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Plant communities of the Mongolian Transaltay Gobi

With one Map, 12 Figures and 14 Tables

Summary

Here we present the first detailed phytosociological description of the plant communities of the Transaltay Gobi, the driest region within Outer Mongolia. It was originally gazetted as a national park by the Mongolian parliament in 1976, which included also the Dzungarian basin in south-western Mongolia. The status of the Great Gobi A National Park in the Transaltay Gobi, and the Great Gobi B National Park in the Dzungarian Gobi was later raised to the level of Strictly Protected Area. Since the area hosts many endangered wildlife species, we offer an initial vegetation description, which is necessary to understand the habitats of this arid ecosystem. Based on a modified Braun-Blanquet approach we designated eight zonal vegetation units, most of which are impoverished regional variants of vegetation types previously described from adjacent regions; most units contain several sub-units. The altitudinal gradient reflects the climatic regime in the study area; therefore the vegetation distribution follows the precipitation gradient regarding both vegetation cover and diversity. The most important diagnostic species are typical drought–adapted central Asian elements, namely *Haloxylon ammodendron, Ephedra przewalskii, Reaumuria songarica* and *Anabasis brevifolia*. Three new associations were designated based on our vegetation data.

The main determinant for the riparian vegetation types is apparently groundwater availability, leading to locally high soil salt contents due to the high evaporation in the region. Poplar stands, reed beds and *Tamarix* stands are the characteristic vegetation types of the oases in the working area.

Zusammenfassung

Pflanzengesellschaften der mongolischen Transaltai Gobi

Der vorliegende Text stellt die erste detaillierte Beschreibung der Pflanzengesellschaften der Transaltai Gobi dar, der trockensten Region der Äußeren Mongolei. Ursprünglich wurde das Gebiet 1976 durch das Mongolische Parlament als Nationalpark ausgewiesen, der die Dzungarische Senke im Südwesten der Mongolei mit einschloss. Die beiden Nationalparks Große Gobi A und Große Gobi B wurden später in die höhere Schutzkategorie „Streng Geschütztes Gebiet“ eingestuft. Die Region beherbergt zahlreiche bedrohte Tierarten; die hier vorgestellte Vegetationsbeschreibung ist somit eine notwendige Grundlage für das Verständnis der Habitate in diesem ariden Ökosystem. Basierend auf der Braun–Blanquet Methode, die wir leicht modifiziert haben, wurden acht zonale Vegetationseinheiten ausgewiesen, von denen die meisten verarmte regionale Varianten von vorher schon aus benachbarten Regionen beschriebenen Vegetationstypen sind. Zahlreiche Vegetationseinheiten enthalten mehrere Untereinheiten. Die Höhenzonierung der Vegetation spiegelt das klimatische Regime des Untersuchungsgebietes wider; daher folgt die Verteilung der Vegetation dem Niederschlagsgradienten, und zwar sowohl im Bezug auf die Vegetationsdeckung als auch im Bezug auf die Diversität. Die wichtigsten diagnostischen Arten sind typische an Trockenheit angepasste zentral-asiatische Elemente, namentlich *Haloxylon ammodendron, Ephedra przewalskii, Reaumuria songarica* und *Anabasis brevifolia*. Auf Grundlage unserer Vegetationsaufnahmen wurden drei neue Assoziationen ausgewiesen.

Die wichtigste bestimmende Eigenschaft für die extrazonalen Vegetationstypen ist offensichtlich die Verfügbarkeit von Grundwasser; diese führt aufgrund der hohen Verdunstungsraten zu lokal sehr

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hohen Salzkonzentrationen. Pappel-, Schilf- und Tamariskenbestände sind charakteristische Vegetationstypen der Oasen des Untersuchungsgebietes.

1 Introduction

The Great Gobi A Strictly Protected Area is the largest nature reserve in Mongolia. Together with the Great Gobi B Strictly Protected Area, which is situated in the south–western part of Mongolia, it was gazetted by the Mongolian government at 31. 12. 1976 in order to conserve some rare and endangered animal species, some of which are threatened with extinction. Khulans, gobi-bears, snow-leopards and wild camels occur in this protected area (ZEVEGMID & DAWAA 1973), where, unlike in other Mongolian reserves, the presence of humans is low. Hence the Great Gobi A Strictly Protected Area is a key region for the conservation of Gobi ecosystems. Detailed knowledge on the vegetation is one prerequisite for a comprehensive understanding of species habitat conditions (VON WEHRDEN & WESCHE in press), but also for a comprehensive picture on the biodiversity. Moreover, a survey of the current vegetation patterns can serve as an invaluable reference to quantify anticipated future changes (GUNIN et al. 1999).

