

## Vegetation of the Khogno Khan Natural Reserve, Mongolia

Tsolmon, Gombosuren<sup>1</sup> and Jong-Won Kim<sup>2\*</sup>

<sup>1</sup>Land Management Agency, Ministry of Nature and Environment, Ulaanbaatar, Mongolia

<sup>2</sup>Unit of Vegetation Ecology, Keimyung University, Taegu, Republic of Korea

**ABSTRACT :** The vegetation of the Khogno Khan Natural Reserve of the central Mongolia was studied in terms of the Zurich-Montpellier School's method. Twenty plant communities were identified from the three different landscape types such as mountain areas (63%), plains (32%), and wetlands (5%). Actual vegetation map using five vegetation domains was accomplished in order to understand the spatial distribution of regional vegetation. Steppe vegetation of 88% vegetation cover to the whole area is representative, which is composed of a matrix of landscape. The birch-aspen forests and the elm bush forests are relics as a patch distribution. It is recognized that the whole territory of protected area be under the effects of severe grazing from the phytosociological viewpoint.

**Key words:** Actual vegetation map, Khogno Khan Natural Reserve, Mongolia, Phytosociological description, Steppe vegetation.

### INTRODUCTION

The vegetation of Mongolia has been devastated by grazing at an almost whole land cover. Particularly forests have been drastically declined both in quantity and quality. The study area of the Khogno Khan Natural Reserve is one of a few wild areas less affected by anthropogenic activities. After the first description of Mongolia's flora by Messerschmidt in the early 18th century, vegetation of the whole Mongolia has been described and outlined by German phytosociologist Hilbig (1995). A few data with a complete relevé about local vegetation were found in his treatise on Mongolian vegetation classification. Present paper is the first description about the vegetation of the Khogno Khan Natural Reserve in terms of the Zurich-Montpellier School as well as the vegetation map.

### STUDY AREAS AND METHODS

Present study was conducted in the Khangai-Khentii mountains area (46.9 km<sup>2</sup>; 47° 23' ~47° 38' N, 103° 30' ~103° 50' E) of the southernmost part of Bulgan Aymak in the western part of central Mongolia (Fig. 1). The area has been designated as the State Protected Reserve since 1997. The topography is characterized by rocky outcrops and flat or rounded slopes with the highest peak of 1,967 m above sea level and Tarnia river basin and depressions at 1,165 m a.s.l. Undifferentiated soils of weathered rocks and sands are predominantly found on gentle slopes and in depressions. Steep and gentle slopes are respectively covered with rock blocks and golets terraces where frost has

weathered the granite rocks (Plate 1). The climate is classified as extremely continental with a mean annual temperature of -2°C and a mean annual precipitation of 250~300 mm of which 80~90% is rainfall. In January the air temperature may even fall below -44°C (Anon. 2000). In winter there are long periods with clear skies and without wind, whereas in summer the weather is changeable such that on clear days clouds often move during the afternoon and bring cooler thunderstorms accompanied by a gust of wind. Such rapid weather changes cause strong erosion in hilly zone (Hilbig 1995). Most vegetation types have declined drastically by cattle grazing and irregular logging. The study areas overlap two vegetation domains such as the mountain steppe and forest steppe complex and the arid steppe (MNEM 1997). This area belongs to the Middle Khalkha district of the Mongolian Dauria province and the landscape unit of Selenge-Orhon highland (Barthel 1983).

Vegetation inventories were accomplished over the territory of protected area. The Zurich-Montpellier School's method (Braun-Blanquet 1964) was adopted. Such a sampling strategy is advocated in areas where the ecological investigations are still at an exploratory stage. All plant communities were described with structural characteristics and geographical distribution of species and phytocoenosen by using raw materials of 33 relevés. Altitude, slope and aspect were attributed to each relevé. Other abiotic conditions and any anthropogenic traces of disturbances in the plots were noted too. Spatial distribution pattern of actual vegetation domains was analyzed on the basis of detailed distribution map of phytocoenosen investigated by the first author. The nomenclatural solution for plant names and phytocoenosen were referred to Sanczir (1985) and Hilbig (1995), respectively.

