4). For example, the biomass was 594.2 kg/ha when cut four times for one year but 377 kg/ha when cut four times for three years (Fig. 5). Interaction between year duration and cutting frequency (YD*CF) was not significant (P>0.05) regardless of cutting (Table 4).

Within the moderately degraded site the biomass decreased slightly when cutting height was 3 cm and frequency increased; however there was no significant difference for cutting frequency (P<0.1538) (Table 4; Fig. 5). On the other hand, cutting frequency had a highly significant (P<.0001) effect when the cutting height was 0 cm. The effect of duration in years of treatments was not significant (Table 4). When cut at 0 cm the biomass was 30% less during the first year when cut four times compared with a single cutting (Fig. 5). After two and three years of cutting the biomass was 37% and 50% less, respectively, when cut four times compared with a single cutting (Fig. 5). The interaction between cutting frequency and cutting height was not significant (P>0.05) in all different year durations at the moderately degraded site (Table 3).

Within the heavily degraded site cutting height had a significant effect on biomass when treatments had been repeated for two and three years (Table 3). In general, the biomass was less in plots that were cut at 0 cm (Fig. 5). Cutting frequency only significantly (P<0.0146) affected the biomass when cutting height was 3 cm, and the duration of treatments was significant for 0 cm (Table 4).

3.2 Resting impact on rangeland vegetation cover

Total vegetation cover was similar (52-55%) within fenced areas in each experimental site during the first year (2004) of the study (Fig. 6). 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. In 2009 the pattern of dominant species groups was similar to 2004 (Fig. 6). However, in general total vegetation cover and the cover of plant functional groups were lower than in the beginning of the study.

A comparison of ungrazed and grazed sites showed that the total vegetation cover and the cover of plant functional groups was in all cases lower in the grazed areas (Fig. 7). The exception was in the moderately degraded site where the cover of grasses was higher within the grazed area, forbs where higher within the grazed area in the heavily degraded site, and the cover of sedges was higher in grazed areas at all degradation levels (Fig. 7). The cover of grasses was much lower within the grazed site at the heavily degraded site.

Examination of the variation of total vegetation cover among years within both the ungrazed and grazed sites showed fluctuation among years. (Fig. 8) The total vegetation cover was significantly different (P<0.0001) among years at all degradation levels (Table 5). The total vegetation cover was 18-22% higher in the ungrazed site of the slightly degraded site, 8-10%

in the ungrazed site of the moderately degraded site, and 39-58% in the ungrazed site in the heavily degraded area in 2005 to 2006 (Fig. 8). In most years the total vegetation cover was higher (P<0.05) at ungrazed sites than grazed ones (Table 5). The cover was lower at all sites in 2007 through 2009 (Fig. 8).