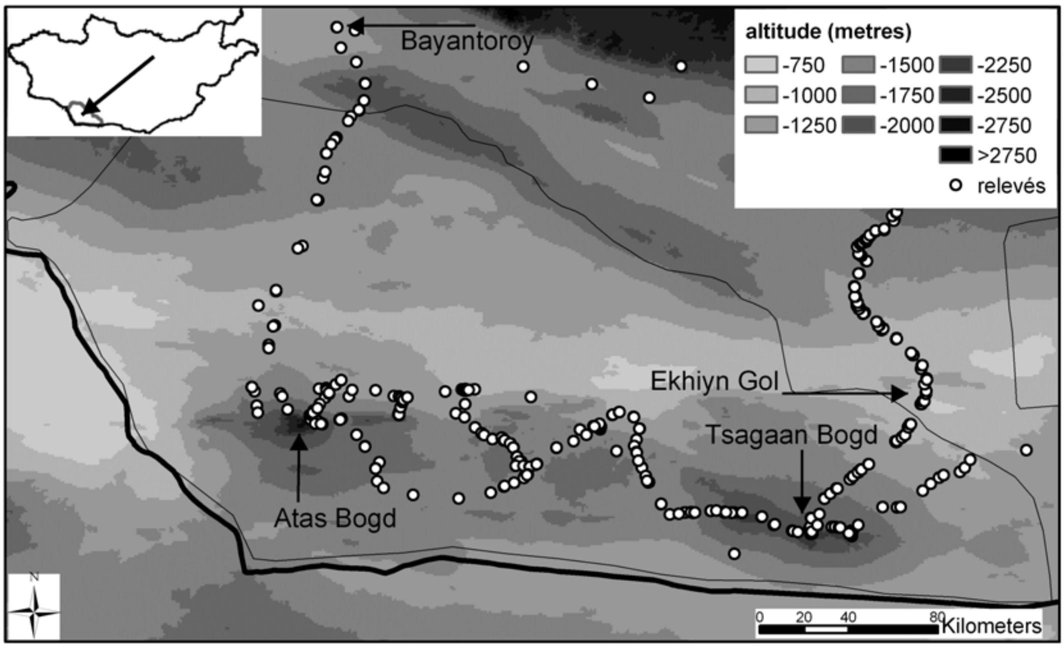
General inventories of the Mongolian vegetation are already available, both on a country–wide and on a local scale (e.g. ANONYMOUS 1990; RACHKOVSKAYA 1993) including a phytosociological system for the entire country (HILBIG 2000). Between 1980 and 1982, Russian scientists conducted extensive research in the then called Great Gobi National Park; studies had a certain focus on large mammals but also included records on climate, soils, water hydrology and vegetation (JIRNOV & ILINSKIY 1985). More detailed research on the vegetation was conducted by RACHKOVSKAJA & VOLKOVA (1977). However, recent publications suggest that the present system is not detailed enough with respect to the southern Mongolian deserts, which have rarely been studied with phytosociological methods so far (see HILBIG 2000; WESCHE et al. 2005; VON WEHRDEN et al. subm.). Here we present new vegetation records for the Great Gobi A Strictly Protected Area and compare the results to the previously published classification system (HILBIG 2000) and other studies from adjacent territories (KÜRSCHNER 2004; WESCHE et al. 2005; HILBIG & TUNGALAG 2006; VON WEHRDEN et al. subm.).

2 Study area

The Gobi is part of the Eurasian dryland belt that reaches from westernmost northern Africa to the eastern parts of northern China. It covers large regions in northern Inner Mongolia, eastern Kazakhstan and in southern Outer Mongolia. The Great Gobi A covers much of the floristic region of the Transaltay Gobi (after GUBANOV 1996), which is situated in the Southwest of Mongolia towards the boundary of China (see map 1), and comprises the driest parts of the Mongolian territory.

2.1 Geomorphology

Altitudinal gradients are the principal determinants of the study area's topology (LEHMKUHL 2000). The mountains of the Great Gobi A are equally distant from the Mongolian Altay in the north, the Gobi Altay in the northeast and the Tien Shan system in the (south)-west. However, the huge depressions surrounding the two main mountain ranges, the Atas Bogd and the Tsagaan Bogd, of the study area isolate them from the neighbouring mountain systems. Sites on the dry mountain slopes are characterised by strong physical erosion creating steep flanks with extensive areas covered by bare rocks or rock screes. Deflation is the main erosive process flattening the surrounding pediments (Mongolian "bel"), which are subsequently dissected by drainage lines forming an endorheic river system. The presence of coarse gravel in these dry river beds (Mongolian "sayr") indicates the power of the episodic water flows. Fine sand is ubiquitous, yet higher dunes are rare and mostly linked to oases. The lowermost depressions, i.e. north of the Atas Bogd and Tsagaan Bogd (Map 1) reach below 1200 m asl. and show deflated gypsum soils.



Map 1
Overview of the working area. Each dot represents a vegetation record. The insert shows the location of the area within Mongolia

2.2 Climate

The area is part of the cold deserts of Central Asia and has a highly continental climate (WEISCHET & ENDLICHER 2000). Two atmospheric circulation systems control the precipitation patterns in this part of Mongolia. The monsoon system is responsible for the almost exclusive summer precipitation east of some 100° E longitude, while the western, i.e. Dzungarian parts of Mongolia are influenced by western disturbances from the Mediterranean region, which cross the Turanic highlands. The Transaltay Gobi is screened against both circulation systems, and neither gets much rain in summer nor in winter. Detailed climatic data are only available from the village Bayantoroy at the northern boundaries of the study region (see Fig.1), but a general interpolation model (HIJMANS et al. 2005) suggests that mean annual precipitation is below 100 mm/a in most parts of the working area. Mountains generally receive more precipitation than lowlands in the Gobi (WESCHE et al. 2005; RETZER et al. 2006), and peaks might receive slightly above 100 mm even in the dry Transaltay Gobi (HIJMANS et al. 2005). The rainfall is largely restricted to the summer; snow seems to be rare.

Hot summers and cold winters characterise the temperature regime. The diurnal temperature ranges are generally smaller in summer than during winter, when the Siberian anticyclone dominates the climate resulting in temperatures below −20 °C. Due to the low cloud cover, radiation heats the surface during the day, while intense re–radiation at night leads to cold conditions and thus to extreme diurnal temperature changes. In spring, the Siberian anti−cyclone collapses resulting in high wind speeds and often intense storms (BARTHEL 1983). This and the overall low amount of atmospheric moisture and dust result in a high annual evaporation.