\* Author for correspondence; Phone: 82-53-580-5213, Fax: 82-53-580-5164, e-mail: jwkim@kmucc.keimyung.ac.kr

## RESULTS AND DISCUSSION

Three landscape types and 5 vegetation domains were recognized in the study area (Table 1). Each landscape type is composed of several vegetation types. From the analysis of distribution pattern of actual vegetation, it is signified that 63% of studied area is mountainous landscape type, and the other 37% is plain and wetland types which locate lower than 1,400 m above sea level (Fig. 2). Meadow and steppe are representative of regional vegetation that has an 88% vegetation cover to the whole area. In the mountainous areas we found much diversified vegetation types such as secondary birch forests, steppes, elm bushes, and rock shrubberies. Forty three percent of the study area is covered by meadow and dry steppe in the flat and hilly areas which is located between 1,200 and 1,400 m a.s.l. A small fraction of wetlands is partially found in the western and southern girdle of protected area. Although the Khogno Khan State Natural Reserve is legally protected, it is phytosociologically recognized that the whole territory is under the effects of severe grazing. The best example is a high constancy of *Artemisia frigida* in every site. It is highly difficult to find plant association possessing a syn-taxonomically homogeneous species combination.

### Secondary birch-aspen forests

The summergreen broad-leaved birch-aspen forests dominated by *Betula platyphylla* are found at northward slopes of upper mountain belt in the study area. This forest was classified as *Betulo platyphyllae-Populetum tremulae* Hilbig (1987) 1990 characterized by a mixture of *Betula platyphylla* and *Populus tremula* in the canopy and the poor development of ground layer. Due to the severe logging, the stands of *Betulo-Populetum* have replaced the Siberian pine (*Pinus sibirica*) forests. Three strata were recognized, tree-layer of 10 meter high and 70% cover, shrub-layer of 1.5 m and 10%, and herb-layer of 0.8 m and 90%. Shrubbery with *Rosa acicularis*, *Cotoneaster melanocarpa*, *Spiraea media*, and *Dasiphora fruticosa* occurs in direct contact with the forest as described exactly by Hilbig (1995). Soil condition is relatively poor. Granite boulders are exposed with about

20% cover in a plot.

### Relic elm bush forests

Bush forests of Siberian elm (*Ulmus pumila*) occur at the foot of rock formations and sandy streamlet terraces (Plate 2). These Siberian elm groves in the study area are identified as relic associations such as *Spiraea aquilegifoliae-Ulmetum pumilae* Hilbig 1987 and *Stipo sibiricae-Ulmetum pumilae* Mirkin *et al.* 1986. *Spiraea-Ulmetum* develops at the foot of rock formations, which contains several diagnostic species such as *Spiraea aquilegifolia*, *Urtica cannabina*, *Chenopodium album*, *Artemisia dracuncululus*, *Euphorbia* sp.. *Stipo-Ulmetum* occurs in sandy terraces along the valley, which is characterized by *Stipa sibirica*, *Medicago ruthenica*, *Allium ramosum*, and *Poa attenuata*. The stands developing along the periodically water-bearing streamlets of 2 meters wide appear like a gallery forests (Hilbig 1995). Owing to anthropogenic interference, the community structure has been defectively assembled and lacked shrub species. Tree-layer is less than 10 meter high and very sparsely canopied with less than 50% cover. *Ulmus pumila* (Siberian elm) is an East Asian-Mongolian-Daurian species and its cold- and drought-hardiness enables it to succeed where few other broad-leaved trees can. Its southernmost distribution is found at the southern part of Korean Peninsula (Lee 1996).

### Rock shrubbery in mountain belt

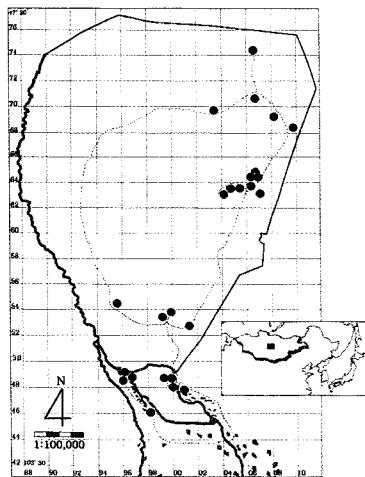
Rock shrubberies are found at south-facing slopes near the tourist camp. These are classified as *Juniperus sabina-Amygdalus pedunculata* community where two species of community name admix with *Spiraea aquilegifolia*, *Dasiphora fruticosa*, *Thymus* sp. *Thalictrum minus*, and *Artemisia scoparia*. The communities occur in the scree between big boulders, and the characteristic species is *Juniperus sabina* listed in the Mongolian Red Data Book (MNEM 1997). These native sites of *J. sabina* are under threat of cattle and goat grazing.

