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VEGETATION PATTERN AND ENVIRONMENTAL FACTORS IN SEMI-DESERT AND DESERT AREAS OF MONGOLIA: CASE STUDY IN KHANBOGD SOUM

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ABSTRACT

The aim of this study was to assess the vegetation patterns in the semi-desert and desert areas of Khanbogd soum and to determine the relationship between these vegetation patterns and environmental factors. The study provides reference data of the natural undisturbed vegetation before mining and information on natural fluctuations in the area for assisting the future rehabilitation and conservation efforts of desert areas in Mongolia. Data were collected in 24 plots from 2007-2009 on a cover of vascular plant species using visual estimation. Environmental variables such as slope, altitude, and habitat type were recorded. Temperature and precipitation were obtained for the study period from the Khanbogd weather station. The vegetation pattern was explored using Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA) was used to quantify and test the effects of environmental variables. A total of 107 species were recorded and species composition varied greatly in the study area. The temporal variation in the three study years was considerable; however the spatial variation was relatively much larger. Most of the variation in species composition is best explained by two habitat types (sandy hill, riverside) and topography (altitude, slope). There were natural fluctuations in plant cover, species richness and species composition – these changes may most likely have been related to precipitation which varied greatly between the study years.

Key words: vegetation pattern, precipitation, environmental factors, desert and semi-desert area, ordination

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1. INTRODUCTION

Mongolia is found in the very centre of the Asian continent and occupies an area of 1,565 million km^2. It stretches almost over 2400 km from the high mountains in the west to hilly plains in the east and 1200 km from north to south where the landscape changes from the taiga forest to the Gobi desert plains and low mountains. The vast area of the country contains a great array of different ecosystem types; from high mountain tundra to deserts (Pavlov, Galbaatar, Kamelin, & Ulziykhutag, 2005). The Joint Russian and Mongolian complex Biological Expedition in 2005 estimated that the desert steppe and desert zones of the southern part of Mongolia occupy almost a half million km^2 area or 30.8% of Mongolia (Vostokova & Gunin, 2005). Paleontology, paleographic and paleo-climatologic studies have reported that this dry territory was covered by wet forest at the end of the Mesozoic and in the beginning of the Cenozoic eras (Dorjsuren & Sanjid, 2006). Remnants of vegetation which are currently known include *Ulmus pumila, Populus diversifolia, Eurota ceratoides* and *Allium mongolicum*. The Small Gobi Strictly Protected area (SPA) in Khanbogd soum (soum=district), which is situated in this dry territory, was established in 1993 and occupies more than 1.8 million hectares of land in two discrete areas in the Umnugobi aimag (aimag=province) and Dornogobi aimag. The SPA is the main habitat for the animals *Equus hemionus, Gazella subgutturosa, Ovis ammon* and *Capra sibirica*.

Nowadays the mining sector in Mongolia is a major contributor to its economy, accounting for about 17% of gross domestic product (GDP), 65% of industrial value added, and 58% of export earnings. Major export-related minerals include copper, molybdenum, gold, coal, and fluorspar concentrates. Copper mining alone earns some 25% of all foreign exchange, and provides almost one-quarter of government revenues. Since 1992, there has been a rapid rise in mineral exploration and the number of local Mongolian companies, some co-operating with foreign companies, involved in exploration and mining has increased (World Bank, 2006). There are now 2595 exploration licenses in Mongolia covering 40 million ha of land, 26% of its territory (World Bank, 2005). At present, the South Gobi region in Mongolia is in a transition period of developing and exporting its natural resources that is expected to bring wealth and prosperity to the country and its people. During the last decade it has become clear that the area of Khanbogd soum has rich underground mineral resources with major deposits of copper and gold (Kirwin et al., 2005). Mining processes may affect the environment in different ways. Among the environmental problems caused by mining are land degradation during the preparation and implementation phases of mining such as infrastructure built up that may have a negative impact on biodiversity (the flora and fauna), and land compaction due to machinery use. Additionally, acidification of the soil resulting from mining activities may be harmful to plant growth and release metals that increase the acidity of the environment. Similarly, the degradation of surface and underground water due to oxidation and the dissolution of metal bearing minerals can affect the environment. Increased airborne dust and other emissions, such as sulphur oxide and nitrogen oxides, that contaminate the environment and contribute to the global warming are examples of environmental problems caused by mining (Hudson, Fox, & Plumlee, 1999).

Without effective environmental safeguard measures, these sectors have the potential to cause major negative impacts on desert and semi-desert natural habitats and wildlife populations, both through direct activities such as mining construction, tailings storage, etc. and indirect activities such as road and rail development, construction of high voltage power lines, etc. impacts (Bird Life Asia, 2009). With future planning of mining operations in Khanbogd soum a need for a monitoring program was identified and planned. As mining influences natural factors of the desert area and might exploit natural resources (e.g. groundwater) a need for knowledge of the natural dynamics of the vegetation is required as basic information on reference ecosystems for the future.

The objectives of the current study were to (a) assess the vegetation patterns in the semi-desert and desert areas of Khanbogd soum and provide reference data of the natural undisturbed vegetation in the area; (b) determine the relationship between the vegetation patterns and environmental factors including climatic factors (temperature and precipitation), slope, altitude, and habitat types; and (c) gain knowledge and improve skills in using statistical packages such as SAS and CANOCO.

2. MATERIAL AND METHODS

2.1 Study area

2.1.1 Location

The study area is located in the territory of Khanbogd soum of Umnugobi aimag in South Mongolia between 106°27' - 108°1' E and 42°26' - 43°22' N. The territory of Khanbogd soum of Umnugobi aimag occupies 14,963 km^2 through desert steppe and desert zones of the south-eastern part of Mongolia, of which 9.5% is protected area (SPA), 5.3% is mining licensed area and 32.6% is exploration licensed area (Nyamsambuu Purevsuren, personal communication, April 20, 2011).

The altitude of the area ranges from 820 to 1322 m above sea level (m asl). The north-western part of the area is located at a higher altitude ranging from 1292-1322 m asl whereas the south and north-eastern parts are at a lower altitude (833-889 m asl) (Balt & Jadamba, 2010). Figure 1 illustrates the location of the monitoring plots in Khanbogd soum.

2.1.2 Climate

Khanbogd soum is located in a comparatively low valley, surrounded by Gobi low mountains and small hills. The region is classified within the very dry, warm climatic zone (Baldan, 1989) and has a typical continental climate with cool springs and autumns, hot summers, and cold winters. Spring is also very dry and windy (Dulam, 2006). The winter mean temperature is between -11°C and -13°C and the summer mean temperature ranges between 20°C and 22°C according to the Meteorological Institute of Mongolia. The highest temperatures, above +35°C, are recorded in June, July and August, while cold temperatures below -30°C are recorded in December and January (OSMT, 2008). Annual precipitation is low, there is no permanent snow cover during winter, and strong winds occur frequently in the region. Snow cover varies from 2.5 mm to 3.5 mm, which is about 5% of the annual precipitation. The summer precipitation is 70 mm to 95 mm and it is greater than the winter precipitation (OSMT, 2008).

The meteorological data were provided by the Khanbogd weather station which was established in 1975 and is located within the study area (see Table 1).

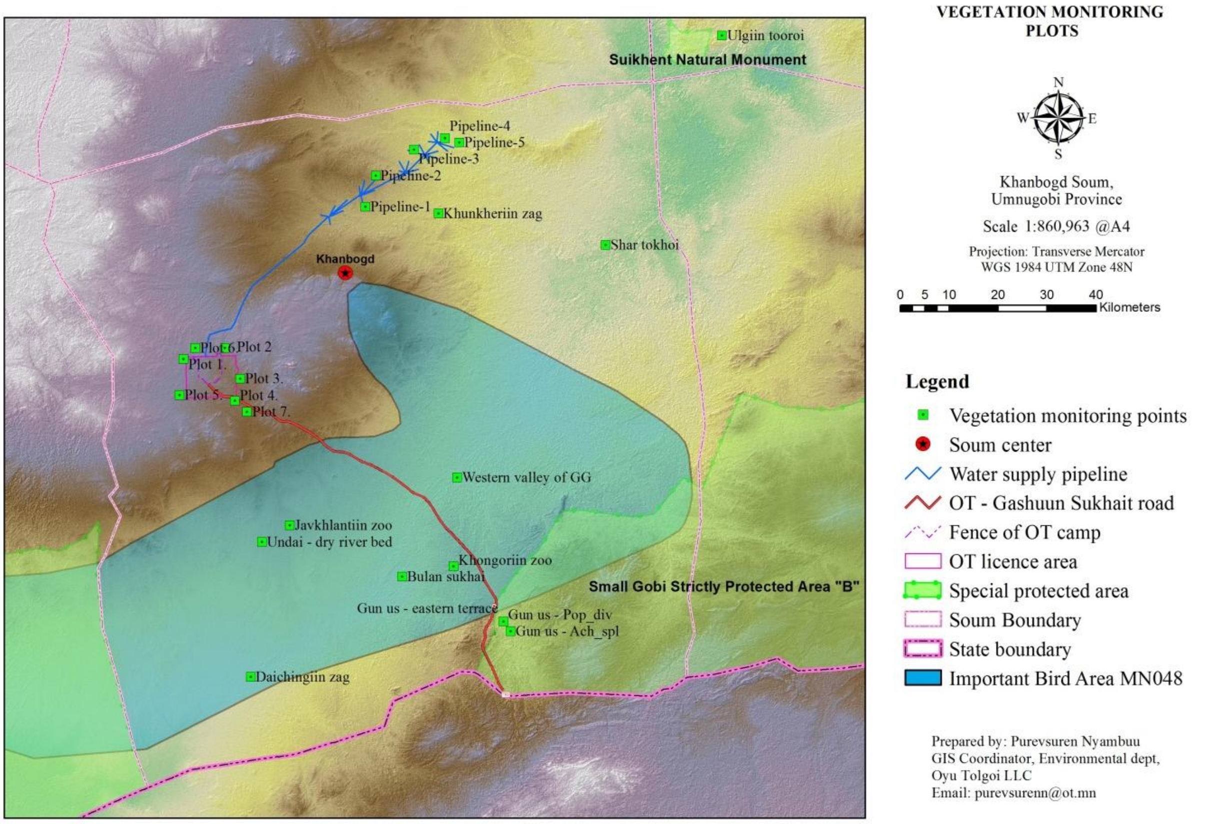

Fig. 1. *The study area and location of monitoring plots. Protected and licenced areas are shown, see the legend for details (Map drawn by Purevsuren Nyambuu, 2011).*