2.3 Flora and vegetation

The study area is generally regarded as a part of the Gobi province within the central Asian flora region (MEUSEL & JÄGER 1992), whereas GRUBOV designates an Irano-Turanian region with a Mongolian subregion (GRUBOV 1959,

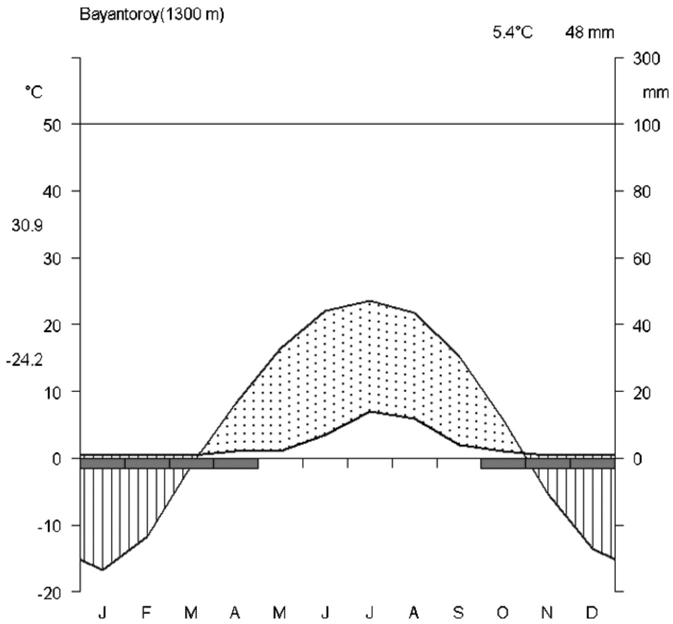


Fig. 1
Climatic diagram from the oasis of Bayantoroy, data based on the worldclim dataset (HIJMANS et al. 2005)

Table 1
Total species richness of major floristic regions according to GUBANOV (1996)

Region	Plant species
Dzungarian Gobi	717
Transaltay Gobi	340
Gobi Altay	752
Alashan Gobi	223

cited from WALTER 1974). A country-wide checklist (GUBANOV 1996) indicates that the overall number of taxa occurring in the Transaltay Gobi is comparatively low (see Table 1). Not surprisingly, most occurring species are adapted to dry conditions, and are shared with drylands of neighbouring countries (mainly China). The southern part of Outer Mongolia hosts only few sub-endemics, and the Transaltay region seems to contain no endemics of its own (GRUBOV 1989). This corresponds to the generally low biodiversity of the region.

Few families dominate the flora and the vegetation. Most prominent are woody Chenopodiaceae, yet Tamaricaceae and Zygophyllaceae are also important. The number of herbaceous plants increases with altitude, at least outside extreme water surplus sites such as oases or sayrs. The flora of the Gobi mountains not only has a higher biodiversity than the lowlands; their flora also shows a wider range of biogeographical affinities, comprising some elements of the northern steppes and even of the northern Holarctic region (JÄGER 2005).

A general description of Mongolian drylands vegetation is given by YUNATOV (1954), the southern deserts have been studied in some detail by RACHKOVSKAYA (1993) and RACHKOVSKAYA & VOLKOVA (1977). Most early works describing the vegetation of Mongolia use the Russian or Scandinavian approach, which designates plant communities according to the relative importance of the dominant species (HILBIG 1990). More recently, vegetation classifications followed the Braun–Blanquet approach and were based on the presence of diagnostic species. General overviews were provided by HILBIG (1995, 2000), but the number of relevés from the Transaltay region available for these syntheses was relatively low, since the Russian authors gave only general vegetation descriptions. Directly comparable are accounts on the vegetation of the neighbouring Inner Mongolian Alashan Gobi situated on the Chinese side of the border (KÜRSCHNER 2004), the studies of HILBIG &

TUNGALAG (2006) in the Borzongijn and the Galbyn Gobi, and a survey of our team for the Gobi Gurvan Saykhan National Park east of the study area (WESCHE et al. 2005; VON WEHRDEN et al. in press). An assessment for the Great Gobi B Strictly Protected Area in the Dzungarian Gobi was recently compiled (VON WEHRDEN et al. subm.).

The vegetation on intermediate elevations in the Transaltay Gobi is diffuse and dominated by perennials, but these become highly contracted to drainage sites in the arid depressions and at water accumulation sites within the oases (BOBROVSKAJA 1985). The driest depressions, e.g. north of the Atas Bogd (Map 1) lack permanent vegetation (Figs. 6, 7), though some annuals may grow in exceptionally moist years. Thus, the interannual and regional variability of precipitation can result in considerable fluctuations of the vegetation cover (HILBIG 1995; KÜRSCHNER 2004).

2.4 Human impact

The present Mongolian landscape has been formed and altered by human activity over centuries (HILBIG 1995; FERNANDEZ-GIMENEZ 1999). Logging of fuel wood and timber, but even more importantly grazing and browsing by domestic livestock have been the principal modes of impact. Though its importance is debated for the drier parts of the country (FERNANDEZ-GIMENEZ 1999; STUMPP et al. 2005), grazing of domestic livestock is responsible for large-scale pasture degradation in much of northern and central Mongolia (BATKHISHIG & LEHMKUHL 2003; OPP & HILBIG 2003; HILBIG & OPP 2005). However, Mongolian steppes were always grazed by large wild herbivores such as khulan, gazelle, argali, ibex, Przewalski horse and camel (READING et al. 1999; SCHALLER 2000; MIX et al. 2002), but their combined impact was presumably lower than the present levels of livestock grazing (BEDUNAH & SCHMIDT 2000). However, small mammals are also an important group of herbivores from the steppes to the drier parts of the country (SAMJAA et al. 2000; RETZER 2004).

All livestock depends on drinking water. Only camels can graze widely distant from wells or rivers, and thus exert a relatively moderate grazing regime. All other animals need to drink daily and are hence rarely found more than 20 kilometres away from wells or open water (BEDUNAH & SCHMIDT 2000). This is of major importance in the Transaltay region because wells and open water bodies are extremely rare. The exceedingly dry climate ensures that most parts of the region remain free from anthropo–zoogenic impact; among the few exceptions are some sites north of the Tsagaan Bogd and a few military outposts near the Chinese border. This lack of human impact makes the study area unique among other southern Mongolia regions.

