Influence of grazing on vegetation, surface energy balance and water balance over the Mongolian steppe

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Introduction

Mongolia in the earthen Eurasia locates in arid to semi-arid area. Since 1990, the social system in Mongolia has changed radically, and resulted in transformation of lifestyle and the way of grazing. The serious influence of such a change is anticipated because Mongolian grassland is a sensible area to the changes of external conditions (Sugita et al., 2006). In addition to the condition in Mongolian steppe, the interannual variation in precipitation influenced aboveground biomass (Fernandez- Gimenez and Allen-Diaz, 1999) and increase of surface temperature and decrease of precipitation according to the climate change in recent year were reported (Yatagai and Yasunari, 1994). Therefore the long-term research is necessary.

The object of this study is to assess influence of grazing on vegetation, surface energy balance and water balance over the Mongolian grassland through three-year research.

Methods

(1) Site description

The study site is a steppe grassland in Kherlen Bayaan-Ulaan (KBU, 47˚ 28'N, 108˚ 78'E, 1200 m above mean sea level), and locates at some 250 km southeast of Ulaanbaatar. The mean annual temperature is 2˚C and the mean annual precipitation is 202 mm during 1993-1998. Grazing has been carried on all the year round. In this area, a protected area (200 m by 170 m) was constructed in autumn 2002 in order to study the possible grazing impact.

(2) Grazing intensity data

The grazing intensity was evaluated from the statistics showing the number of registered animal by the State Statistical Office, Mongolia.

(3) Measurements

Two flux stations which employ on eddy correlation method, one in a protected area and the other in a pastoral area, have been installed and operated since March 2003. At those stations, heat balance (W m^{-2}), volumetric water contents (%) and precipitation (mm) were measured continuously, while aboveground biomass (g m^{-2}), vegetation height (m) and leaf area index (LAI) were also measured between June and September 2003, July 2004 and August 2005.

Results

(1) The grazing intensity

A simulation study by Chen et al.(2006) suggested that the maximum sustainable grazing intensity was 0.7 sheep equivalent unit per ha at KBU. Figures 1 shows in KBU grazing intensity during winter is higher than 0.7.

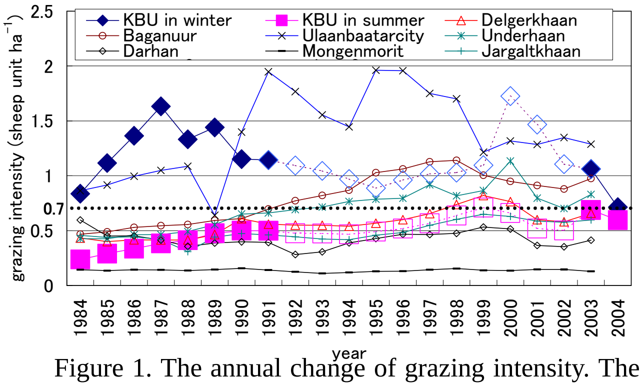

Figure 1. The annual change of grazing intensity. The values except for KBU are sheep equivalent unit (SEu) per each district area. For KBU village, which is a part of Delgerkhaan district, the values in summer and winter are given as SEu per KBU grazing area in summer (62856 ha) and in winter (130000 ha), respectively. The KBU values between 1992 and 2002 are estimated by those form the other years.

