Chapter V　Ecosystem

Characteristics of grassland soil of the northeastern Mongolia

Introduction

The rangelands of Mongolia are primarily a region of semiarid steppe, where the most prominent soil-forming process is the translocation of calcium carbonate ($CaCO_3$) from the surface soil to an accumulation layer at varying depths (Bk horizon). The depth and composition of salts in the Bk horizon depend strongly on soil water flow and mean annual precipitation. In this study, we clarified the soil characteristics in the steppe region of the northeastern Mongolia.

Methods

Morphological and physico-chemical characteristics of five soil profiles were studied [(1)]. Study sites were located in the villages of Baganuur (BGN), Jargalthaan (JGH), Kherlenbayan-Ulaan (KBU), Underhaan (UDH), and Darhan (DH) of the Kherlen River basin of Mongolia. BGN was located on mountain forest steppe, while JGH, KBU, UDH, and DH were located on steppe.

Plant compositions and Soil properties

Floristic compositions reflected varying moisture conditions among the study sites [(1)]. BGN and JGH were relatively humid, DH and UDH were relatively dry, and KBU had moderate conditions. The soil profile morphologies were characterized by the presence of a mollic horizon and the Bk horizon (Fig. 1). The Bk horizons appeared at shallower depths in the southern sites.
Regarding chemical properties, there was a significant difference in the inorganic carbon content, pH, EC, and water soluble ions in the Bk horizons.

The amount of water soluble ions tended to increase in the Bk horizon at drier sites [(1)]. These differences reflect the amount of precipitation, potential evapotranspiration and properties of groundwater at each study site.

Soil characteristics and soil degradation

Fig. 2 summarizes the dominant plant species, morphology and physico-chemical characteristics of the studied soils at each study sites. At drier sites, soil degradation caused by grazing is more advanced due to low precipitation, thin vegetation cover, and soil compaction. The present morphology and physico-chemical characteristics suggest that even if the same soil degradation were to occur throughout this river basin, the grassland ecosystems in UDH and DH would be more heavily damaged and require more time for reclamation than soils in BGN, JGH, and KBU, although the five soils were classified as Kastanozems, essentially in the same soil group. These differences reflect differences in the thickness of the A horizon and the depth of the Bk horizon, which is characterized by an alkaline and high salt content.

Fig. 1 Picture of soil profile at JGH for example. White colored horizon is the Bk horizon.

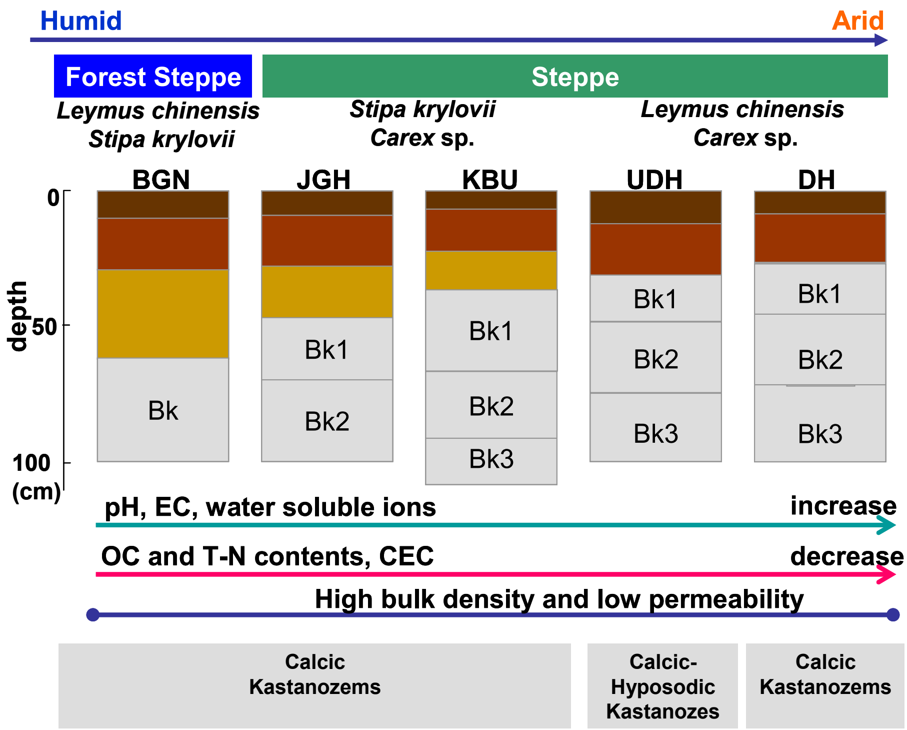

Fig. 2 Schematic diagram of the physico – chemical characteristics of the studied soils. Soil pH, EC, water soluble ions were increase, while organic C and total N were decrease with drier site.