Obviously, grazing has not only a spatial but also a historic dimension. Though land use as such is old, technical developments during the second half of the 20th century like the improvement of irrigation systems in the oases of Bayantoroy and Ekhiyn Gol have partly altered the landscape even in the Transaltay Gobi. More recently, political changes since 1990 have resulted in several changes in land use, affecting the number of animals and the land–use patterns (NATIONAL STATISTICAL OFFICE OF MONGOLIA 2001, 2003). Nothing specific is known for our study region, except that the impact remains overall low in comparison with other southern Mongolian regions. Thus, the Great Gobi A represents one of the last near–natural regions in whole Central Asia.

3 Methods

Sampling followed a modified Braun-Blanquet approach, which has proven suitable in earlier studies (WESCHE et al. 2005; VON WEHRDEN et al. subm.). Most sampling plots were 10 × 10 metres in size; locations were fixed with a handheld Garmin GPS receiver. Site selection was partly governed by logistic constraints, but we used Landsat data to select representative plots. Unsupervised classifications using different channel combinations as well as Red-Green-Blue pictures were taken as paper printouts to the field. Additionally, topographical maps and spatially explicit information on the climate were generated from various available datasets (see http://glcf.umiacs.umd.edu/index.shtml).

Mixed samples of top-soil were collected for most relevés and taken to the lab in Halle for basic analyses including soil pH, conductivity (measured in aqua dest.), and carbonate (reaction with HCl).

Table 2
Supplementary data available for interpretation of plant community composition in a given relevé

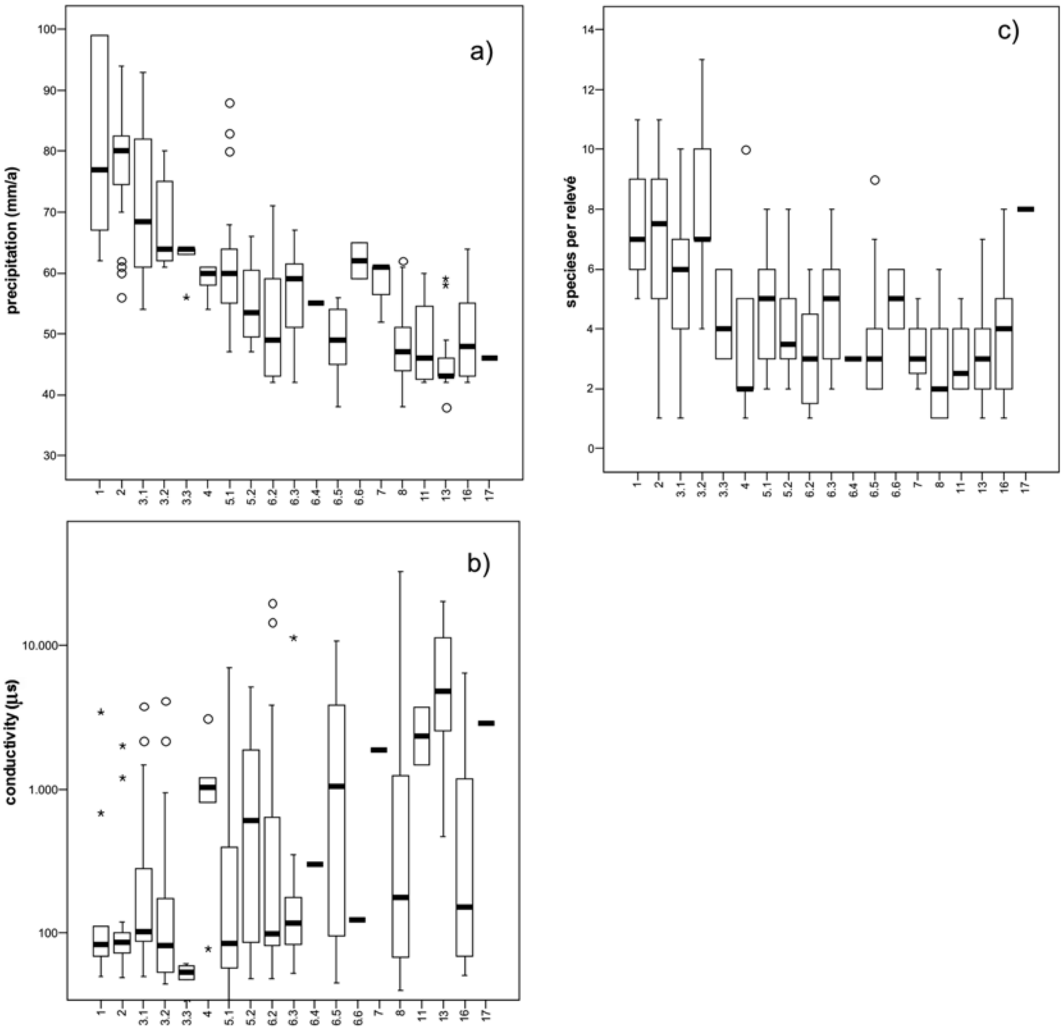
Parameter	Method
Geographical position	GPS (in decimal degrees)
Elevation	altimeter, GPS (m asl.)
Aspect	Compass (degrees)
Inclination	clinometer (degrees)
Carbonate	estimated with HCl addition (%)
Grazing influence	estimated (ordinal scale with 4 divisions)
Cover of vegetation strata (tree, shrub, herb layer)	visually estimated (percentage scale)
Lab: soil pH in water	in pH units, values for 1 and 24 hrs. of soaking
Lab: soil conductivity in water	µS, values for 24 hrs. of soaking
Climate: mean annual temperature	Data from HIJMANS et al. 2005, in °C
Climate: mean annual precipitation	Data from HIJMANS et al. 2005, in mm