### Steppe vegetation in the mountain belt

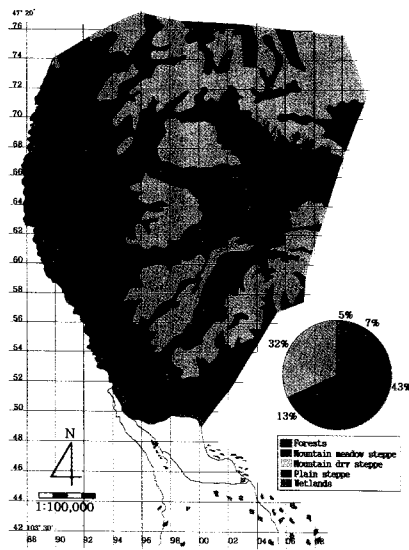
Steppe vegetation in the mountain areas is composed of various communities such as *Carex pediformis-Polygonum angusti-*

Table 1. Vegetation types classified in the study area

Landscape type	Vegetation domain	Vegetation type
Mountainous areas	Forest vegetation	<ul style="list-style-type: none"> <li>• Secondary birch-aspen forests in upper mountain belt</li> <li>• Relic elm bush forests in valley</li> </ul>
	Mountain dry and meadow steppes	<ul style="list-style-type: none"> <li>• Rock shrubbery in mountain belt</li> <li>• Steppe and meadow vegetation in mountain belt</li> </ul>
Flat lands and hilly areas	Plain steppe	<ul style="list-style-type: none"> <li>• Arid steppe and meadow steppe in the plain</li> <li>• Sand dune (<i>incl.</i> semidesert)</li> </ul>
	Wetland	<ul style="list-style-type: none"> <li>• Streamlet</li> <li>• Lake, tall marsh vegetation</li> <li>• Hummock swamp</li> </ul>



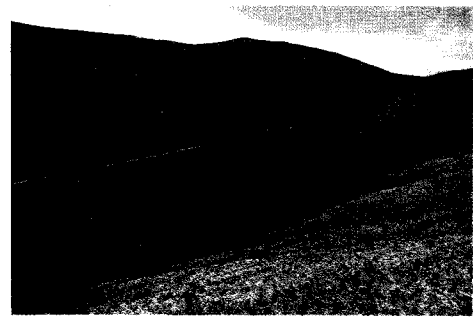
**Fig. 1.** Study sites in the Khogno Khan Natural Reserve of Mongolia. A dotted line indicates expedition routes. A bold line is the Tamir river.



**Fig. 2.** Actual vegetation map of the Khangai-Khentii mountains area.



**Plate 1.** A typical landscape of the southwestern territory in the Khogno Khan Natural Reserve. Aeolian dune (front), vast plain (middle), and Khangai-Khentii mountains (back). Different physiognomies depending on granite and gneiss in the mountain zone are clearly observed.



**Plate 2.** Relic groves of *Ulmus pumila*. In winter this site is used to become a shelter against harsh climate.



**Plate 3.** Plants with well-developed root-stock growing in the windy and drought habitat of upper mountain (1,550m a.s.l.).



**Plate 4.** Patch distribution of the *Artemisia frigida*-*Caragana micropylla* community in the plain (1,300m a.s.l.).



**Plate 5.** A hummock swamp meadow, *Parnassia palustris*-*Leontopodium leontopodioides* community (1,300m a.s.l.)

*folium* community, *Festuca lenensis*-*Androsace incana* community, *Leymus chinensis*-*Artemisia commutata* community, *Artemisia commutata*-*Stipa krylovii* community, *Poa attenuata*-*Stipa krylovii* community, and *Stipa grandis* community (Table 2). These dry steppe communities cover 32% of the study area. Flat ridges of upper mountain higher than 1,540 m a.s.l. are predominantly covered by the *Festuca lenensis*-*Androsace incana*. Wind and drought are main environmental conditions of habitat. Vegetation height is merely 5 to 10 cm and its cover is rather sparse only 40 to 50% of surface. Differential species of the community are *Festuca lenensis*, *Androsace incana*, *Veronica incana*, *Fillifolia sibiricum*, *Pulsatilla ambigua*, and a repository of aroma herbs (Plate 3). *Carex pediformis*-*Polygonum angustifolium* community is classified by diagnostic species such as *Carex pediformis*, *Polygonum angustifolium*, *Aster alpinus*, *Poa attenuata*, and *Fillifolium sibiricum*. This community is mainly found at northward and upper slopes where are swept by wind. Some dwarf shrubs such as *Dasiphora fruticosa*, *Amygdalus pedunculata* and *Spirarea aquilegifolia* are observed in the mild habitat. Vegetation height and coverage are 20 cm and 60%, respectively. In the middle parts of mountain slope the *Leymus chinensis*-*Artemisia commutata* community is found. This *Leymus* grass vegetation occurs mainly at northern slope about 1,500 m a.s.l. Vegetation height ranges from 30 to 40 cm, which is higher than the *Carex*-*Polygonum* community. Stands developing at gully of the valley in the mountain belt possess *Allium anisopodium* and *Galium verum* that are principal components of the *Artemisia commutata*-*Stipa krylovii* community. On the other hand, the *Artemisia commutata*-*Stipa krylovii* community occurs mainly at southern and gentle slopes. This community is representative of the secondary weed vegetation. *Artemisia frigida*, *Artemisia*