Table 1. *Monthly mean temperature and accumulated precipitation during the study in 2007, 2008 and 2009. For comparison long term data for the period 1976 to 2006 are shown (Data from Institute of Meteorology and Hydrology, Mongolia, 2011).*

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Temperature, °C (mean)													
1976-2006	-11.5	-7.4	-0.5	8.8	16.5	22.1	24.6	22.3	16.4	7.9	-2.2	-9.2	**7.3**
2007	-9.5	-0.6	-0.3	9.1	18.4	24.8	25.2	24.9	19.7	7.7	-0.8	-8.3	**9.2**
2008	-14.4	-9.3	3.1	11.7	15.7	22.2	25.5	22.7	17.7	9.6	0.3	-9.7	**7.9**
2009	-11.4	-6.1	0.4	12.4	18.5	22.0	25.9	23.8	17.0	8.5	-5.2	-10.7	**7.9**
Precipitation, mm (accumulated)													
1976-2006	1.2	1.2	2.7	3.0	7.4	11.4	25.5	28.5	7.2	3.3	1.6	0.7	**93.7**
2007	0.0	0.7	8.9	1.3	0.0	17.8	27.2	5.0	14.7	5.0	0.7	0.7	**82.0**
2008	0.4	0.5	1.0	10.0	0.0	24.7	44.5	57.0	5.3	1.9	0.3	5.3	**150.9**
2009	0.0	0.0	0.0	0.0	3.4	26.1	20.5	3.9	11.7	0.6	1.7	1.4	**69.3**

Climate data for the study period showed the dynamics of the climate during a plant growing season and differences among the three years. The monthly average temperature in the three years of the study period did not show any deviation from the long term record of average monthly temperature for the period 1976 to 2006 (Fig. 2a). Similarly, the monthly average precipitation in 2007 and 2009 showed only a small variation from the long term record of average monthly precipitation. However, the average monthly precipitation was much higher in 2008 than the long term records for the period 1976 to 2006 (Fig. 2b).

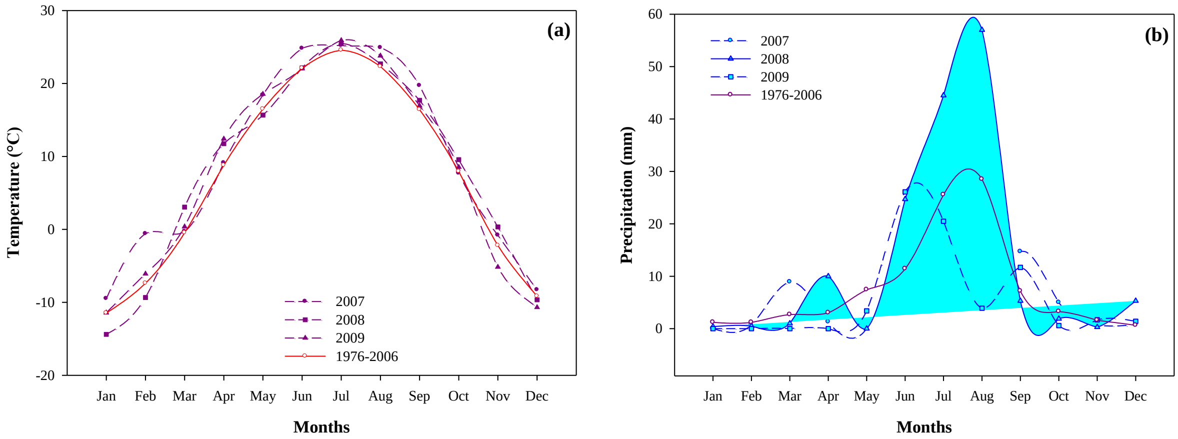

Fig. 2. *Monthly average temperature (a) and precipitation (b) of the study area for 2007, 2008 and 2009. Long-term data for the period 1976-2006 are shown for comparison. Data from Khanbogd weather station.*

2.1.3 Vegetation and soil

The flora of the Khanbogd soum is representative of the eastern region of the Gobi Central Zone within the Central Asian Greater Zone. The Mongolian bio-geographic classification includes the study area within the Galbyn Gobi sub-region of the Eastern Gobi Desert Steppe (Eco-Trade, 2006). The region is bordered to the east and north by the moist grasslands of Mongolia and Manchuria, and to the west and south by the semi-deserts of the Alashan Plateau.

Vegetation within the study area generally consists of sparse drought tolerant perennial shrubs with less than 5% cover, and lower than 0.5 m in height (Eco-Trade, 2006). Annual grasses and herbaceous species emerge following seasonal rainfall providing pasture for domestic livestock and wildlife. Currently, over 180 species of 101 genera and 33 families of vascular plants are registered in Khanbogd soum, of which 21 species are classified as rare and very rare plants in the Red Book of Mongolia (Balt & Jadamba, 2010). The Red Book of Mongolia documents rare plants and endemic plants that have a risk of becoming extinct. The list includes *Potaninia Mongolica*, *Nitraria sibirica*, *Brachanthemum mongolica* and *Ephedra Przewalskii* that grow only in Khanbogd soum (Nadmid, 1985).

The soils in the study area are of several types. The Khanbogd area falls within the 12th district having Gobi light brown and desert brown and grey soils of the Gobi region with bio-climatic latitudinal zoning according to soil-geographic division. The Gobi light brown soil is predominant and the northern area has desert brown grey soil. The basic soil horizon is mixed and varies depending on the rocky and hilly surface (Ochirbat & Bat-Amgalan, 2011).

2.1.4 Fauna

The varying landscapes provide habitats for a range of wildlife. The climate of Khanbogd soum is also more favourable for wildlife than the central and northern parts of Mongolia because of its milder winters.

The Galba Gobi Important Bird Area in Khanbogd soum has been identified as an important area of critical natural habitat in Mongolia by BirdLife International and the Wildlife Science and Conservation Center. This area, which stretches between, and partly overlaps the Small Gobi A and B Special Protected Areas in Khanbogd soum, supports two globally threatened mammals, the Asian Wild Ass or Khulan *Equus hemionus* (endangered) and the Goitered or Black-tailed Gazelle *Gazella subgutturosa* (vulnerable). Additionally, the area is important for breeding populations of three globally threatened bird species (Saker falcon *Falco cherrug*, Houbara bustard *Chlamydotis undulata* and the Lesser kestrel *Falco naumanni*, the later considered vulnerable) (Batbayar, Batsukh, Stacey, & Braunlich, 2009).

3.2 Data collection

Vegetation monitoring data from the Oyu Tolgoi project sampled in 2007-2009 were used in the current study. Before collecting the data a reconnaissance survey was carried out to identify what sampling system to use. In the survey the dominant plant species were used to classify the area into different vegetation types and life forms. After identifying the plant community groups, sample plots were randomly chosen within community groups.

A total of 24 plots were laid out and marked with wooden sticks in four corners. Each plot was 25 x 25 m and they were distributed around Khanbogd soum territory (Fig. 1.) Within each plot, all vascular plant species and the total vegetation percentage cover were recorded. The percentage cover of vegetation was determined by visual estimation of all vascular plant species. The altitude was obtained using GPS and the slope was measured by clinometers. Data have been collected for six years; however due to missing data in some years the current study only included data from 2007, 2008 and 2009.

The climatic data were collected for the same years from the Khanbogd weather station situated in the soum centre. Here the mean monthly temperature and precipitation were used.

Nomenclature for vascular plants follows Grubov. V.I (1982) and Nadmid (1985).

3.3 Environmental (explanatory) variables

In this study, environmental factors such as climatic factors (temperature and precipitation), physical factors such as slope, altitude and habitat types were used to determine the relationship between vegetation pattern and environmental factors. In addition, biotic factors such as species richness, the Shannon index (species density), life form and total vegetation cover were also used for understanding vegetation patterns in the study area. Vegetation types include, here, three types; phanerophyte, chamaephyte and hemicryptophyte. An overview of environmental (explanatory) variables is given in Table 2.

3.4 Data analysis

Descriptive statistics such as mean, frequency and distribution graphs were carried out on the data. Analysis of Variance with repeated measures was used to test differences in total cover, annual cover, shrub and grass cover, species richness and species diversity between the three study years on the same 24 sample plots. A Bonferroni adjustment was used to test the difference between individual years (Townend, 2002). Two measures were used for species diversity, i.e. species richness which is the simplest appearance of diversity and the Shannon-Wiener index, which considers not only number of species but also species abundance

(Barbour, Burk, & Pitts, 1987). The Shannon diversity was computed by the following formula:

$$H' = -\sum_{i=1}^{s}(p_i * \ln p_i)$$

where: *H'* = the Shannon-Wiener diversity index
Pi = fraction of the entire population made up of species *i*
s = numbers of species encountered
∑ = sum from species 1 to species *s*

An increasing value of H´ represents more diverse communities and a value of 0 refers to a community with only one species.