Table 3
Overview of the communities, containing the reference to the two constancy tables and the individual tables

	Community name	Constancy table	Individual table-number
4.1.	Eurotio ceratoidis-Zygophylletum xanthoxyli	tab. 4,1	tab. 6
4.2.	Sympegmo regelii-Caraganetum leucophloeae	tab. 4,2	tab. 6
4.3.1.	Stipo glareosae-Anabasietum brevifoliae, typical sub-association	tab. 4,3	tab. 7
4.3.2.	*Ephedra przewalskii* sub-association	tab. 4,4	tab. 7
4.3.3.	*Reaumuria songarica* sub-association	tab. 4,5	tab. 7
4.4.	*Convolvulus gortschakovii* community	tab. 4,6	tab. 8
4.5.1.	*Ephedra przewalskii* community, typical sub-community	tab. 4,7	tab. 8
4.5.2.	*Reaumuria songarica* sub-community	tab. 4,8	tab. 8
	Calligono mongolici-Haloxyletum ammondendronis,		
4.6.1.	*Haloxylon* dominance stands	tab. 4,9	tab. 9
4.6.2.	typical sub-association	tab. 4,9	tab. 9
4.6.3.	*Ephedra przewalskii* sub-association	tab. 4,10	tab. 9
4.6.4.	*Nitraria sphaerocarpa* sub-association	tab. 4,11	tab. 10
4.6.5.	*Reaumuria songarica* sub-association	tab. 4,12	tab. 10
4.6.6.	*Kalidium gracile* sub-association	tab. 4,13	tab. 10
4.7.1.	*Reaumuria songarica-Nitraria sphaerocarpa* community	tab. 4,14	tab. 11
4.7.2.	*Reaumuria songarica* community	tab. 4,15	tab. 11
4.8.	*Iljinia regelii* community	tab. 4,16	tab. 11
4.9.	*Halimodendron halodendron* community	–	see text
4.10.	Ephemeral vegetation	–	see text
4.11.	Phragmitetum communis	tab. 5,1	tab. 12
4.12.	*Leymus* cf. *paboanus* community	tab. 5,2	tab. 12
4.13.1	Glycyrrhizo uralensis-Populetum euphraticae, typical sub-association	tab. 5,3	tab. 12
4.13.2	*Reaumuria songarica* sub-association	tab. 5,4	tab. 12
4.14.	Sophoro alopecuroidis-Populetum euphraticae	tab. 5,5	tab. 12
4.15.	Glycyrrhizo uralensis-Achnatheretum splendentis	tab. 5,6	tab. 12
4.16.	*Tamarix ramosissima* community	tab. 5,7	tab. 13
4.17.	Blysmetum rufi	tab. 5,8	tab. 14

Table 2 summarizes all supplementary variables available for the vegetation description.

Plants were preliminarily identified in the field with the standard flora (GRUBOV 2001); specimens of all species and unknown plants were taken to the Herbarium in Halle and later identified using further references (FRIESEN 1995; GUBANOV 1996; GRUBOV 2000); most identifications were cross-checked by



specialists (see acknowledgements). Nomenclature followed GUBANOV (1996), with some modifications regarding some few taxa.

Classification of plant communities was based on phytosociological table work (e.g. MUELLER-DOMBOIS & ELLENBERG 1974; DIERSCHKE 1994). A crude initial sorting was based on the available classification system for Outer Mongolia (HILBIG 2000). Due to the general dryness of the site, several units had to be described as impoverished versions of already known communities; in all these cases reference was made to recent vegetation descriptions from adjacent regions. However, we stayed as closely as possible to the previously published system; and thus also adopted the former scheme for naming sub-associations. In order to save printing space, we did not always compile all relevés into separate tables but made a selection when many samples were available. In such cases only the most representative relevés are shown.

4 The plant communities

A few notes on the names of the vegetation formations are necessary, because naming is not coherent in literature (ZEMMRICH 2005). We understand desert-steppes as moderately dry semi-deserts; the short grass cover might vary with precipitation over the year. The other semi-desert communities often have a lower

◀ Fig. 2
Boxplots summarising some important characteristics of the 17 plant communities described in the text (boxes give the interquartile range, medians are indicated by a horizontal line).
a) Estimated mean annual precipitation, based on a model by HIJMANS et al. (2005)
b) Conductivity of the top soil as measured in the lab (µS)
c) Species richness

Explanation table for Fig. 2. The numbers in the figure correspond to the numbers and names of the vegetation units in the text.

Number	Name
1	Eurotio ceratoidis-Zygophylletum xanthoxyli
2	Sympegmo regelii-Caraganetum leucophloeae
3.1	Stipo glareosae-Anabasietum brevifoliae, typical sub-association
3.2	Stipo glareosae-Anabasietum brevifoliae, *Ephedra przewalskii* sub-association
3.3	Stipo glareosae-Anabasietum brevifoliae, *Reaumuria songarica* sub-association
4	*Convolvulus gortschakovii* community
5.1	*Ephedra przewalskii* community, typical sub-community
5.2	*Ephedra przewalskii* community, *Reaumuria songarica* sub-community
6.2	Calligono mongolici-Haloxyletum ammondendronis, typical sub-association
6.3	Calligono mongolici-Haloxyletum ammondendronis, *Ephedra przewalskii* sub-association
6.4	Calligono mongolici-Haloxyletum ammondendronis, *Nitraria sphaerocarpa* sub-association
6.5	Calligono mongolici-Haloxyletum ammondendronis, *Reaumuria songarica* sub-association
6.6	Calligono mongolici-Haloxyletum ammondendronis, *Kalidium gracile* sub-association
7.1	*Reaumuria songarica-Nitraria sphaerocarpa* community
8	*Iljinia regelii* community
11	Phragmitetum communis
13	Glycyrrhizo uralensis-Populetum euphraticae
16	*Tamarix ramosissima* community
17	Blysmetum rufi

cover of grasses and are instead mainly dominated by shrubs. True deserts by definition lack continuous plant cover. Mountain steppes are also found, but these are communities with a denser vegetation cover restricted to relatively moist mountain zones (see WESCHE et al. 2005 and VON WEHRDEN et al. subm.). In the Transaltay region the overall precipitation seems to be too low to support true mountain steppes.