*adamsii*, *Allium anisopodium*, *Veronica incana*, *Cymbaria dahurica* and *Leymus chinensis* show relatively high frequency and coverage in the community. *Spirarea aquilegifolia* and *Galium verum* are often found at the concave microsites. In the northern part of the study area, the *Poa attenuata*-*Stipa krylovii* community is the most frequent, particularly at wide and plat topography. The stands locate mainly at around 1,445 m a.s.l. The vegetation cover is rather sparse less 70% of surface due to grazing effect. The diagnostic species are *Agropyron cristatum*, *Allium bidentatum*, *Galium berum*, *Poa attenuata*, and *Stipa krylovii*. An impoverished steppe at overgrazed sites contains *Carex duriuscula* and *Artemisia frigida*. A needle grass vegetation of the *Stipa grandis* community is identified. *Stipa grandis*, *Poa attenuata*, *Agropyron cristatum*, *Pulsatilla tueczaninovii*, and *Koeleria gracilis* are diagnostic species group. This community distributes mainly at northward and lower part of mountain slope with gentle inclination of 3 to 5°. Moisture condition of the sites ranges from semidry to moderate. Forb species such as *Artemisia frigida* and *Bupleurum bicaule* show a high constancy due to cattle grazing. The *Stipa grandis* community is considered as a vicarious type of *Poa attenuata*-*Stipetum grandis* Kashapov *et al.* 1987.

#### Meadow vegetation in the mountain belt

*Phlomis tuberosa*-*Dasiphora fruticosa* community is representative of meadow vegetation, which is characterized by shrub *Dasiphora fruticosa* and tall herbaceous plants such as *Thalictrum simplex*, *Galium boreale*, *Adenophora lamarckii*, *Sanguisorba officinale*, *Vicia cracca*, *Aconitum barbatum*, *Geranium pratense*, and *Artemisia laciniata*. This tall herbaceous community is found at forest edges in the vicinity of *Pinus sibirica* forests and *Betula fruticosa* forests. The stand occurs mainly at

**Table 2.** Summary of steppe vegetation in the mountain belt

Phytocoenosen	Diagnostic species	Topography	Moisture condition
<i>Festuca lenensis</i> - <i>Androsace incana</i> community	<i>Festuca lenensis</i> , <i>Androsace incana</i> , <i>Veronica incana</i> , <i>Fillifolia sibiricum</i> , <i>Pulsatilla ambigua</i> , <i>Potentilla sericea</i> , <i>Arenaria capillaria</i> , <i>Koeleria gracilis</i> , <i>Poa attenuata</i> , <i>Agropyron cristatum</i> , <i>Artemisia frigida</i>	Ridge & hill top	Dry
<i>Carex pediformis</i> - <i>Polygonum angustifolium</i> community	<i>Carex pediformis</i> , <i>Polygonum angustifolium</i> , <i>Aster alpinus</i> , <i>Poa attenuata</i> , <i>Fillifolium sibiricum</i>	North & upper slope	Semidry
<i>Leymus chinensis</i> - <i>Artemisia commutata</i> community	<i>Leymus chinensis</i> , <i>Artemisia commutata</i> , <i>Allium anisopodium</i> , <i>Galium verum</i>	North & middle slope	Moderate
<i>Stipa grandis</i> community	<i>Stipa grandis</i> , <i>Artemisia frigida</i> , <i>Poa attenuata</i> , <i>Agropyron cristatum</i> , <i>Pulsatilla tueczaninovii</i> , <i>Bupleurum bicaule</i> , <i>Koeleria gracilis</i>	North at lower slope	Semidry to moderate
<i>Artemisia commutata</i> - <i>Stipa krylovii</i> community	<i>Artemisia frigida</i> , <i>Artemisia adamsii</i> , <i>Allium anisopodium</i> , <i>Veronica incana</i> , <i>Cymbaria dahurica</i> , <i>Leymus chinensis</i> , <i>Stipa krylovii</i>	South & gully of the valley	Dry to semidry
<i>Poa attenuata</i> - <i>Stipa krylovii</i> community	<i>Stipa krylovii</i> , <i>Poa attenuata</i> , <i>Agropyron cristatum</i> , <i>Allium bidentatum</i> , <i>Galium berum</i>	Northward valley	Semidry to dry

gentle slope around 1,600 m a.s.l. This community is considered as an incomplete fraction of *Phlomidia tuberosae-Epilobietum angustifolii* Hilbig (1987) 1990.