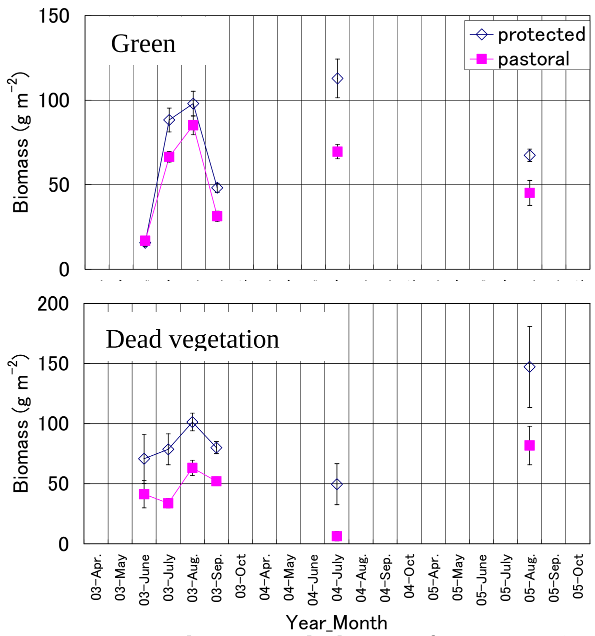

Figure 2. The seasonal change of Biomass. (2003 data by Urano, 2005)

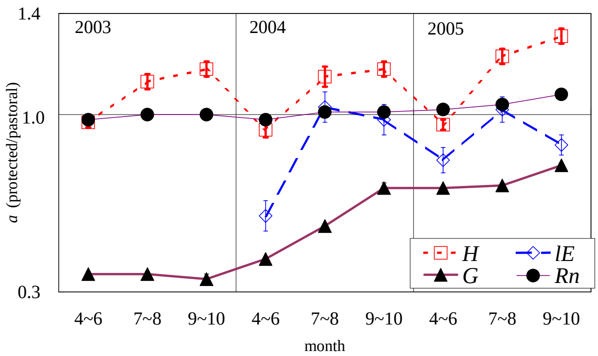

Figure 3. The seasonal change of regression coefficient a values ($F_{protected} = a\ F_{pastoral}$, F; the 30-minute average values of surface heat balance).

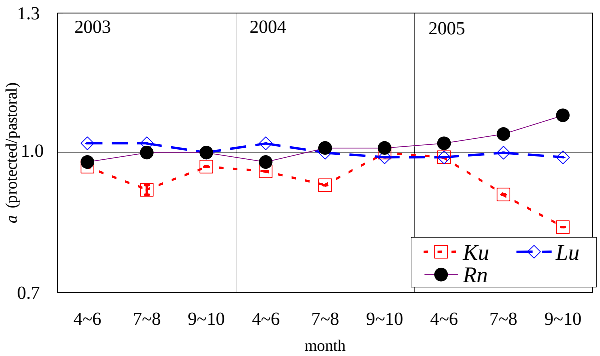

Figure 4. The seasonal change of regression coefficient a values ($F_{protected} = a\ F_{pastoral}$, F; the 30-minute average values of surface radiation balance).

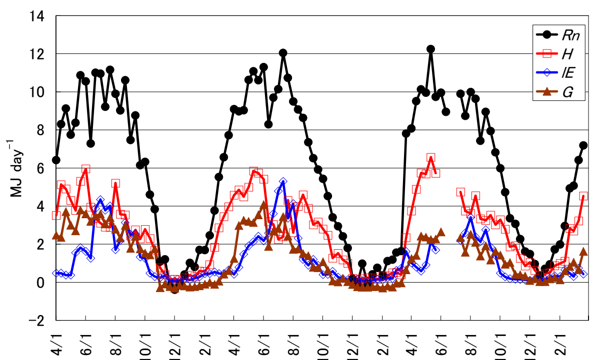

Figure 5. The seasonal change of daytime integrated values of surface heat balance in pastoral area.

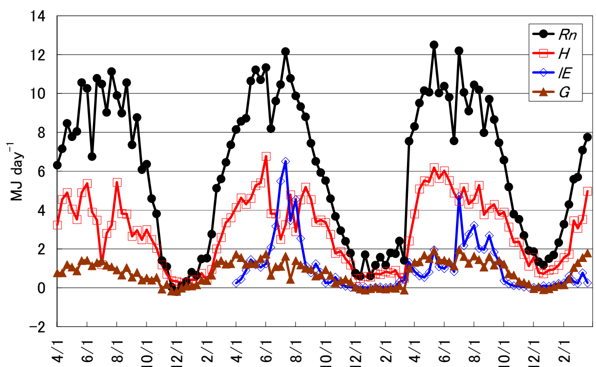

Figure 6. The seasonal change of daytime integrated values of surface heat balance in protected area.