Table 2. *Environmental variables used in the analyses.*

No	Variables	
1.	**Physical variables**	Temperature, °C
2.		Precipitation, mm
3.		Altitude, m
4.		Slope, °
5.		Habitat (terrace, valley, sandy hill and riverside)
6.	**Biotic variables**	Total mean cover, %
7.		Shrub cover, %
8.		Grass cover, %
9.		Annual plants cover, %
10.		Vegetation type (woodland, shrubland and grassland)
11.		Species richness
12.		Species diversity, H´
13.		Life form (phanerophyte, chamaephyte and hemicryptophyte)

Ordination was used to analyse the distribution of plant species along the gradient axes. Ordination is a general term used to describe multivariate techniques that arrange sites along axes on the basis of species composition data. It arranges sites with similar species composition closer to each other and sites with different species composition are displayed far from one another in an ordination biplot (Jongman, Ter Braak, & Van Tongeren, 1995). Thus, the aim of the ordination is to find and display the axes of greatest variability in the community composition (Lepš & Šmilauer, 2003).

The choice of ordination method depends on the variation in the dataset reflected in gradient lengths. A short gradient (< 3) demands linear methods and longer gradients (> 4) call for unimodal methods including detrended correspondence analysis (DCA) and canonical correspondence analysis (CCA).

In the current dataset the longest gradient was 4.751; thus the data from Khanbogd soum were analysed using DCA to explore the overall vegetation patterns with detrended by segments and non-linear rescaling. The data were log-transformed and rare species were down weighted. CCA was used to quantify and test the effect of environmental (explanatory) variables. Unrestricted Monte Carlo permutation tests were used to assess significance of individual environmental variables to include in the final model and to analyse the statistical significance of the final model.

SAS for Windows, version 9.2, was used for descriptive statistics and ANOVA and CANOCO for Windows, version 4.5, was used for ordination analyses.

Table 3. *Taxonomic plant families recorded in Khanbogd soum. Number and percentage of genera and species are also shown and families ranked from the one with the highest number of species to the fewest ones.*

No.	Family names	No. of genera	Percentage (%)	No. of species	Percentage (%)
1	*Asteraceae*	11	13.9	21	19.6
2	*Chenopodiaceae*	14	17.7	20	18.7
3	*Poaceae*	13	16.5	15	14.0
4	*Fabaceae*	6	7.6	9	8.4
5	*Zygophyllaceae*	4	5.1	5	4.7
6	*Boraginaceae*	3	3.8	4	3.7
7	*Polygonaceae*	3	3.8	3	2.8
8	*Liliaceae*	2	2.5	3	2.8
9	*Cruciferea*	2	2.5	3	2.8
10	*Rosaceae*	2	2.5	2	1.9
11	*Tamaricaceae*	2	2.5	2	1.9
12	*Iridaceae*	1	1.3	2	1.9
13	*Gereniaceae*	1	1.3	2	1.9
14	*Convolvulceae*	1	1.3	2	1.9
15	*Cyperaceae*	1	1.3	1	0.9
16	*Salicaceae*	1	1.3	1	0.9
17	*Ulmaceae*	1	1.3	1	0.9
18	*Aizoaceae*	1	1.3	1	0.9
19	*Ranunculaceae*	1	1.3	1	0.9
20	*Papaveraceae*	1	1.3	1	0.9
21	*Euphorbiaceae*	1	1.3	1	0.9
22	*Apiaceae*	1	1.3	1	0.9
23	*Plumbaginaceae*	1	1.3	1	0.9
24	*Verbenaceae*	1	1.3	1	0.9
25	*Labiatae*	1	1.3	1	0.9
26	*Solanaceae*	1	1.3	1	0.9
27	*Scrophulariaceae*	1	1.3	1	0.9
28	*Orobanchaceae*	1	1.3	1	0.9
		79	**100.0**	**107**	**100.0**

3. RESULTS

3.1 Species diversity

A total of 107 vascular plant species were recorded. These were of 78 genera and belonged to 28 families. Of all families found in the study area, *Asteraceae, Chenopodiaceae* and *Poaceae* were the most common families in the area containing 19.6%, 18.7% and 14.0% of all species, respectively (Table 3). Vascular species were classified by the Raunkiaer system (Gurevitch, Scheiner, & Fox, 2002) and hemicryptophytes were the dominant (most species) life form (43%) followed by therophytes (24.3%), phanerophytes (13.1%) and chamaephytes (13.1%) (Table 4). However, the abundance (percent cover) of the chameophytes and therophytes was higher than for the others (Table 5).

Table 4. *Growth forms for recorded species during study period based on the Raunkiaer system in 24 study plots in Khanbogd soum.*

No	Life form	No. of species	Percentage, (%)
1	Hemicryptophyte (perennial herbs with buds at the ground surface)	46	43.0
2	Therophyte (annual plant)	26	24.3
3	Phanerophyte (trees & tall shrubs)	14	13.1
4	Chamaephyte (small shrubs)	14	13.1
5	Cryptophyte (perennial herbs with perennating organs below the ground surface)	7	6.5

Table 5. *Most abundant species and their frequency during study period.*

No	Vescular plant species	Cover (%)	Frequency	Plant life form
1	*Anabasis brevifolia*	27	33	Chamaephytes
2	*Halogeton glomeratus*	17	42	Therophytes
3	*Salsola passerina*	17	41	Chamaephytes
4	*Eragrostis minor*	16	39	Therophytes
5	*Aristida heymannii*	15	43	Therophytes
6	*Nitraria sibirica*	15	29	Phanerophytes
7	*Sympegma Regelli*	13	28	Phanerophytes
8	*Potaninia mongolica*	12	23	Chamaephytes
9	*Bassia dasyphylla*	9	36	Therophytes
10	*Tribulus terrestris*	9	33	Therophytes
11	*Haloxylon ammodendron*	9	12	Phanerophytes
12	*Kalidium foliatum*	9	9	Chamaephytes
13	*Reaumuria soongorica*	8	40	Chamaephytes
14	*Allium polyrrhizum*	8	14	Cryptophytes
15	*Peganum nigellastrum*	7	26	Hemicryptophytes
16	*Corispermum mongolica*	7	18	Therophytes
17	*Achnatherum splendens*	7	14	Hemicryptophytes
18	*Convolvulus fruticosus*	6	11	Chamaephytes
19	*Brachanthemum gobicum*	6	6	Chamaephytes

The mean species richness over the whole study period was 16.6 per 25x25 m plot and the mean species number for individual years was 16.3, 22.9 and 10.6 for 2007, 2008 and 2009, respectively (Fig. 3a). The species diversity measured with the Shannon-Wiener index was 1.8 over the three years and 1.9, 2.0 and 1.5 in 2007, 2008 and 2009, respectively (Fig. 3b).

Species richness differed significantly between individual years, and species diversity between 2007 and 2009; 2008 and 2009 (Table 6). Table 6 shows the comparison between mean species richness and species diversity.

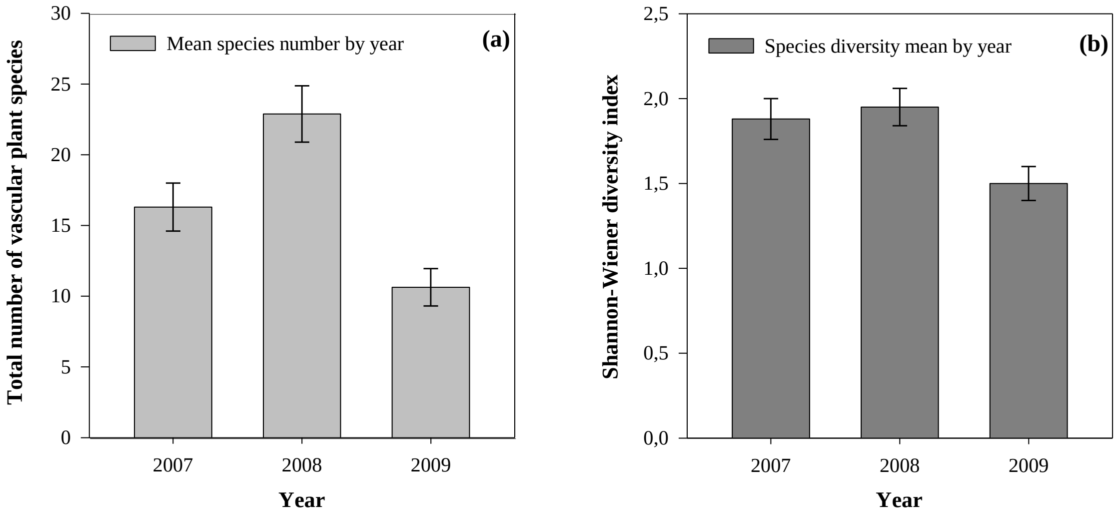

Fig. 3. *Mean species richness number (a) and species diversity (b) (Shannon H') in the years 2007-2009 with ± standard error (1 SE)*

Table 6. *Summary of repeated ANOVA results on mean species richness and diversity in Khanbogd soum over a three year study period. N=24; n.s.: not significant.*

Differences of Least Squares Means					
				Adj P	
Effect	**Year**	**Year**	**Adjustment**	**Species richness**	**Species diversity**
Year	2007	2008	Bonferroni	0.0003	n.s.
Year	2007	2009	Bonferroni	0.0004	0.0130
Year	2008	2009	Bonferroni	<0.0001	0.0025

The mean vascular plant cover in all plots over the three years was 24.8%. The mean total cover for each of the three years was 19.0%, 41.4% and 14.1% for 2007, 2008 and 2009 respectively (Fig. 4a). There was a significant difference in total cover between 2007 and 2008 and between 2008 and 2009, but there was no significant difference between 2007 and 2009 (Table 7, Fig. 4). Similarly there was a significant difference in annual plant cover between 2007 and 2008 and between 2008 and 2009, but there was no significant difference between 2007 and 2009.