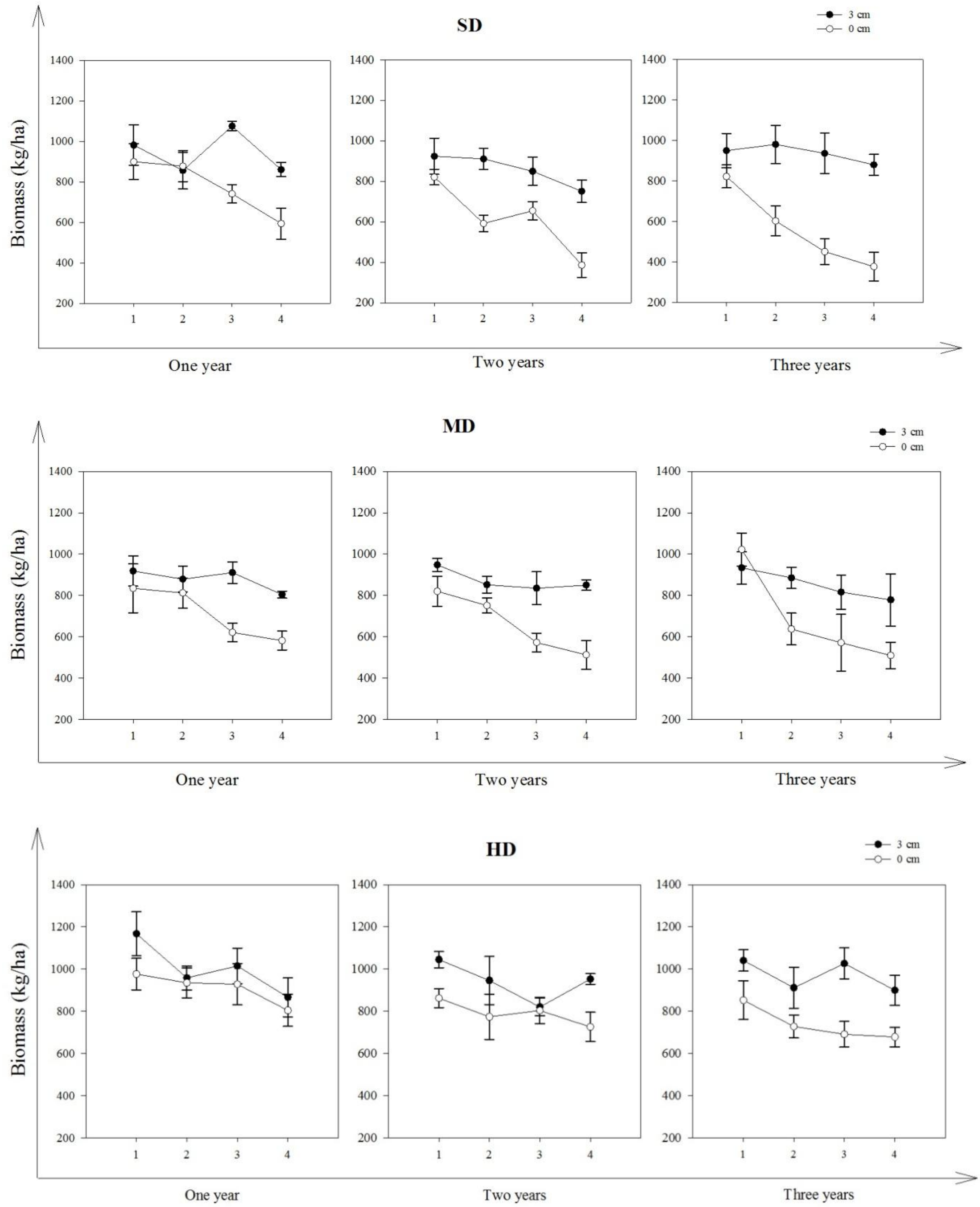

Fig. 5. *Weight (kg/ha) of aboveground biomass in 2009 within slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites. The treatments included different cutting heights (0 and 3 cm), different cutting frequencies (1=August, 2=July and*

August, 3=June, July and August, and 4=May, June, July and August,) and different duration of treatments (one year=2008, two years=2007-2008 and three years=2006-2008).