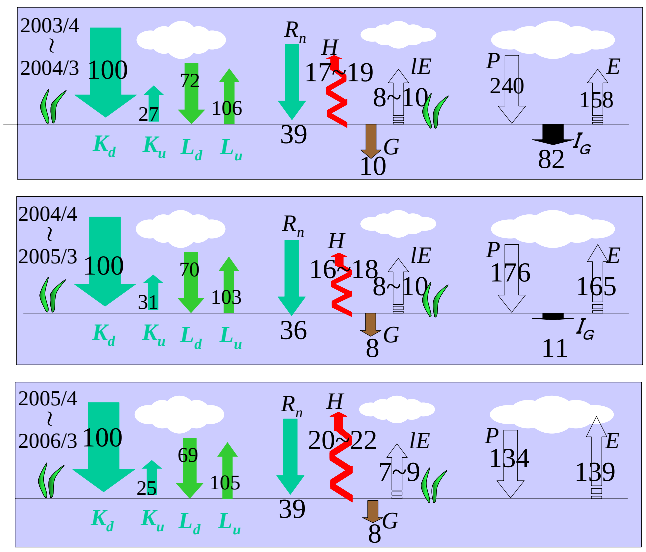

Figure 7. The annual daytime integrated values of surface heat balance (the ratio of downward short wave K_d) and water balance (mm) in pastoral area.

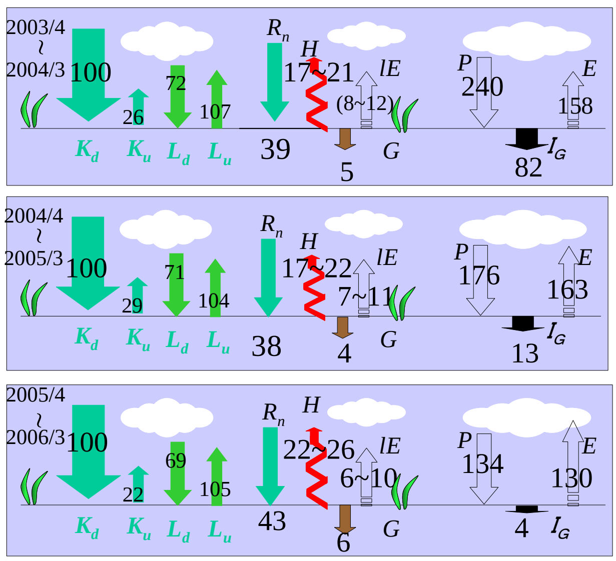

Figure 8. The annual daytime integrated values of surface heat balance (the ratio of K_d) and water balance (mm) in pastoral area.

(2) Relationship between vegetation and grazing

Figure 2 shows that the difference of the green biomass values of the two areas appears significantly after July and the values of both areas in 2004 are higher than in 2003 in spite of no significant difference of precipitation in growing season between the two years. And the value of dead vegetation biomass in the protected area is constantly bigger than that in the pastoral area. Therefore the grazing activity appears to have controlled biomass.

(3) Relationship between surface energy, water balance and grazing.

Figures 3 and 4 show the seasonal change of regression coefficient *a* values ($F_{protected} = a\ F_{pastoral}$, F; the 30-minute average values of surface energy balance) of surface heat balance and radiation, respectively. After July in 2004, *a* values of net radiation R_n values are lager than 1.0, and therefore the R_n values of protected area are higher than those of pastoral, which corresponds with results of biomass and albedo (upward short wave radiation K_u). The result of R_n values causes the higher values of soil heat flux G and H in protected area. For H values in protected area, the bigger values of roughness length, because of the bigger values of biomass, also contribute to the higher fluxes.

In 2004 and 2005, evaporation values were almost same as precipitation (Fig. 5 and 6). This result is in agreement with Batima and Dagvadori (2000) who reported in Mongolian steppe 90.1% of the annual precipitation was evaporated. In 2003, the infiltration value was higher. This is because of larger number of major rainfall events (> 10 mm) (Table 1) and the larger number of the infiltration to the deeper layers (Figure 9 and 10).