#### Plain steppe and meadow vegetation

The *Artemisia frigida-Caragana microphylla* community spreads out in the vast plain of southwestern territory. The plain locates around 1,300 m a.s.l. Important species showing a high frequency and coverage are *Caragana microphylla*, *Artemisia frigida*, *Stipa krylovii*, *Cleistogenes squarrosa*, and *Leymus chinensis*. Predominant soil is sand and site surface appears flat. The landscape type is characterized by a patch distribution of prostrate *Caragana microphylla*. The patch is almost a globular shape of 1 to 2 m diameters. The areas are heavily grazed (Plate 4). Vegetation height and coverage are 20 cm and 40%, respectively. Another plain steppe is the *Seratula centauroides-Amygdalus pedunculata* community. Differential species of the community is *Seratula centauroides*, *Amygdalus pedunculata*, *Scabiosa fischerii*, and *Caragana microphylla*. Site conditions of this community are similar to those of the *Artemisia frigida-Caragana microphylla* community, whereas ground surface is not flat but uneven and stable. Vegetation height and coverage are 1.2 m and 20%, respectively.

#### Sand dune

A vast expanse of sand dune distributes at the western margin and southwestern corner of the protected area. This is an aeolian dune extending south and north along valley due to the deflation of dune crests in the Tarna-Tuul region (Y.I. Lee, personal communication). According to the stability of sand dune, different vegetations occur: (1) *Polygonum-Oxytropis* herb community at the beginning stage of dune formation, (2) *Salix* shrub community at early pioneer stage and (3) *Betula* shrub community at later pioneer stage of it. Among them the *Betula* shrub community dominates at the most stabilized sand dunes. Two shrub communities of *Salix* sp. and *Betula* sp. show a bushed and mono-dominated physiognomy. Cutting for fire-chops is a main disturbance factor to the shrubs.

#### Streamlet

Wide terrace by channel incision is found in the Schiluust streamlet of the Tarna river. Floodplain of stream channel at base flow is about 15m wide, bankful channel (thalweg) is 1m wide and 0.2 m deep, and scrap slope is very sharp. *Iris bungei* community is typical on sandy soil of wide terrace. This community is a grazing facies from the effect of overgrazing in dry grassland in the semi-desert zone. Cattle avoids *Iris bungei* and *Achnatherum splendens* that are diagnostic species to this community. Mirkin *et al.* (1984) has described such an *Iris* weed communities as *Artemisia laciniatae-Iridetum lactae* in the Orhon valley of Bulgan aymak. It is assumed that absence of grazing can

lead to the reestablishment of *Salix* bushes (Hilbig 1995). Actually patches of willow bushes are observed at floodplain terraces in the study areas. This willow bushes are representative of *Carex duriuscula-Salix* community.

#### Marsh vegetation

In the southernmost part of the protected area there is a small lake behind aeolian dune extending south and north in the Tarna-Tuul region. This waterbody is highly significant to support pasturing in this area. Lake is nutrient-rich due to extensive pasturing. Reed (*Phragmites communis*) is a dominant species of tall marsh vegetation there and eutrophication has led to the occurrence of the *Bidentetea* members.

#### Hummock swamp

At the southernmost tip of the protected area a kind of swamp forest might have been destroyed due to severe grazing and wood cutting in the lower mountain belt. A swamp meadow, *Parnassia palustris-Leontopodium leontopodioides* community, develops on a foundation of sandy sediments with small size pebbles in wide terrace of streamlet of the Tarna river (Plate 5). This community contains some wet meadow species such as *Potentilla anserina*, *Tragopogon trachycarpus*, *Carex duriuscula*, and *Ranunculus acer*. Enclaves of this community occur differently depending on microsite of hummock like tussock's form. *Parnassia palustris* facies is mainly found at the concave part and *Leontopodium leontopodioides* facies at the convex part. These two species are never found at the same habitats in the temperate region. The even-eroded shape of hummock is 40~50 cm wide and 40 cm high. Sedge and grass species occur convergently in the top of convex part of hummock.

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(Received October 29, 2001, November 26, 2001)