The names of plant associations and rankless plant communities, which we found in the Great Gobi A, refer to the vegetation system of HILBIG (2000), to which we add some new described associations. In order to interpret characteristic environmental factors (altitude and precipitation) and the biodiversity of the plant communities, we refer to Fig. 2 in this chapter.

4.1 Eurotio ceratoidis-Zygophylletum xanthoxyli

Table 4, no. 1; Table 6, no. 1 – 11

Krascheninnikovia ceratoides (= *Eurotia ceratoides*) is a typical determinant of Central Asian semi-deserts. In combination with *Zygophyllum xanthoxylon* (including *Z. kaschgaricum*, see below) it forms a community, which is typical for soils with a coarse or at least sandy matrix (HILBIG 1995). Thus, most stands were sampled in sayrs or along other drainage lines. The community is widespread in the area and a similar unit is indicated in the Atlas of Mongolia for the Transaltay region (ANONYMOUS 1990). Regular disturbance and water surplus allows establishment of a number of species and thus this association has one of the highest biodiversity of all communities described for the Transaltay (see Fig. 2c). *Sympegma regelii* is found with a high consistency and cover values comparable to the name-giving species, and can be understood as a geographical differential species, which also occurs in other plant communities in the area, often dominating the vegetation (see Fig. 3).

Unfortunately, some of the species mentioned by HILBIG (1995) for the Eurotio-Zygophylletum xanthoxyli do not occur in our samples, leaving only *Krascheninnikovia ceratoides* itself as a differential species. We regard this community as an impoverished regional *Sympegma regelii* variant, which nonetheless exemplifies the linkages to the west, the north and the east, e.g. the Valley of lakes (HILBIG 1995), the Gobi-Altay (WESCHE et al. 2005), the Dzungarian Gobi (VON WEHRDEN et al. subm.) and the Alashan Gobi (YUNATOV 1954; HILBIG & TUNGALAG 2006). A species poor *Sympegma regelii* semi-desert was also mentioned by KASHAPOV et al. (1988) for the regions around the Atas Bogd and Aj Bogd, as listed by HILBIG (1995).

In this context we have to give some additional notes on the two shrubby *Zygophyllum* species. Differences between *Z. xanthoxylon* and *Z. kaschgaricum* given by GRUBOV (2001) are not convincing, as we often found diagnostic features of both species (number of wings at the fruit, length of leave petioles) together on one plant. LICHTENEGGER et al. (1997) examined the root system of *Z. xanthoxylon* and digged about 4.5 metres deep following the roots, which reached wet soil layer at this depth. About half of the relevés contain *Reaumuria songarica*; this species is used as an indicator species for a sub-association that has habitats with a higher soil salinity.

4.2 Sympegmo regelii-Caraganetum leucophloeae ass. nov.

Table 4, no. 2; Table 6, no. 12–35

Open scrub-communities with *Caragana leucophloea* are very widespread in the semi-deserts of southern and south-western Mongolia (HILBIG 1995; WESCHE et al. 2005). However, stands in the Transaltay Gobi differ from previously described communities. *Sympegma regelii* is found in the majority of samples from the Transaltay Gobi (see Fig. 3). *Asterothamnus centrali-asiaticus* occurs, but is not common in any of the communities listed by HILBIG (2000) for the Caraganion leucophloeae. RACHKOVSKAYA (1993) mentions a comparable community. We describe the stands, which are characterised by the presence of *Caragana leucophloea* and *Sympegma regelii* as an association vicariating to the other *Caragana*–associations of the Caraganion leucophloeae (see HILBIG 2000). The type relevé is found in Table 6 (W52, running no. 15).

The community covers gentle slopes on hills and mountain sites, with sandy soils and a high fraction of coarse stones in the matrix. Deflation appears to be strong. The presence of *Caragana leucophloea* depends on relatively moist sites, and thus on the microcrelief. The somewhat heterogeneous site conditions are also indicated by the occasional presence of diagnostic species of other communities. We encountered *Caragana* stands mainly in the north-eastern part of the working area, which seems to be transitory to the Gobi-Altay, where the Caraganion is also common. The species richness is comparatively low compared to the *Caragana leucophloea* shrubs recorded by WESCHE et al. (2005) for the Gobi Gurvan Saykhan; the openness of the stands found in the Transaltay hints at the dryness even of these bels. *Caragana leucophloea* covers quite often less than 10% of the surface; yet in some stands the shrub layer reached 50% and even more, mainly dominated by *C. leucophloea* and *Sympegma regelii*.

4.3 Stipo glareosae-Anabasietum brevifoliae

4.3.1 Stipo glareosae-Anabasietum brevifoliae, typical sub-association

Table 4, no. 3; Table, no. 7, 1–16

Semi-deserts with *Stipa glareosa* are very widespread in southern Mongolia (HILBIG 1995). The short-growing feather grass is usually accompanied by *Allium polyrrhizum*; the presence of *Anabasis brevifolia* characterises a dry habitat. The onion-species (*Allium polyrrhizum*, *A. mongolicum*) become rare with increasing aridity of the sites, explaining why they are almost missing in the Transaltay Gobi. This is consistent with results from the Outer and Inner Mongolian part of the Alashan Gobi (KÜRSCHNER 2004; HILBIG & TUNGALAG 2006), where semi-deserts with *A. polyrrhizum* are missing or restricted to higher elevations. The absence of *Cleistogenes songorica*, common in adjacent regions, underlines the fact that the Stipo glareosae-Anabasietum brevifoliae is much impoverished in the Transaltay region. The vegetation cover varies between 5–10 %.