Table 7. *Summary of repeated ANOVA results on mean plant cover in Khanbogd soum over a three year study period. N=24.*

Differences of Least Squares Means							
					Adj P		
Effect	**Year**	**Year**	**Adjustment**	**Total cover**	**Shrub cover**	**Grass Cover**	**Annual cover**
Year	2007	2008	Bonferroni	<0.0001	0.2621	n. s	<0.0001
Year	2007	2009	Bonferroni	0.6320	n. s	0.0455	n. s
Year	2008	2009	Bonferroni	<0.0001	0.0338	0.0029	<0.0001

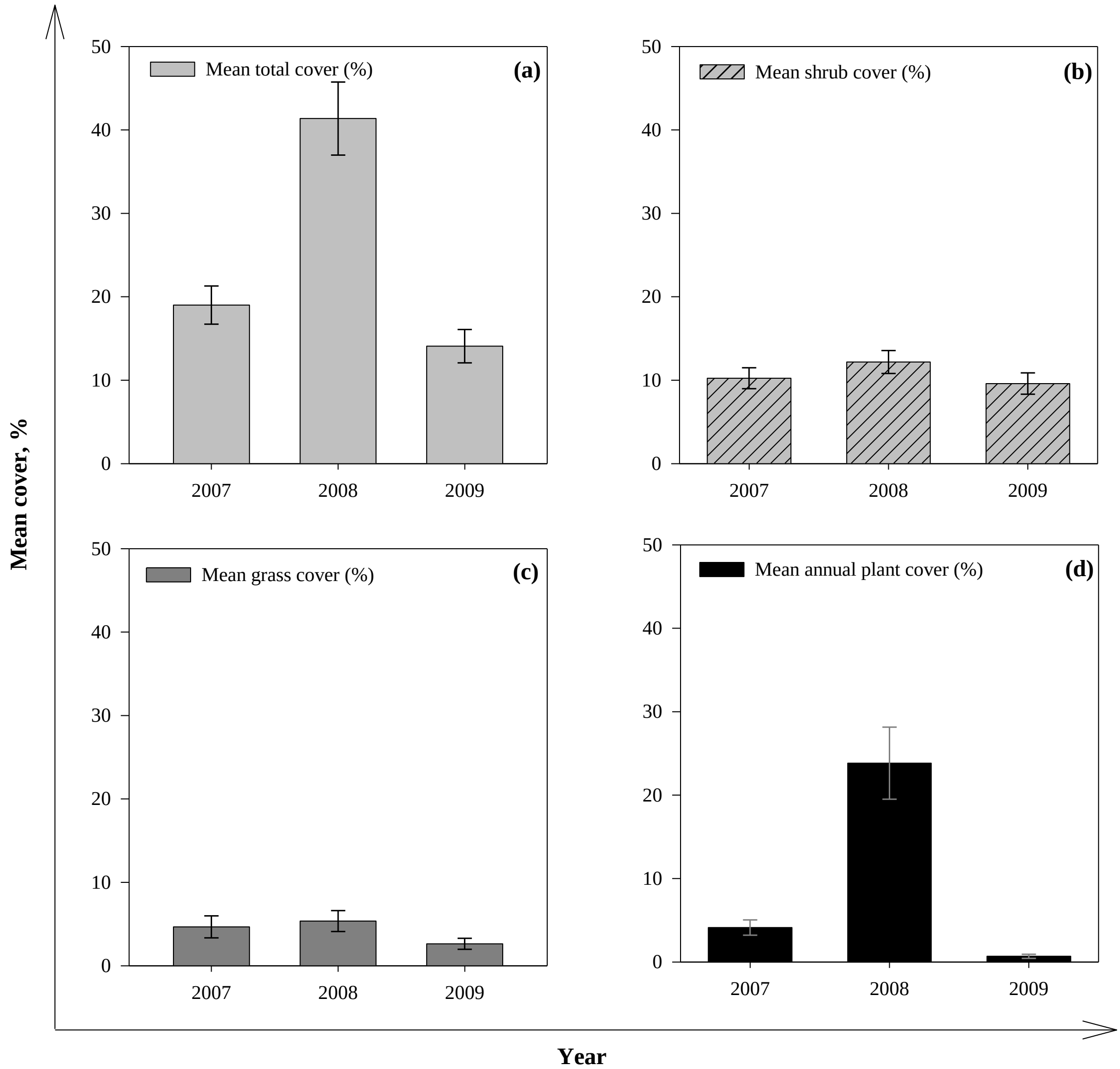

Fig. 4. *Mean cover for total vegetation (a), shrub (b), perennial grass and herb (c) and annual (d) plant cover for 2007-2009 with ± standard error (1 SE) in 24 plots in Khanbogd soum.*

3.2 Vegetation pattern

A correlation analysis was made among 20 environmental variables (Table 8) and the vegetation pattern along the ordination axes. The DCA ordination of all 24 plots over the three year study period showed a large variation. The first two gradients explained most of the variation with eigenvalues of 0.587 and 0.420 for axis 1 and axis 2, respectively (Table 9). The length of the first axis gradient was 4.75 and the second axis was 4.03, and the first two axes accounted for 11.7 and 8.4 % of the inertia, respectively (Table 9).

The first DCA axis was explained by different habitat types with Sandy hills and Riverside receiving the highest scores and Terrace and Valley the lowest scores, and altitude and slope negatively correlated with axis 1 (Table 8).

Table 8. *Inter-set correlations of environmental (explanatory) variables with the first two DCA axes at from 24 plots at Khanbogd soum.*

No.	Environmental variables	DCA axis 1	DCA axis 2
1	Woodland	0.5996	0.5012
2	Habitat - Sandy hill	0.4820	0.5711
3	Habitat - Riverside	0.4728	-0.3855
4	Cover of annual plants	0.3322	0.3360
5	Total cover	0.2826	0.1917
6	Cover of grasses	0.0978	-0.2906
7	Annual total precipitation	0.0903	0.2412
8	2008	0.0878	0.2399
9	Grassland	0.0555	-0.1997
10	Total number of species	-0.0141	-0.0253
11	2007	-0.0367	-0.1350
12	Mean of temperature	-0.0373	-0.1363
13	2009	-0.0662	-0.1417
14	Cover of shrubs	-0.0743	0.0210
15	Species diversity, H´	-0.2372	-0.1219
16	Altitude	-0.2899	-0.5972
17	Slope	-0.3665	0.0008
18	Habitat - Valley	-0.4109	0.0867
19	Habitat - Terrace	-0.4547	-0.1213
20	Shrubland	-0.5768	-0.3290

Woody plants were highly correlated with axis 1 and shrubs were negatively correlated with the first axis. Woody vegetation was related to sandy hill and riverside habitats and the characterizing species in the woodland were *Haloxylon ammodendron, Populus diversifolia* and *Ulmus pumila* together with *Calligonium mongolicum, Tragus mongolorum, Corispermum mongolica, Bassia dasyphylla, Trebulus terrestris, Chloris vergata, Echinops Gmelinii* (plots 8, 10, 18, 23 and 24), whereas shrubs were more common in valley and terrace habitats. Some of the shrubland plots (1-4, 11, 13, 14, 16 and 19) were clustered, indicating that they had similar species composition and preferred a terrace habitat as they were highly correlated with it (Fig. 5). The characterizing species in these plots were *Salsola passerina, Anabasis brevifolia, Sympegma Regelli, Potaninia mongolica toghter with Salsola laricifolia, Allium polyrrhizum, Dontostemon senilis, Cleistogenes soongorica* (Fig. 6).

Table 9. *Summary of the DCA ordination of all plots and three years of sampling.*

	Axes				
	1	**2**	**3**	**4**	
Eigenvalues	0.587	0.420	0.237	0.164	
Lengths of gradient	4.751	4.025	2.756	3.625	
Cumulative percentage variance of species data	11.7	20.1	24.9	28.1	
Sum of all eigenvalues					5.007

A few shrubland plots (5, 7 and 15) together with a perennial herb plot (12) were positively correlated with riverside habitat (Fig. 5). These plots were characterized by species such as *Tamarix ramosissima, Achnatherum splendens, Kalidium foliatum and Nitraria sibirica* together with *Phragmites communis, Clematus tangutica, Lycium truncatus, Eragrostis minor*. Plot 20 (shrubland) differed from other plots (Fig. 5) in terms of slope and landscape. The vegetation community was desert steppe with elevated terrace in the desert with *Eurota* *ceratoides*, *Potaninia mongolica*, *Stipa glareosa* and *Cleistogenes soongorica*. Similarly, plots 9 and 21 (shrub) grew in a valley habitat and their dominant vegetation type were shrubs, *Brachanthemum mongolica* species dominating in association with *Zygophyllum xantaxylon, Potaninia mongolica and Caragana brachypoda.*