References:
(1) Asano et al., 2007: J. Hydrol., 333 100-108.

Species composition of grassland in central Mongolia

Introduction

We investigated species composition of a plant community to comprehend qualitative information of grassland under over-grazed environment in Kherlen Bayan-Ulaan, Mongolia (Fig. 1).

Methods

We carried out field survey to clarify species composition in 2002. We measured plant height and coverage for each species at 36 points using 1 m^2 quadrate. We calculated summed dominance ratio (SDR_3) was derived from the measures of plant height, coverage and occurrence frequency.

Species composition and biomass

We found 28 species in study site in 2002 (Table 1). These species showed exponential relations between occurrence frequent ranking of each species and score of SDR_3. It became clear that two species of *Artemisia adamsii* and *A. frigida* did dominance in study site.

From the above, we concluded the *Artemisia* genus did dominance at grassland under over-grazed environment in Kherlen Bayan-Ulaan.

Fig. 1 Landscape of grassland in Kherlen Bayan-Ulaan.

Table 1 Mean coverage (C: %), mean plant height (H: cm), frequency (F: %) and SDR_3 in the stand in summer, 2002.

Species	C	H	F	SDR_3
Artemisia adamsii	1.33	15.0	27.0	77.1
Artemisia frigida	1.15	15.7	26.0	72.2
Heteropappus altaicus	0.21	10.0	32.0	48.9
Stipa krylovii	0.23	9.3	32.0	48.7
Cleistogenes squarrosa	0.28	8.0	31.0	47.6
Caragana stenophylla	0.28	19.4	15.0	42.8
Carex sp.	0.06	7.6	30.0	40.7
Kochia scoparia	0.09	6.0	30.0	39.9
Linum stelleroides	0.20	32.0	1.0	39.4
Astragalus galactites	0.05	4.0	25.0	31.4
Potentilla bifurca	0.11	4.6	21.0	29.4
Convolvulus ammannii	0.10	5.3	16.0	24.7
Haplophyllum dauricum	0.04	7.1	14.0	23.0
Chenopodium acuminatum	0.08	13.8	4.0	20.5
Stellaria sp.	0.12	8.8	8.0	20.5
Caragana microphylla	0.20	13.0	1.0	19.6
Potentilla acaulis	0.34	2.9	7.0	18.9
Chenopodium aristatum	0.04	13.0	4.0	18.7
Leymus chinensis	0.04	13.0	4.0	18.7
Salsola collina	0.04	15.0	2.0	18.7
Bupleurum scorzonerifolium	0.04	6.5	10.0	18.2
Ephedra sinica	0.20	8.0	1.0	14.4
Allium tenuissimum	0.04	10.0	2.0	13.5
Cymbaria dahurica	0.04	7.0	4.0	12.5
Agropyron cristatum	0.09	6.7	3.0	12.4
Potentilla tanacetifolia	0.04	3.9	7.0	12.3
Serratula centauroides	0.04	7.0	1.0	9.3
Koelerla cristata	0.04	4.5	2.0	7.8

References:

(1) Kawada et al., 2007: Submitted to J. Arid Land Studies

Vegetation recovery from abandoned vehicle tracks

Introduction

In Mongolia, over three fourth of the terrestrial ecosystems in the country is subjected to various degrees of desertification. Vehicle tracks are important contributors to desertification. As of 2001, total road length in Mongolia was 11100 km, out of which 75.6% was unpaved earthy tracks. The unpaved earthy tracks are created on-site by compaction of many vehicles driving on the same spoor. As of 1997, vehicle tracks have led to *ca.* 8000-10000 km^2 of land desertified across the country. In this paper, through investigating vegetation and soil surface changes on the abandoned tracks at a central Mongolian grassland, we attempt to address: (1) what plants firstly invade the abandoned tracks, and (2) how soil surface conditions change with the recovery.

Methods

Research site is located in Kherlenbayan-Ulaan (KBU), Hentiy province, Mongolia (47°12.838'N, 108°44.240'E) (Fig.1)[(1)].

There were many unpaved earthy multi-lane vehicle tracks at the KBU steppe. These tracks were created by changing lane, passing, and randomly driving. When its surface conditions became unsuitable for driving, the track was thus abandoned. The abandoned tracks may be naturally recovered through revegetation. At the KBU steppe, we selected two abandoned tracks (Track B and Track C), which were in parallel adjacent to the current track (Track A) (Fig. 1), to investigate the vegetation recovery. Each investigated track extended over 500 m and was 2-3 m in width. A section of the steppe close to Track C (D in Fig. 1) was selected as a reference treatment.