The high presence of *Sympegma regelii* additionally hints at the uniquely dry conditions. The roots of this species intrude deeply

Fig. 3
Sympegma regelii semi-desert with *Zygophyllum xanthoxylon* (left); photo by W. HILBIG

into the soil; nearby erosion lines they reach groundwater levels. LICHTENEGGER et al. (1997) found a deep root layer up to 3.5 metres deep. This species of the Chenopodiaceae forms a distinct association in the semi-desert regions of Mongolia (HILBIG 2000); it is very widespread in the Great Gobi A and characterises the climate dependent plant geographic situation of the region. This corresponds to results from the Inner Mongolian Alashan, although somewhat similar stands with *Anabasis brevifolia* were regarded by KÜRSCHNER (2004) as an impoverished variant of the Potaninio mongolicae-Sympegmetum regelii (see also HILBIG & TUNGALAG 2006). This seems unreasonable at least in our case, as the accompanying species clearly justify a classification of our relevés as a Stipo glareosae–Anabasietum brevifoliae, even though as a *Sympegma regelii* variant.

Not surprisingly, the distribution of this community in the Great Gobi A follows a pattern different from the situation in the Dzungarian Gobi or in the Gobi-Altay (WESCHE et al. 2005; VON WEHRDEN et al. subm.). There, this community covers wide areas on the pediments and the lower hills with usually deep soils. Instead, in the Transaltay Gobi it is characteristic of all hill and mountain regions − apart from the highest peaks − with shallow soils over weathered rocks. It can grow also on relatively steep sites, where the average precipitation should be around 60–70 mm/a (Fig. 2a). Thus, habitat conditions are relatively dry compared to the other Gobi regions.

4.3.2. Stipo glareosae-Anabasietum brevifoliae, *Ephedra przewalskii* sub-association

Table 4, no. 4; Table 7, no. 17–28

Ephedra przewalskii characterises a regional sub-association. This species occurs along drainage lines, therefore underlines the sometimes different ecology of the Stipo glareosae–Anabasietum brevifoliae in the Transaltay

Gobi, since the community is normally found on deflated pediments in adjacent regions. *Anabasis brevifolia* becomes unusually tall on such spots, presumably due to the relatively high groundwater table or a low grazing impact. Therefore we separated these stands in Table 7.

4.3.3 Stipo glareosae-Anabasietum brevifoliae, *Reaumuria songarica* sub-association

Table 4, no. 5; Table 7, no. 29–38

HILBIG (1995) described a *Reaumuria songarica* sub-association of the community from soils with slightly higher salt contents. We also recognize this sub-association, although other differential species are absent. This is supported by the values of soil conductivity, which are relatively high in the context of desert steppes. Compared to the previous unit, the soils are less shallow and built of a finer matrix. Stands were mainly found at lower elevations than the typical Stipo glareosae-Anabasietum brevifoliae; the mean number of species on a given plot is lower compared to the typical sub-association (Fig. 2c), as well as the overall species set is much smaller (see Table 7).

4.4 *Convolvulus gortschakovii* community

Table 4, no. 6; Table 8, no. 38–42

In our account, we follow a proposal by HANELT & DAVAŽAMC (1965) and unite *Convolvulus gortschakovii* und *C. frutescens* as the morphological differences are rather obscure. In any case, both taxa are typical for dry semi-deserts of south-western Mongolia.

The precipitation model suggests that sites of the present community receive less rainfall than the previous association (see Fig. 2a). The crucial environmental factor is the presence of sandy soils, which are apparently avoided by *Anabasis brevifolia*. However, these species-poor stands are mainly defined by the lack of certain semi-desert species and not by exclusive character species apart from *C. gortschakovii* itself. Thus, the phytosociological position of the community is not clear. Similar stands were placed as a rankless unit in the Caraganion leucophloeae by HILBIG (1990), but the alliance's character species *C. leucophloea* is usually absent. The occurring *Oxytropis aciphylla* is found in dry communities of the Allion polyrrhizi, but is also common in the Caraganion (HILBIG 1995), and indicates sandy soils. HILBIG (1995) describes similar stands from the Valley of Lakes. With respect to the almost complete lack of other character species of the Allion polyrrhizi except for the rather widespread *Stipa glareosa*, the presence of several species from the Caraganion, and the overall appearance as a low shrub community we plead for the position in the Caraganion. The precipitation (Fig. 2a) indicates that the community mediates between the moderately dry semi-deserts and the other drier semi-desert communities.

4.5 *Ephedra przewalskii* community

4.5.1 *Ephedra przewalskii* community, typical sub-community

Table 4, no. 7; Table 8, no. 1–21

This community belongs to the Zygophyllo xanthoxyli-Brachanthemion gobici; stands are dominated by both *Zygophyllum xanthoxylon* and *Ephedra przewalskii*. The latter is the only potential diagnostic species, but it is however also found in other units (Table 3). Thus, we follow HILBIG (2000) and refrain from establishing an association. However, the rare presence of *Calligonum mongolicum* adds to the general good correspondence to phytosociological tables given by HILBIG (1995); similar stands have indeed also been described by RACHKOVSKAYA & VOLKOVA (1977) for a "hammada"-habitat, representing a stony desert aspect. Its transitory syntaxonomic position might reflect a transitory character within the landscape; both species richness and median precipitation support this assumption (see Fig. 2a and Fig. 2c).