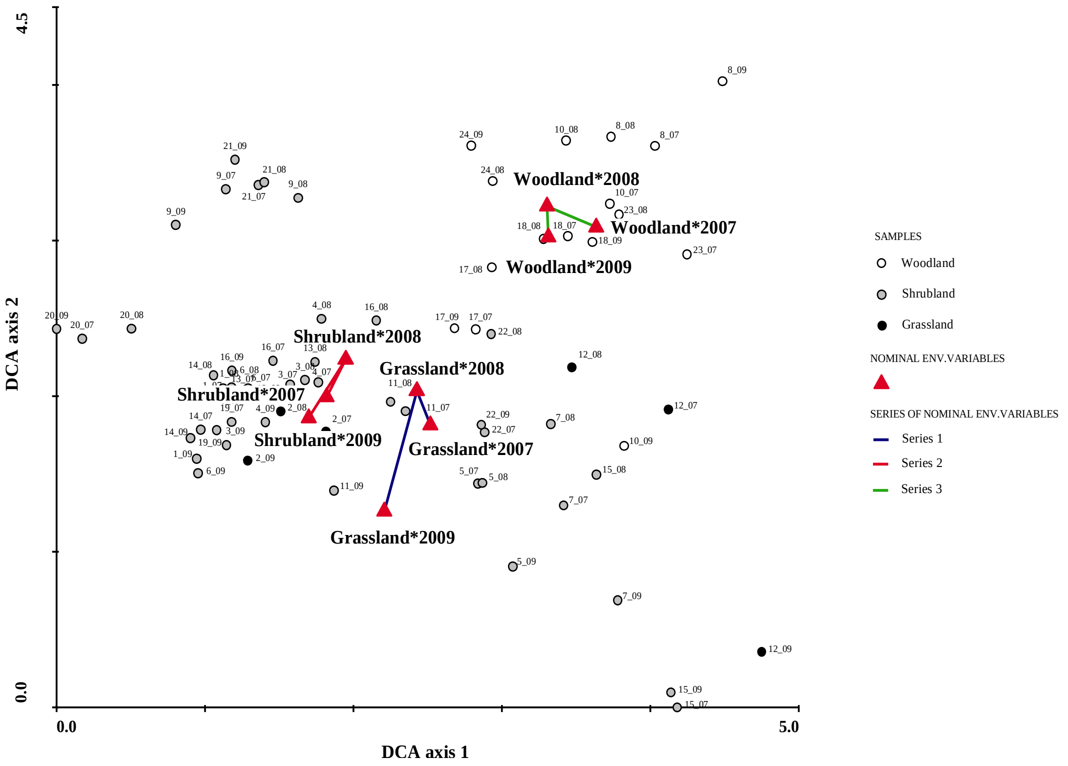

Fig. 5. *Detrended correspondence analysis (DCA) diagram of 24 plots from Khanbogd soum which were sampled repeatedly 2007-2009. Lines are drawn between average species scores of three vegetation types for each year indicating changes in species composition of the vegetation types during the study. Plots were classified based on these three vegetation types (woodland, shrubland and grassland) and different symbols correspond to these. Plot names consist of plot number and a sampling year.*

According to the DCA diagram (Fig. 5) different vegetation types showed different changes through time. The temporal variation indicated by vectors between average scores of the plots of the three vegetation types for each sampling year was smaller than the spatial variation in the dataset (Fig. 5). The species composition varied however through the study time with the largest changes from 2008 to 2009 in shrubland and grassland plots. Of the three vegetation types the temporal changes were the largest in grasslands. The overall trends showed a shift of 2008 species composition to higher second axis scores, indicating higher cover of annuals and total cover (Table 8).

The first two CCA axes explained most of the variation in the species data with eigenvalues 0.490 and 0.316 for axis 1 and axis 2, respectively. The final model included nine environmental (explanatory) variables (Table 10 and Fig. 7) and was obtained by forward selection using the Monte Carlo test. The final CCA model was significant (p=0.002, F ratio=3.82) and it explained 36% of the total variation of the species composition data. Two habitat types, sandy hill and riverside, contributed the greatest to the model or almost 40% of explained variation (Table 10). Together with these habitat types, altitude and cover of annual species and annual grasses were correlated to the first CCA axis and thus explained much of the composition data variation (Fig. 7). Sandy hill, riverside, altitude and cover of grasses explained best the second CCA axis (Fig. 7).

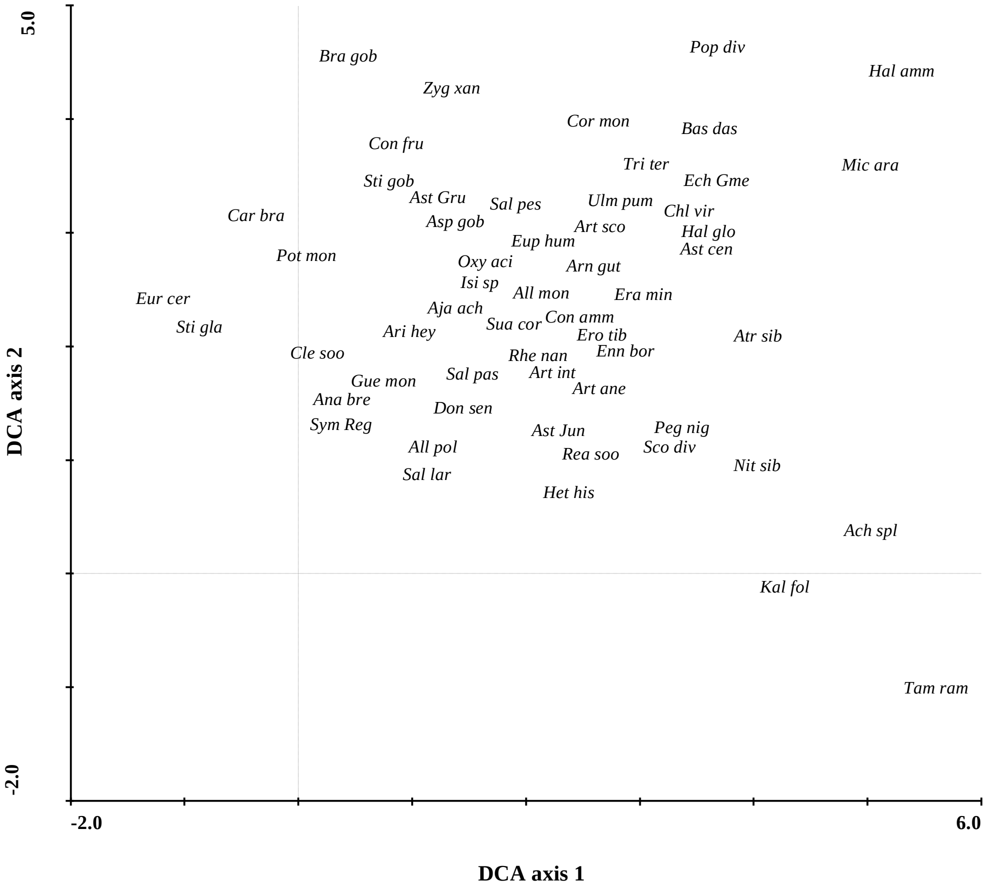

Fig. 6. *DCA ordination diagram of vascular plant species in 24 plots at Khanbogd. Species with more than 5% weight (contribution to the ordination results) are shown and only three first letters of genus and species names are shown. Full meaning of abbreviations are given in Appendix 1.*

Table 10. *The environmental variables included in the final CCA model. Variance explained shows how much variance individual variables explained and variance explained in stepwise forward selection refers to how much a given variable explained of the remaining variance.*

Environmental variable	**Variance explained**	**Variance explained in stepwise forward**	**F-ratio**	**P**
Sandy hill	0.36	0.36	5.40	0.002
Riverside	0.31	0.35	5.53	0.002
Slope	0.25	0.21	3.50	0.002
Altitude	0.28	0.19	3.26	0.002
Annual grasses cover	0.20	0.16	2.80	0.002
Species richness	0.17	0.15	2.67	0.002
Annual species cover	0.21	0.13	2.30	0.002
Terrace	0.24	0.13	2.34	0.002
Shrub cover	0.13	0.13	2.38	0.002

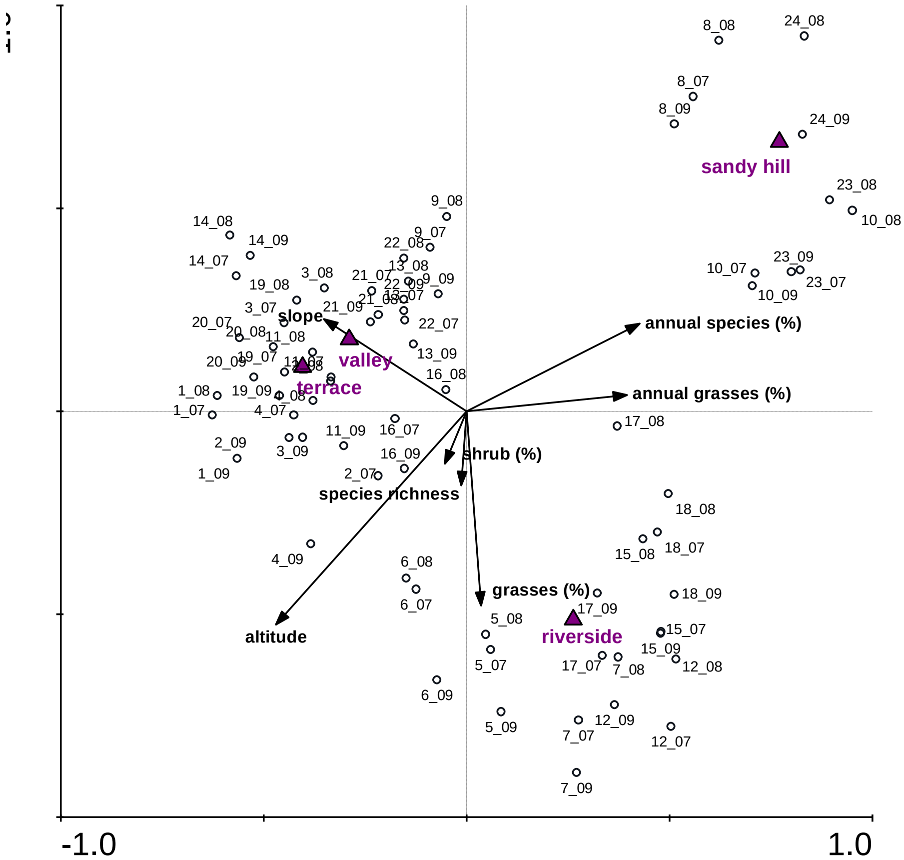

__Fig. 7.__ Canonical correspondence analysis (CCA) ordination diagram of 24 plots from Khanbogd soum. The plots were sampled repeatedly in 2007-2009. Different symbols show different vegetation types (woodland, shrubland and grassland) and numbers show plot number in different years (´07-´09). Quantitative environmental variables such as all covers, altitude, slope and species richness are indicated by arrows. Nominal environmental variables (habitats and vegetation types) are indicated by triangles.