Vegetation recovery

The pioneering plant species that firstly invaded the abandoned tracks are those that could germinate, root and survive in the compacted track surface. <u>*Salsola collina*</u> is one of these candidate plants (B in Fig. 1). Due to revegetation, soil surface hardness was reduced (Fig. 2). With the improvement of surface microenvironmental conditions, other plants began to colonize and establish, concomitantly species richness and species diversity increased.

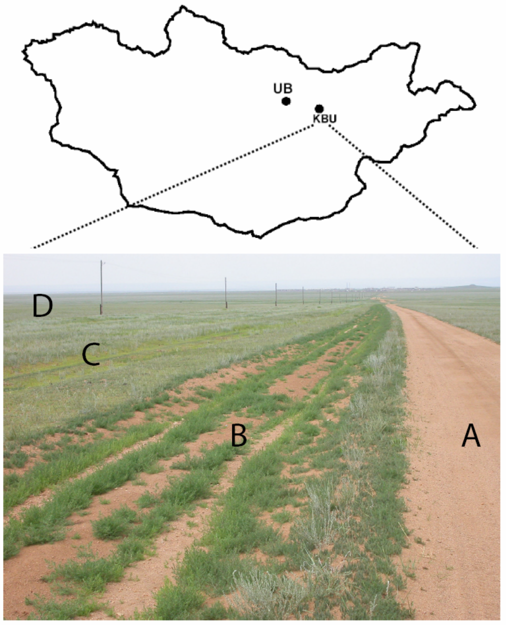

Fig. 1 Location of the study site

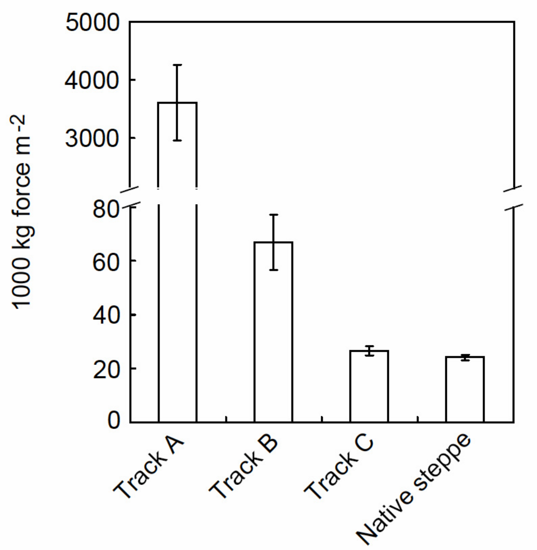

Fig. 2 Variation of soil hardness with the revegetation on the abandoned tracks.

References:
(1) Li S.-G. et al., 2006: J. Biosciences, 31, 101-111.

Vegetation and grazing impact in a Mongolian grassland

Introduction

Steppes are the second largest areas of temperate grasslands and occur in Eurasia where steppes cover 250 million ha of rolling plains that extends as a broad belt across the continent from Hungary to Manchuria(1). Mongolia vegetation is represented by steppes. The present study describes flora and grazing impact in a steppe grassland located at Kherlenbayan-Ulaan (KBU), the Hentiy province of Mongolia (47^{o}13'N, 108^{o}44'E, 1235 m a.s.l.), about 250 km southeast of Ulaanbaatar.

Flora

Table 1 shows the species component and their dominance degree (max 100) of the KBU flora. The number of species found in 36 plots (36×1 m^2) was 28 species. The top three dominants (*A. adamsii, A. frigida Stipa krylovii, H. altaicus*) belong to Compositae. The dominant species are different from those of the prairies in North America, the most extensive temperate grasslands, in which dominant species are tall and/or short grasses. C4 species composition of Mongolian flora shows a strong dominance by Chenopodiaceae, which make up over 50% of the total C4 species(2). This study demonstrated the high abundance of C4 chenopod species. The abundance of Chenopod species is closely correlated with aridity rather than temperature. Mongolian belongs to an Afro-Asian or Saharo Gobian desert region characterized by common features of their desert flora, i.e. a high abundance of Chenopod species.

Grazing impact

In 2002, ungrazed and grazed plots were placed in the KBU steppe grassland. Ungrazing resulted in an increase in vegetation cover and biomass, and a slight decrease. Decline in abundance often occurs as a result of overgrazing(1). Model simulation has shown that the stocking rate for preventing further degradation of grasslands is estimated to be 0.7 sheep ha^{-1}(3).