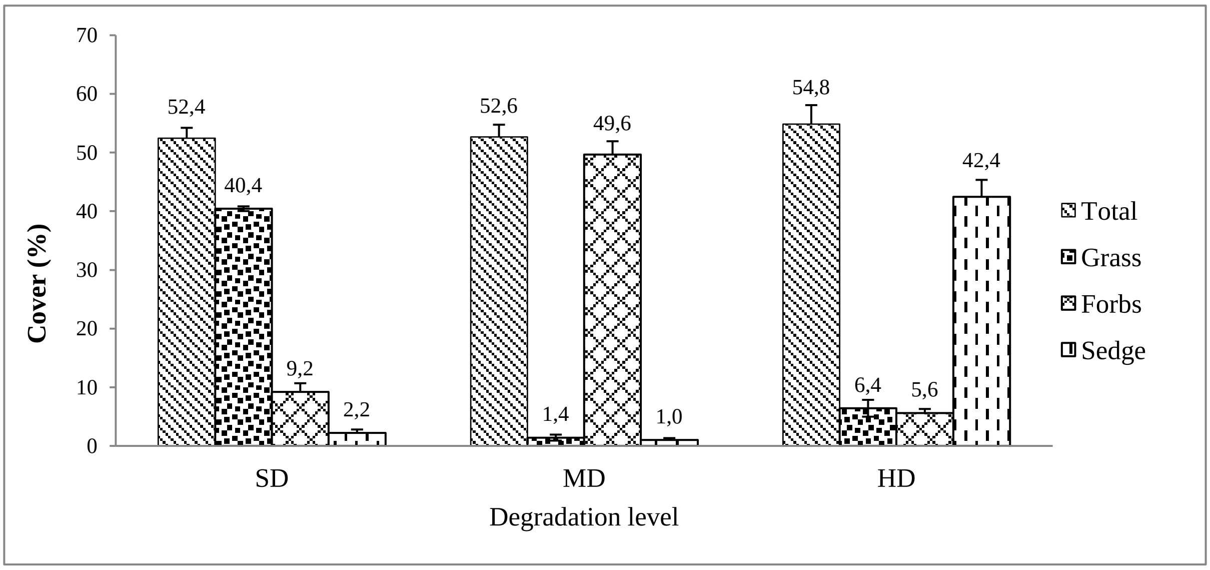

Fig. 6. *Total vegetation cover and cover of grasses, forbs and sedges (%) of Fescue-forb rangeland in 2004 in slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites.*

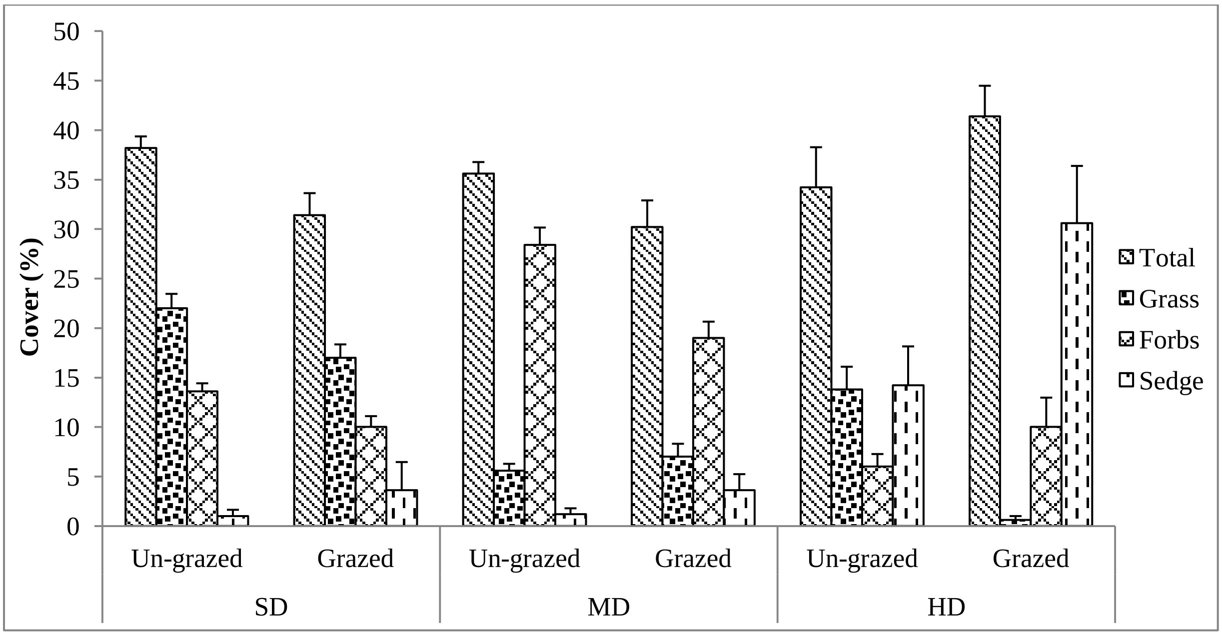

Fig. 7. *Total vegetation cover and cover of grasses, forbs and sedges (%) of Fescue-forbs rangeland in 2009 in ungrazed area and grazed areas of slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites.*