4. DISCUSSION

The aim of this study was to provide reference data of the natural undisturbed vegetation in Khanbogd soum before mining had taken place, and relate the floristic information to environmental factors, in addition to investigate changes in species composition during the study years to observe natural fluctuations.

The study results will be useful reference data for the development of criteria for restoration of vegetation if needed after mining. The study showed that hemicryptophyte (perennial grass and forbs) was the most common plant life form; however, the abundance of chameophytes (shrubs) and therophytes (annual plants) was the highest. This is probably best explained by the semi-arid conditions and erratic or unpredictable rainfall (Jadeja, Patel, & Odedra, 2011) as annuals respond to small precipitation changes and shrubs tolerate low rainfall and scarce nutrients. In arid and semi-arid regions, water availability is a key limiting factor and determines plant performance, abundance, and distribution (Zhao, Xiao & Liu, 2006). This implies that in restoration planning, it is not only the trees and shrubs but also the annuals that should be given due consideration, as annuals sustain ground cover and modify the biological condition of the area.

The vegetative cover differed significantly between the study years with the highest total cover in 2008 followed by 2007 (Fig. 4a). This was most likely because of the difference in precipitation as almost double precipitation was recorded in 2008 compared to the other study years and much higher than the long-term precipitation record in 1976-2006 (Table 1, Fig. 2). This indicated that precipitation appeared to be the most important measured environmental factor governing the total vegetative cover in the area. Similar results were found by Klein and Roehrig (2006). These results support the conclusion that precipitation in dry areas is one of the major driving forces for vegetation growth (Beatley, 1974; Klein & Roehrig, 2006).

Los, Collatz, Bounoua, Sellers, & Tucker (2001) identified that land surface vegetation was positively related to precipitation throughout the tropics and subtropics in mid-latitudes and in the central parts of continents. In coastal temperate climates such as in Europe and eastern Asia anomalies in vegetation was positively linked to anomalies in temperatures (Los et al. 2001). These associations between temperature and vegetation may be explained by the sensitivity of the length of the growing season to variations in temperature. Similarly, Xu, Lin, Xue, & Zeng (2003), addressed the correlation between climate factors and the vegetative cover in different parts of China. They predicted that vegetation will be further affected if the total precipitation goes over 45-65 days. In the mid-variable zones and semi-drought regions, vegetation is very sensitive to rainfall. As a consequence, rainfall coming within 15-45 days is most important for vegetation in these regions.

Similarly, as illustrated in Fig. 4d, there was a significant difference in annual plant cover between years, and comparison of individual years showed that 2008 differed significantly from both 2007 and 2009, but there was no significant difference between 2007 and 2009. This indicates that annual plant cover influenced the total cover. According to Bainbridge (2007) short lived annuals may appear profusely only once every 5-10 years when precipitation and soil moisture are favourable. Facelli and Chesson (2008) have indicated that seeds of annual plants in dry ecosystems often have dormancy mechanisms that allow only a fraction of all seeds present to germinate at any given time, creating a long-lasting soil seed bank. As to the results of this study, some annuals such as *Aristida heymannii, Bassia dasyphyla, Eragrostis minor, Halogeton glomeratus,* and *Tribulus terrestris*, increased their cover from 5% to 80% in 2008 (Appendix 1). This may indicate that the amount of precipitation was also the key factor for seed dormancy and ignition of germination, of special annual seeds (Walck, Hidayati, Dixon, Thompson, & Poschlod, 2011).

Although annual plant cover was more associated with woodland vegetation type (Fig. 7, CCA diagram), annual plant cover was also found higher in some of the shrubland plots (plots 3, 4, 7, 8, 10, 12, 16, 17, 19, 20, 23) in 2008. Similar findings were reported by Facelli & Temby (2002), i.e. annual plants were more common under canopies of some dominant shrub than in open space. This is because woods and shrubs provide more shelter, thereby improving environmental conditions for establishment and growth. It is a potential mechanism of allowing the coexistence of annual plants with woods and shrubs.

Species composition varied during the study time (Fig. 5, DCA diagram), believed to have been due to fluctuations in precipitation, as discussed above. This temporal variation was however relatively small compared to the spatial variation in the dataset as seen in the whole ordination space. The spatial variation was best explained by habitat types and topography.

CCA results showed that of the environmental variables that significantly explained the species variation, two habitat types (sandy hill and riverside) and topography (altitude and slope) were the components that contributed most to explaining the compositional data (Table 1).

As mining activities are planned in parts of the study area it is foreseen that in those areas their ecosystems will experience some disturbances. Thus, there may become need for restoration in the future. Resilience refers to the ability of an ecosystem to recover following a disturbance (Hobbs, 1999) and planning of ecological restoration may include ecosystem variability to provide and maintain resilience (Cooke & Johnson, 2002).

Knowing how resistant and resilient an ecosystem is to a disturbance is an important point to know before deliberate disturbance use in mining in practiced. Species diversity is commonly used as a criterion for assessing the resilience of an ecosystem with generally a positive relationship between diversity and resilience (Mitchell, Auld, Le Duc, & Robert, 2000). In this study area, the species average Shannon-Wiener diversity index was found to be 1.77, which indicates low diversity (Barbour, et al., 1987). This indicates that the study area is vulnerable to a disturbance such as mining, which is recently starting up in the area.

5. CONCLUSION

Species composition varies greatly in the study area of Khanbogd soum. There are temporal changes which show natural fluctuations in plant cover, species richness and species composition, and these changes may most likely be related to precipitation. Most of the variation in species composition is best explained by two habitat types, sandy hill and riverside, and the topographical variables altitude and slope. Shrub species were the most abundant, followed by annual species. If restoration is needed in the area in the future it is important to consider not only trees and shrubs but also the annuals to sustain ground cover.