Table 1 Species and dominance

Species	Dominance
Artemisia adamsii	77.1
Artemisia frigida	72.2
Heteropappus altaicus	48.9
Stipa krylovii	48.7
Cleistogenes squarrosa	47.6
Caragana stenophylla	42.8
Carex korshinskyi	40.7
Kochia scoparia	39.9
Linum stelleroides	39.4
Astragalus galactites	31.4
Potentilla bifurca	29.4
Convolvulus ammannii	24.7
Haplophyllum dauricum	23.0
Chenopodium acuminatum	20.5
Stellaria sp.	20.5
Caragana microphylla	19.6
Potentilla acaulis	18.9
Chenopodium aristatum	18.7
Leymus chinensis	18.7
Salsola collina	18.7
Bupleurum scorzonerifolium	18.2
Ephedra sinica	14.4
Allium tenuissimum	13.5
Cymbaria dahurica	12.5
Agropyron cristatum	12.4
Potentilla tanacetifolia	12.3
Serratula centauroides	9.3
Koelerla cristata	7.8

Table 2 Impact of grazing on vegetation

	Vegetation cover (%)	No. of species (m^{-2})	Biomass (g dw m-^{2})
grazed	52.1	8.8	85.1
ungrazed	54.2	8.0	97.9

References:
(1) Archibold, 1995: Ecology of World Vegetation.
(2) Pyankov et al., 2000: Oecologia.
(3) Chen et al., 2006: Plant Ecology.

Influence of grazing on grassland water and energy balance

Introduction

Mongolia in the earthen Eurasia locates in arid to semi-arid area. Mongolia also locates in an ecotone from the Siberian taiga forest to the Gobi Desert of central Asia, so that vegetation of this area is sensible to the changes of external conditions. The social system in Mongolia has changed radically since 1990, and this resulted in transformation of lifestyle. Thus, the serious influence of such a change is anticipated. At present, it is reported that 97.4% of national land area are grassland and about 70% of which are overgrazed[(1)]. The object of this study is to assess influence of grazing on grassland over the Mongolian steppe through a three-year research.

Methods

The study site is a steppe grassland in Kherlen Bayaan-Ulaan, and locates at some 250 km southeast of Ulaanbaatar. Grazing has been carried on all the year round. In this area, a protected area (200 m by 170 m) was constructed in autumn of 2002 in order to study the possible grazing impact. Two stations by which hydrologic and meteorological phenomena were measured, one in the protected area and the other in a pastoral area, have been installed and operated since March of 2003. We also carried out vegetation measurements of aboveground biomass (dry matter) and vegetation height 1-4 times a year.

Results

(1) Vegetation

AGB (aboveground green biomass) of the protected area was always larger than that of the pastoral area, which shows that protection of the grassland from grazing caused a favorable condition for the growth of vegetation. However, the result of AGB in third year shows that too much dead vegetation. This was because vegetation in the protected area could not be eaten and remained in upstand position, might have disturbed the vegetation growth.

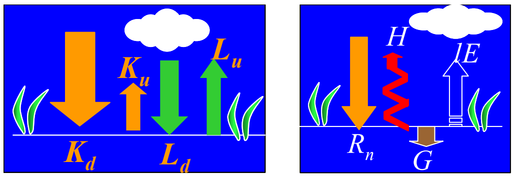

Fig. 1 The images of radiation and heat balance. K and L show shortwave and longwave radiation, respectively. Subscript u and d denote upward and downward. R_n is net radiation ($R_n = K_d - K_u + L_d - L_u$). H, lE and G are sensible, latent and soil heat fluxes, respectively. (Heat balance: $R_n = H + lE + G$)

(2) Energy and water balance

Larger biomass caused albedo (α, reflectivity) of the protected area to be smaller than that of the pastoral area. Therefore, in protected area, the shortwave radiation (solar energy) was absorbed more efficiently, and net radiation was larger. This was why soil heat flux and sensible heat flux (the energy to heat atmosphere from soil surface) were larger. However, influence of grazing on evapotranspiration E didn't appear significantly; there was no significant difference of the annual integrated E values between the two areas during the three years. However there is a possibility that E values were too small to clarify the difference, because the amount of precipitation in this area was small. Further research is necessary.