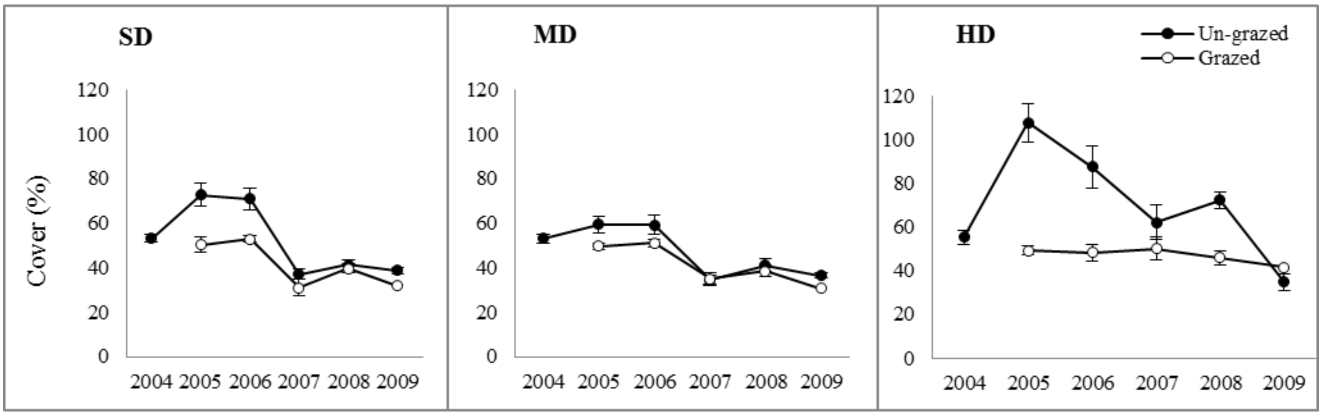

Fig. 8. *Total vegetation cover by year within ungrazed and grazed areas of slightly degraded (SD), moderately degraded (MD) and heavily degraded (HD) sites.*

Table 5. *Results of two-way ANOVA for resting impact on vegetation cover changes of different degradation levels of Fescue-forbs rangeland. Bold figures indicate significant differences (P<0.05).*

Treatment	**Source**	***DF***	***F Value***	***Pr > F***
Slightly degraded	Year	5	33.2	**<.0001**
	Resting impact	1	27.6	**<.0001**
	Year* Resting impact	4	4.9	**0.0023**
Moderately degraded	Year	5	30.3	**<.0001**
	Resting impact	1	6.7	**0.0132**
	Year* Resting impact	4	2.3	0.0695
Heavily degraded	Year	5	16.7	**<.0001**
	Resting impact	1	35.6	**<.0001**
	Year* Resting impact	4	13.4	**<.0001**

4. 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 gave an indication of the vegetation changes that can be observed in *Fescue-forbs* rangeland following different grazing intensities (Fig. 6). However, it has to be kept in mind that the three sites varied to some extent in characteristics; for example, the heavily degraded site was about 500 m from the Khanui River, the moderately degraded site 4.5 km, and the slightly degraded site 6.5 km from it.

In a study in the northern Flint Region of Kansas three palatable forbs species from ungrazed, low, moderate and high grazed areas were studied by Hickman and Hartnett (2002). The results showed that when the grazing intensity increased, the total shoot biomass and percentage of reproductive stems of *Ruellia humilis* decreased. At the same time, stem height was reduced and total shoot biomass of *Aster ericiodes* significantly decreased due to increased grazing intensity.