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APPENDIX

No	Vascular plant species name	Abbreviation	12_07	12_08	12_09	13_07	13_08	13_09	14_07	14_08	14_09	15_07	15_08	15_09	16_07	16_08	16_09	17_07	17_08	17_09	18_07	18_08	18_09	19_07	19_08	19_09	20_07	20_08	20_09	21_07	21_08	21_09	22_07	22_08	22_09	23_07	23_08	23_09	24_08	24_09
1	*Achnatherum splendens*	*Ach spl*	20	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	*Agriophyllum pungens*	*Agr pun*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3
3	*Ajania achilloides*	*Aja ach*	0	0	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0,3	0	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0,3
4	*Allium mongolicum*	*All mon*	0	0	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0,3	0,3	0	0	0,3	0	0,3	0,3	0,3	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0,3	0	0	0	0,3	0
5	*Allium polyrrhizum*	*All pol*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0
6	*Amygdalus pedunculata*	*Amy ped*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	*Anabasis brevifolia*	*Ana bre*	0	0	0	5	5	5	8	5	2	0	0	0	2	6	2	0	0	0	0	0	0	5	6	1	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0
8	*Aristida heymannii*	*Ari hey*	0	0,3	0	0,3	4	0	0	0	0	0	0,3	0	0,3	0,3	0	0	0,3	1	0	0	0	1	30	0	5	10	2	0,3	0,3	0,3	0,3	0,3	0,3	0	0,3	0	0,3	0,3
9	*Arnebia fimbriata*	*Arn fim*	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0,3	0,2	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0,3
10	*Arnebia guttata*	*Arn gut*	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0,3	0	0	0,3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
11	*Artemisia anetifolia*	*Art ane*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	*Artemisia annua*	*Art ann*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3
13	*Artemisia caespitosa*	*Art cae*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	*Artemisia intricata*	*Art int*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0,3	1	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
15	*Artemisia pectinata*	*Art pec*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	*Artemisia scoparia*	*Art sco*	0	0,3	0	0	0	0,3	0	0	0	0	0	0	0,3	0	0,3	1	5	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3
17	*Artemisia sieversiana*	*Art sie*	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	*Artemisia sphaerocephala*	*Art sph*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
19	*Artemisia xerophytica*	*Art xer*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0,3
20	*Asparagus gobicus*	*Asp gob*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0,3	0,3	0	0	0	0	0
21	*Asterothamnus centraliasiatica*	*Ast cen*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3
22	*Astragalus Grubovii*	*Ast Gru*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0
23	*Astragalus Junatovii*	*Ast Jun*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	*Astragalus melilotoides*	*Ast mel*	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
25	*Astragalus variabilis*	*Ast var*	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5	0	0	0,3	0,2	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	*Atraphaxis pungens*	*Atr pun*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	*Atriplex sibirica*	*Atr sib*	0,3	0,3	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0,3	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	*Bassia dasyphylla*	*Bas das*	0	0,3	0	0	0	0	0	0,3	0	0	0,3	0	0	0	0	0,3	15	0	0,3	0	0	0,3	0,3	0	0	0,3	0	0,3	0,3	0,3	0,3	0,3	0	0	0,3	0	3	1
29	*Brachanthemum gobicum*	*Bra gob*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	10	0	0	0	0	0	0	0	0
30	*Calligonium mongolicum*	*Cal mon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0,3
31	*Cancrinia discoidea*	*Can dis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	*Caragana brachypoda*	*Car bra*	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0,3	2	2	0	0	0	0	0	0	0	0	0	0	0
33	*Carex sp.*	*Car sp*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	*Caryopteris mongolica*	*Car mon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	*Chenopodium acuminatum*	*Che acu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	*Chenopodium album*	*Che alb*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	*Chenopodium glaucum*	*Che gla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	*Chiazospermum lactiflorum*	*Chi lac*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	*Chloris virgata*	*Chl vir*	0	0,3	0	0	0,3	0	0	0	0	0	0,3	0	0	0	0	0	0,3	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0,3	0	0,3	0
40	*Cleistogenes soongorica*	*Cle soo*	0	0	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0,3	0	0	0	0	0,3	0,3	0	0,3	5	3	0,3	0,3	0,3	0	0	0	0	0	0	0	0
41	*Clematis tangutica*	*Cle tan*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	*Convolvulus ammanii*	*Con amm*	0,3	0,3	0	0	0,3	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0,3	0,3	0	0	0	0	0
43	*Convolvulus fruticosus*	*Con fru*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	3	9	8	0	0	0	0	0	0	0	0
44	*Corispermum mongolica*	*Cor mon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0,3	0	1	1	0,3	0,3	2	0,3	0	5	0,3	10	1
45	*Dontostemon crassifolius*	*Don cra*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0
46	*Dontostemon senilis*	*Don sen*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0,3	0	0	0,2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	*Echinops Gmelinii*	*Ech Gme*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0,3	0	0,3	0,3	0	0	0	0	0	0,3	0
48	*Enneapogon borealis*	*Enn bor*	0	0,3	0	0,3	0,3	0	0	0	0	0	0,3	0	0	0,3	0	0	0,3	0	0,3	0	0	0	0,3	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0,3	0
49	*Eragrostis minor*	*Era min*	0	10	0	0,3	3	0	0	1	0	0	0,3	0	0,3	0,3	0	0,3	6	1	0,3	3	0	0	0,3	0	0	0,3	0	0	1	0,3	0,3	2	0,3	0	2	0	0,3	0
50	*Erodium stephanianum*	*Ero ste*	0	0,3	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	*Erodium tibetanium*	*Ero tib*	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0,3	0	0,3	0,3	0,3	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0
52	*Euphorbia humifusa*	*Eup hum*	0	0	0	0	0,3	0	0	0,3	0	0	0	0	0	0,3	0	0	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
53	*Eurotia ceratoides*	*Eur cer*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	9	9	0	0	0	0	0	0	0	0	0	0	0
54	*Ferula Bungena*	*Fer Bun*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0
55	*Glycyrrhiza uralensis*	*Gly ura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	*Gueldenstaedtia monophylla*	*Gue mon*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	*Halogeton glomeratus*	*Hal glo*	7	10	0	0,3	0,3	0	0,3	0,3	0	0	1	0	0,3	45	0	0	5	0	0,3	4	0	0,3	0,3	0	0	0	0	0	0	0	0,3	3	0,3	1	20	0,3	7	0,3
58	*Haloxylon ammodendron*	*Hal amm*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	2	0	0	0	0	0	0	0	0	0	0	0	0	5	10	10	0	0
59	*Hedysarium pumilum*	*Hed pum*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	*Heteropappus altaicus*	*Het alt*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	*Heteropappus hispidus*	*Het his*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	*Inula salsoloides*	*Inu sal*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3
63	*Iris lactae*	*Iri lac*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
64	*Iris sp.*	*Isi sp*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3
65	*Kalidium foliatum*	*Kal fol*	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
66	*Lactuca tatarica*	*Lac tat*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	*Lagochilus ilicifolius*	*Lag ili*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	*Lappula intermedia*	*Lap int*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	*Limonium erythrorhizum*	*Lim ery*	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	*Lycium truncatum*	*Lyc tru*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71	*Micropeplis arachnoidea*	*Mic ara*	3	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0,3	0,3	0	1	0,3	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	15	0	0	0
72	*Microstigma deflexum*	*Mic def*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	*Molluga cerviana*	*Mol cer*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
74	*Nitraria sibirica*	*Nit sib*	0	0	0	0	0	0	0	0	0	0,5	1	1	0	0	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	9	7	7	3	5	4	0	0
75	*Orobanche coerulescens*	*Oro coe*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
76	*Oxytropis aciphylla*	*Oxy aci*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0
77	*Panicum miliaceum*	*Pan mil*	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	*Peganum nigellastrum*	*Peg nig*	0	0	0	0	0	0	0	0	0	0,3	1	0,3	0	0	0	0	0,3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3
79	*Phragmites communis*	*Phr com*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	*Populus diversifolia*	*Pop div*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	15
81	*Potaninia mongolica*	*Pot mon*	0	0	0	0	0	0	1	7	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	3	4	4	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0,3
82	*Psammochloa villosa*	*Psa vil*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	*Ptilagrostis Pelliotii*	*Pti Pel*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	*Reaumuria soongorica*	*Rea soo*	0	0	0	0	0	0	0,3	0	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0,3	0,3	0,3	0	0,3	0,3	0	0	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0
85	*Rheum nanum*	*Rhe nan*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0,3	0,3	0	0	0,3	0	0	0,3	0	0	0	0	0	0	0	0	0
86	*Salsola collina*	*Sal col*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0,3	0
87	*Salsola laricifolia*	*Sal lar*	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	*Salsola passerina*	*Sal pas*	0	0	0	0	0	0	6	2	2	0	0	0	0,5	0,3	0,5	0	0	0	0,3	0,3	0,3	3	4	4	0	0	0	0,3	0	0,3	1	0,3	0,3	0	0	0	0	0
89	*Salsola pestifera*	*Sal pes*	0	0	0	0,3	0	0	0,3	0,3	0	0	0	0	0	0	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0,3
90	*Scorzonera divaricata*	*Sco div*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
91	*Scorzonera pseudadivaricata*	*Sco pse*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0,3	0,3
92	*Scrophularia incisa*	*Scr inc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93	*Setaria glauca*	*Set gla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0,3	0	0,3	0
94	*Setaria viridis*	*Set vir*	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0,3	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0
95	*Stipa glareosa*	*Sti gla*	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	7	5	0	0	0	0	0	0	0	0	0	0	0
96	*Stipa gobica*	*Sti gob*	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	1	4	3	0	0	0	0	0	0	0	0
97	*Suaeda corniculata*	*Sua cor*	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0,3	0	0	0	0	0,3	0,3	0	0	0,3	0	0	0	0	0	0
98	*Sueade salsa*	*Sua sal*	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
99	*Sympegma Regelli*	*Sym Reg*	0	0	0	0,3	0	0,3	4	4	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	*Tamarix ramosissima*	*Tam ram*	0	0	0	0	0	0	0	0	0	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	*Tournefortia sibirica*	*Tou sib*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3
102	*Tragus mongolica*	*Tra mon*	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
103	*Tribulus terrestris*	*Tri ter*	0,3	5	0	0	0,3	0	0	0,3	0	0	0,3	0	0	0	0	0	0,3	0,3	0,3	6	0	0	0,3	0	0	0,3	0	0	1	0	0	1	0	0	0,3	0	2	1
104	*Ulmus pumila*	*Ulm pum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105	*Xanthium strumarium*	*Xan str*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	*Zygophyllum pterocarpum*	*Zyg pte*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3
107	*Zygophyllum xantaxylon*	*Zyg xan*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	1	1	0	0	0	0	0	0	0,3	0,3