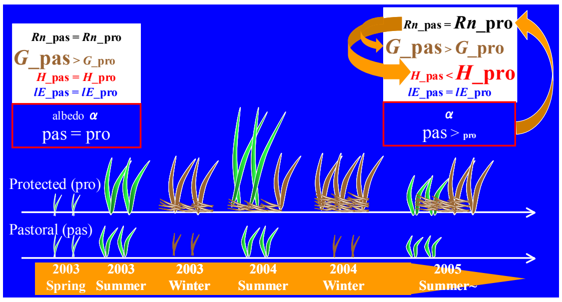

Fig. 2 The annual change of vegetation and heat balance[2].

References:

(1) National Agency for Meteorology, Hydrology and Environment Monitoring (2001): Mongolia's Initial National Communication, Ulaanbaatar.

(2) Kato (2007): MS Thesis, Univ. of Tsukuba.

Productivity of grassland in central Mongolia

Introduction

Grassland covers over 80% of the total land area in Mongolia. The Mongolian grassland has been grazed over many centuries, evaluation of its productivity and how it is used in an ecological perspective is quite important. This study provides some information of the productivity of the grassland in central Mongolia.

Methods

The gross ecosystem productivity (GEP) is the total biomass assimilated by grasses through photosynthesis. This biomass includes its above-ground and below-ground components. The above-ground biomass is grazed throughout year by stocking animals. Measurements of aboveground standing biomass are useful for evaluating the availability of foods to stocking animals. The GEP cannot be measured directly because some GEP is lost due to autotrophic respiration by plants. GEP is usually estimated through indirect method, such as the eddy covariance (EC) technique. The EC approach is now widely used to measure net ecosystem productivity (NEP). Nighttime NEP measured by this method can be used to estimate ecosystem respiration (*R*). The sum of NEP and *R* yields GEP. We used the EC method to measure NEP and estimate GEP. We also used the clipping method to measure the aboveground standing biomass in grazed and fenced grasslands. These measurements were conducted in 2003 at the grassland of Kherlenbayan-Ulaan (KBU), Hentiy province of Mongolia (47°12.838'N, 108°44.240'E)[1].

Biomass distribution in Mongolian grassland

Fig. 1 shows the annual cumulative amount of GEP, NEP and *R*. On the annual basis, the grassland assimilated 437 g biomass m^{-2} y^{-1} (179 g C m^{-2} y^{-1}), and the biomass lost due to ecosystem respiration was 337 g biomass m^{-2} y^{-1} (138 g C m^{-2} y^{-1}). Thus, the biomass available to the stocking animals is around 100 g biomass m^{-2} y^{-1} (41 g C m^{-2} y^{-1})[1].

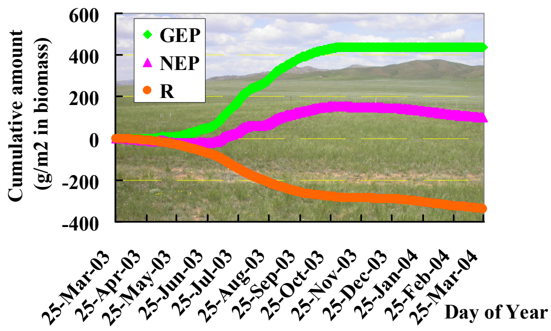

Fig. 1 Cumulative values of gross ecosystem productivity (GEP), net ecosystem productivity (NEP) and ecosystem respiration (*R*). Data were taken from the EC measurements from 25 March of 2003 to 24 March of 2004 over the grassland in central Mongolia.

Aboveground biomass investigation suggests that the amount reduced due to grazing in the growing season (from mid June to early

October) is around 36 gram per square meter. The standing aboveground biomass in early October is around 40 gram per square meter. This biomass was mainly grazed by the stocking animals in the non-growing season (data not shown). It is found that the EC and clipping methods gave different biomass amount available to the stocking animals (100 vs. 76). This is caused by the probable errors involved in each method.

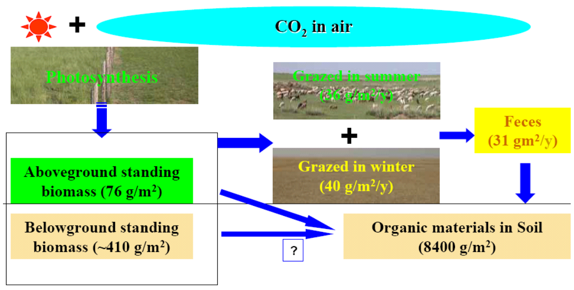

Fig. 2 Biomass distribution in the grassland in central Mongolia.

References:

(1) Li S.-G. et al., 2005: Global Change Biol., 11: 1941–1955.