In a study in north-eastern Inner Mongolia grazing intensity negatively affected plant growth and dominant plant species changed from the original when moving from the reference area to a heavily grazed area (Liang et al. 2009). The aboveground biomass also decreased with increased degradation. Other results from the Mongolian steppe zone also showed that grass cover, palatable species and aboveground biomass were lower in a heavily grazed area compared with a lightly grazed area (Yoshihara et al. 2009).

The percentage of annual aboveground biomass utilized by herbivores varies greatly, but estimates generally range between 20% and 50% (Briske & Heitschmidt 1991). Although much higher levels of utilization can occur, in excess of 90%, they are generally restricted to specific regions or year.

The results of this study showed reduction of aboveground biomass due to different cutting frequencies and cutting height (Fig. 5). Cutting more than twice and lower (0 cm) cutting height highly affected the aboveground biomass in slightly and moderately degraded *Fescue-forbs* rangeland. Within the heavily degraded site the sod forming grass *Carex duriuscula* was dominant. This species is tolerant of grazing and usually grows in heavily grazed areas and it is also a palatable species for livestock (Yunatov 1954).

When cut four times the cutting period started in May and ended in August, with one cutting per month, but started the following month as cutting frequency became lower (Table 2). It is well known that plants are more sensitive to grazing in spring and more resistant in summer. Studies in Mongolia have shown that as cutting frequency increased the total biomass decreased during the first year in meadow rangeland (Baatar 2008). The present study showed similar results; with increased cutting frequency the total biomass decreased in all three experimental sites when vegetation was cut at 0 cm (Fig. 5). Similar result were obtained in Mongolian meadow rangeland; the cutting frequency was twice a year at 0 cm, where the yield decreased by 25-44% on the second year but no biomass reduction was detected when cut at 3 cm (Baatar 2008). In this study the year duration treatment was significantly different in terms of 0 cm cutting at the slightly and heavily degraded sites, but no difference between years was found in the moderately degraded site in the *Fescue-forbs* rangeland (Table 4).

Resting is a well-known method to restore rangeland 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 the evolutionary history of herbivores (Díaz et al. 2002). Different plant traits can predominate in areas with the same annual precipitation and livestock density, depending on whether or not grazing has been a strong selective pressure over evolutionary time. Heavy grazing is associated with a 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 is the factor that changes the species abundance on the steppe rangeland in Mongolia the most according to a study by 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 my study the grazing tolerant species *Carex duriuscula* was dominant within the heavily degraded site, *Artemisia frigida* within the moderately degraded site, and within the slightly degraded site grasses were dominant (Fig. 6).

In most cases in the present study total vegetation cover was higher in the ungrazed than in the grazed areas (Fig. 7). Total vegetation cover was the highest in the ungrazed sites after one and two years of resting at all three degradation levels (Fig. 8). The lowest vegetation cover was in 2007 in both ungrazed and grazed sites (Fig. 8), which could be related to drought during June and July that year and a high annual air temperature (Fig. 1; 2). We believed that accumulation of litter at the study sites negatively affected grass tiller and plant growth in the ungrazed site. Therefore we removed the litter by hand from the ungrazed site in April 2007 to 2009. In 2009 the cover of grasses and forbs was higher in the ungrazed area compared to the grazed area at the slightly degraded site, the forbs cover was higher in the moderately degraded site, and cover of grasses was higher in the heavily degraded site (Fig. 7). Similarly, a study in the forest steppe zone in Mongolia showed that total plant cover was higher within a fenced area (Fujita et al. 2009).

5. CONCLUSIONS

The total aboveground biomass was influenced by cutting frequency and cutting height and duration of cutting. In general, biomass decreased with increased frequency and duration and lower cutting height. However, there is another important factor that strongly influences the biomass production of a rangeland and that is the timing of grazing. It is clear that grazing intensity is important when it comes to utilization and sustainability issues. This study showed that rangeland production or livestock forage are easily disturbed due to utilization but rangeland recovery is slow given the dry condition of Mongolian rangelands. Therefore, I would recommend that Mongolian herders and range managers adjust their grazing intensity in conformity with the rangeland health and weather conditions.

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