No	Vascular plant species name	Abbreviation	1_07	1_08	1_09	2_07	2_08	2_09	3_07	3_08	3_09	4_07	4_08	4_09	5_07	5_08	5_09	6_07	6_08	6_09	7_07	7_08	7_09	8_07	8_08	8_09	9_07	9_08	9_09	10_07	10_08	10_09	11_07	11_08	11_09
1	*Achnatherum splendens*	*Ach spl*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	1	0	0	0	12	12	8	0	0	0	0	0	0	0,3	0	0,3	0	0	0
2	*Agriophyllum pungens*	*Agr pun*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	15	0,3	0	0	0	0	0	0	0	0	0
3	*Ajania achilloides*	*Aja ach*	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	*Allium mongolicum*	*All mon*	0,3	0,3	0	0,3	0,3	0	1	0,3	0	0,3	0,3	0	0	0	0	0,3	0,3	0,1	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3
5	*Allium polyrrhizum*	*All pol*	1	2	1	12	15	3	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	*Amygdalus pedunculata*	*Amy ped*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	*Anabasis brevifolia*	*Ana bre*	0,3	0,3	0,3	6	2	2	2	2	1	1	2	2	0	0	0	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1
8	*Aristida heymannii*	*Ari hey*	0	0,3	0	9	6	0,3	3	30	0	1	12	0	1	0,3	0,3	0,3	0,5	0,3	0,3	0,3	0	0	0	0	0,3	3	0,3	0	0	0	0,3	0,3	0
9	*Arnebia fimbriata*	*Arn fim*	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	*Arnebia guttata*	*Arn gut*	0	0	0	0		0	0	0	0	0	0,3	0	0	0	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0
11	*Artemisia anetifolia*	*Art ane*	0	0	0	0	0,3	0	0,3	0,3	0	0,3	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	*Artemisia annua*	*Art ann*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	*Artemisia caespitosa*	*Art cae*	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	*Artemisia intricata*	*Art int*	1	1	0,3	0,3	0,3	0	0	0,3	0	0	0	0	0,3	0	0,3	1	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	*Artemisia pectinata*	*Art pec*	0,3	0,3	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	*Artemisia scoparia*	*Art sco*	0,3	0	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0	0	0,3	0,3	0	0	0	0	0,3	0	0	0	0	0	0	0	0
17	*Artemisia sieversiana*	*Art sie*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	*Artemisia sphaerocephala*	*Art sph*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	*Artemisia xerophytica*	*Art xer*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	*Asparagus gobicus*	*Asp gob*	0,3	0	0	0	0,3	0	0	0,3	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0
21	*Asterothamnus centraliasiatica*	*Ast cen*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0,3	0,3	0
22	*Astragalus Grubovii*	*Ast Gru*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0
23	*Astragalus Junatovii*	*Ast Jun*	0	0	0	0	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0,3	0
24	*Astragalus melilotoides*	*Ast mel*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	*Astragalus variabilis*	*Ast var*	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	*Atraphaxis pungens*	*Atr pun*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	*Atriplex sibirica*	*Atr sib*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0,3	0	0,3	0,3	0
28	*Bassia dasyphylla*	*Bas das*	0	0	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0	0,3	0	0	6	0	10	10	0,3	0,3	0,3	0	5	80	0	1	0,3	0
29	*Brachanthemum gobicum*	*Bra gob*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	6	0	0	0	0	0	0
30	*Calligonium mongolicum*	*Cal mon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0
31	*Cancrinia discoidea*	*Can dis*	0	0,5	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	*Caragana brachypoda*	*Car bra*	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
33	*Carex sp.*	*Car sp*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	*Caryopteris mongolica*	*Car mon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	*Chenopodium acuminatum*	*Che acu*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	*Chenopodium album*	*Che alb*	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	*Chenopodium glaucum*	*Che gla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	*Chiazospermum lactiflorum*	*Chi lac*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	*Chloris virgata*	*Chl vir*	0	0	0	0,3	0	0	0,3	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0,3	0	0	0,3	0	0	0,3	0	0	0,3	0	0	0,3	0
40	*Cleistogenes soongorica*	*Cle soo*	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	*Clematis tangutica*	*Cle tan*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0
42	*Convolvulus ammanii*	*Con amm*	0	0	0	0,3	0,3	0	0	0,3	0,3	0	0,3	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
43	*Convolvulus fruticosus*	*Con fru*	0	0	0	0	0	0	0	0	0	1	11	3	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0,3	0	0	0	0	0	0
44	*Corispermum mongolica*	*Cor mon*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0,3	0	0	0,3	0	0,3	15	0	0	0	0	0	0	0
45	*Dontostemon crassifolius*	*Don cra*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
46	*Dontostemon senilis*	*Don sen*	0,3	0,3	0	0,3	0	0	0,3	0	0	0	0	0	0	0,3	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	*Echinops Gmelinii*	*Ech Gme*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0
48	*Enneapogon borealis*	*Enn bor*	0,3	0,3	0	3	0,3	0	0,3	0,3	0	0	0,3	0	0	0,3	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0,3	0	0	0	0	0,3	0,3	0
49	*Eragrostis minor*	*Era min*	0,3	2	0	0,3	0,3	0	0,3	10	0	0,3	0,3	0	1	1	0	0,3	0,5	0	2	18	0	0	0,3	0	0	0,3	0	0	0,3	0	0	2	0
50	*Erodium stephanianum*	*Ero ste*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	*Erodium tibetanium*	*Ero tib*	0	0	0	0	0	0	0	0,3	0	0,3	0	0	0,3	0,3	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	*Euphorbia humifusa*	*Eup hum*	0	0,3	0	0	0,3	0	0	0,3	0	0	0,3	0	0,3	0	0	0,3	0,3	0	0	0,3	0	0	0	0	0	0,3	0	0	0	0	0	0,3	0
53	*Eurotia ceratoides*	*Eur cer*	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	*Ferula Bungena*	*Fer Bun*	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	*Glycyrrhiza uralensis*	*Gly ura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0	0,3	0	0	0
56	*Gueldenstaedtia monophylla*	*Gue mon*	0,3	0,3	0	0	0,3	0	0	0,3	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
57	*Halogeton glomeratus*	*Hal glo*	1	0,5	0	0,3	0,3	0	0,3	0,3	0	1	15	0	0,3	0,3	0	0,5	0,3	0	3	20	0	1	20	0,3	0	0	0	0	0,3	0	0,3	0,3	0
58	*Haloxylon ammodendron*	*Hal amm*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	8	0,3	0,3	0,3	0	0	0	0	0	0
59	*Hedysarium pumilum*	*Hed pum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	*Heteropappus altaicus*	*Het alt*	0,3	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	*Heteropappus hispidus*	*Het his*	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0
62	*Inula salsoloides*	*Inu sal*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	*Iris lactae*	*Iri lac*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0
64	*Iris sp.*	*Isi sp*	0	0	0	0,3	0,3	0,3	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
65	*Kalidium foliatum*	*Kal fol*	0	0	0	0	0	0	0	0	0	0	0	0	7	7	8	0	0	0	10	10	9	0	0	0	0	0	0	0	0	0	0	0	0
66	*Lactuca tatarica*	*Lac tat*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	*Lagochilus ilicifolius*	*Lag ili*	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	*Lappula intermedia*	*Lap int*	0	0,3	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
69	*Limonium erythrorhizum*	*Lim ery*	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0
70	*Lycium truncatum*	*Lyc tru*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0
71	*Micropeplis arachnoidea*	*Mic ara*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	5	0,3	0	0	0	0	0,3	0	0	0	0	0
72	*Microstigma deflexum*	*Mic def*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	*Molluga cerviana*	*Mol cer*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	*Nitraria sibirica*	*Nit sib*	0	0	0	1	0,3	0,3	0	0	0	0,3	0,3	0,3	5	5	4	0	0	0	10	7	5	0	0	0	0	0	0	0	0	0	0,3	0,3	0
75	*Orobanche coerulescens*	*Oro coe*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	*Oxytropis aciphylla*	*Oxy aci*	0	0,3	0	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0
77	*Panicum miliaceum*	*Pan mil*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78	*Peganum nigellastrum*	*Peg nig*	0	0	0	9	0,3	0,3	0	0	0	0,3	0,3	0,3	1	1	0,3	0	0	0	0,3	0,3	0,3	1	0,3	0,3	0	0	0	0,3	0	0,3	1	0,3	0,3
79	*Phragmites communis*	*Phr com*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0
80	*Populus diversifolia*	*Pop div*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	1	0	0	0
81	*Potaninia mongolica*	*Pot mon*	11	10	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	5	6	0	0	0	0	0	0	0	3	3	3	0	0	0	0	0	0
82	*Psammochloa villosa*	*Psa vil*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0
83	*Ptilagrostis Pelliotii*	*Pti Pel*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
84	*Reaumuria soongorica*	*Rea soo*	0	0	0	0,3	0,3	0,3	0	0,3	0,3	2	0,3	4	0,3	0,3	0,3	0	0	0	2	5	3	0	0	0	0,3	0,3	0,3	0	0	0,3	4	7	5
85	*Rheum nanum*	*Rhe nan*	0	0	0	0,3	0	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0
86	*Salsola collina*	*Sal col*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
87	*Salsola laricifolia*	*Sal lar*	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0,3	0,3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	*Salsola passerina*	*Sal pas*	3	0,3	1	0,3	0,3	2	0,3	0,3	0,3	1	7	5	0,3	0,3	0,3	0	0	0	0,3	0,3	0,3	0	0	0	0,3	0,3	2	0	0	0	1	6	1
89	*Salsola pestifera*	*Sal pes*	0,3	0,3	0	0,3	0,3	0	0,3	0	0	0,3	0,3	0	0	0	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0	0
90	*Scorzonera divaricata*	*Sco div*	0	0	0	0	0	0	0,3	0	0	0	0	0	0,3	0,3	0,3	0	0,3	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0
91	*Scorzonera pseudadivaricata*	*Sco pse*	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
92	*Scrophularia incisa*	*Scr inc*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93	*Setaria glauca*	*Set gla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	*Setaria viridis*	*Set vir*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95	*Stipa glareosa*	*Sti gla*	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
96	*Stipa gobica*	*Sti gob*	0,3	0,3	0,3	0	0	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3	0	0	0	0	0	0
97	*Suaeda corniculata*	*Sua cor*	0,3	0,3	0	0	0	0	0,3	0,3	0	0,3	0,3	0	0	0,3	0	0,3	0,3	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0
98	*Sueade salsa*	*Sua sal*	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
99	*Sympegma Regelli*	*Sym Reg*	5	5	3	0,3	0,3	0,3	5	5	4	4	0,3	3	0,3	0,3	0,3	3	4	3	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0,3
100	*Tamarix ramosissima*	*Tam ram*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0	0	0
101	*Tournefortia sibirica*	*Tou sib*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	*Tragus mongolica*	*Tra mon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0
103	*Tribulus terrestris*	*Tri ter*	0	0	0	0,3	0,3	0	0,3	0,3	0	0,3	0,3	0	0	0,3	0	0	0	0	0,3	0,3	0	0,3	2	0	0,3	0,3	0	0,3	5	0	0,3	1	0
104	*Ulmus pumila*	*Ulm pum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105	*Xanthium strumarium*	*Xan str*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
106	*Zygophyllum pterocarpum*	*Zyg pte*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	*Zygophyllum xantaxylon*	*Zyg xan*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ACRONYMS

GDP Gross Domestic Product
SPA Special Protected Area

DCA Detrended correspondence analysis
CCA Canonical correspondence analysis

Notes:

Aimag (= province) is the largest sub-national administrative unit; below the aimag is the *soum* (= district), which is divided into *bag* (= sub-district). In the capital city districts are called *duureg* and subdistricts *khoroo*.