In addition to the results mentioned above, there is no significant difference of the annual integrated values of latent heat flux *lE* between both areas (Figures 7 and 8). The result agrees with the simulated one by Chen et al.(2006); the reduction of transpiration by grazing in pastoral area is largely compensated by the increase of evaporation.

Table 1. The number of rainfall event

2003	12	11
2004	9	5
2005	9	1

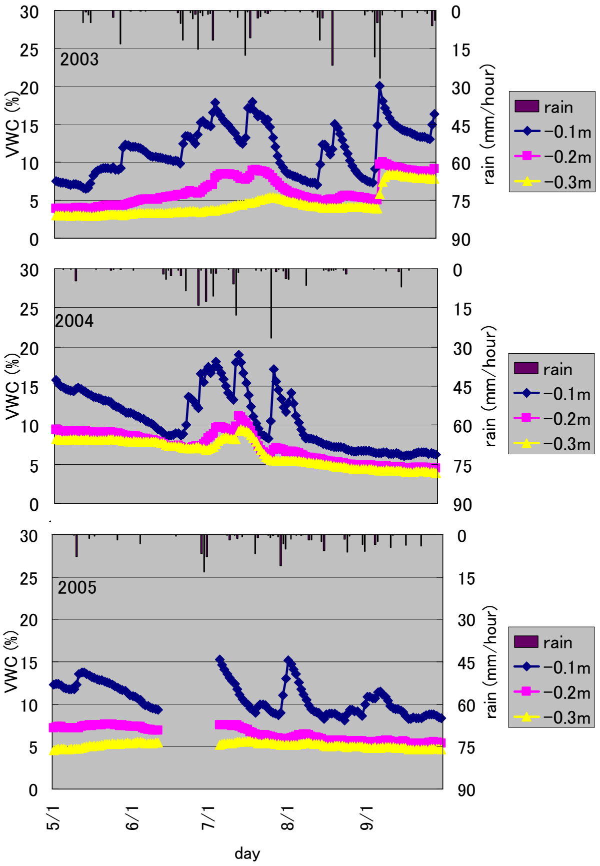

Figure 9. The seasonal change of precipitation and soil moisture values in pastoral area

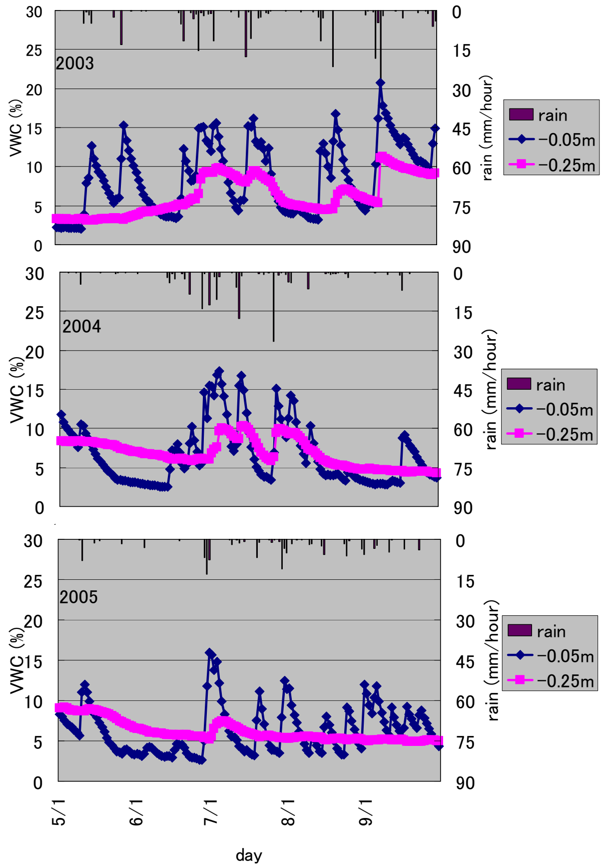

Figure 10. The seasonal change of precipitation and soil moisture values in protected area

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