Stands are regionally common at the bels of the Atas Bogd, the Tsagaan Bogd and their surrounding hills. The community occurs on heterogeneous substrates ranging from coarse gravel to thin clay layers. This hints at the influence of occasional water flows, which is supported by the fact that most stands were sampled in shallow drainage lines. Median precipitation is estimated at around 60 mm/a. *Anabasis brevifolia* characterises sites with

Fig. 4
Haloxylon stands, in the middle of the photo on dune habitats; photo by W. HILBIG

limited disturbance by water; *Ajania achilleoides* and *Dontostemon crassifolium* link to moderately dry semi-deserts described above.

4.5.2 *Ephedra przewalskii* community, *Reaumuria songarica* sub-community

Table 4, no. 8; Table 8, no. 22–37

Reaumuria songarica indicates sayrs with partly stagnant conditions and higher salinity (see the long box in Fig. 2b) within typical *Ephedra przewalskii* stands. Both *Zygophyllum xanthoxylon* and *Calligonum mongolicum* indicate episodic rainfalls at these sites.

4.6 Calligono mongolici-Haloxyletum ammondendronis

Table 4, no. 9–13; Tables 9, 10

The saxaul, *Haloxylon ammodendron*, builds open low forests and scrubs, which are a highly characteristic feature of the central Asian desert (WALTER 1974). In the Transaltay Gobi, stands are exceedingly widespread and cover a wide range of habitats (see Fig. 2 and Fig. 4). Not surprisingly, several distinct sub-communities are found, which are described in the following sections. KAZANTSEVA et al. (2003) distinguished seven saxaul communities and analysed varying soil conditions and regrowth rates within the *H. ammodendron* stands. In our investigation area the shrub-cover ranges between 5–10%; however few stands contained up to some 30% shrub-cover. LICHTENEGGER et al. (1997) examined the root system of *H. ammodendron*; on sand-covered Takyrs in the southern Mongolian Gobi they found dense root systems, spreading horizontally 50–100 cm below the surface; due to the high salinity and salt incrustation of the spots the main root does not reach deep soil layers.

4.6.1 *Haloxylon ammodendron* dominance stands

included in Table 4, no. 9; Table 9, no. 1–5

This community covers lower pediments that are characterised by deflated soils, which are sealed by a stone-net; the soil texture is dominated by fine sands. Conditions are apparently unfavourable for plant growth. Unlike *Haloxylon ammodendron* stands which grow along drainage lines, plants rarely grow higher than 1 metre here; moreover, hardly any species accompany the saxaul. The community is an impoverished version of the Calligono-Haloxyletum (HILBIG 2000) and lacks further diagnostic species; therefore we joined it with the following (hence both unit 9, Table 4). A similarly poor variant is described by HELMECKE & SCHAMSRAN (1979) for the Outer Mongolian Alashan Gobi and by KÜRSCHNER (2004) for sandy spots in Inner Mongolia.

4.6.2 Calligono mongolici-Haloxyletum ammondendronis, typical sub-association

Table 4, no. 9; Table 9, no. 6–20

With increasing precipitation, the number of species within the *Haloxylon ammodendron* stands increases, until at higher elevations a different sub-community can be found. It has a high content of shrubs; annuals are widely missing. The relevés correspond to the Calligono mongolici-Haloxyletum ammodendronis described by HILBIG (2000), although stands in the Transaltay Gobi represent a species-poor variant (see Fig. 2c). The annual plants include species such as *Micropeplis arachnoidea* and *Bassia dasyphylla*; some relevés indicate that the community can tolerate high salt content in the topsoil, although the median is only moderately high (see Fig. 2b). This community gains annual rainfalls at around 50 mm/a, as it is mainly found at the lower pediments.

4.6.3 Calligono mongolici-Haloxyletum ammondendronis, *Ephedra przewalskii* sub-association

Table 4, no. 10; Table 9, no. 21–28

Ephedra przewalskii indicates habitats found along drainage lines, which corresponds with the taller size of saxaul plants here. Within the Calligono mongolici-Haloxyletum ammondendronis the *Ephedra przewalskii* sub-association contains the highest plant biodiversity, with a median of 5 species per relevé (see Fig. 2c). This might be due to the somewhat higher precipitation these stands gain (see Fig. 2a).

4.6.4 Calligono mongolici-Haloxyletum ammondendronis, *Nitraria sphaerocarpa* sub-association

Table 4, no. 11; Table 10, no. 1–9

RACHKOVSKAYA & VOLKOVA (1977) described saxaul stands with *Nitraria sphaerocarpa* from the Transaltay Gobi; the latter species is also diagnostic for a previously described distinct phytosociological sub-association (HILBIG 2000). Some of the accompanying species link to related units (e.g. *Reaumuria songarica*, *Nitraria sibirica*), while *Ephedra przewalskii* is shared with the previous sub-association. This corresponds to patterns in the Alashan Gobi, where *R. songarica* and *N. sphaerocarpa* almost always occur together in saxaul stands (KÜRSCHNER 2004). Whether both units described here are really distinct sub-associations is thus not easily to decide with the limited material available, but we follow RACHKOVSKAYA & VOLKOVA (1977), who also advocated a rather fine division. The salt content in the topsoil is somewhat higher than in the previous sub-association (see Fig. 2b). Under these conditions, the saxaul plants grew up to four metres in height, so this community represents the tallest saxaul stands found in the area.

4.6.5 Calligono mongolici-Haloxyletum ammondendronis, *Reaumuria songarica* sub-association

Table 4, no. 12; Table 10, no. 10–18

Another clearly defined sub-association is characterised by the presence of the dwarf shrub *R. songarica*. This sub-association was described from other sites before (HILBIG 1995, 2000), but the lack of further accompanying species suggests relatively harsh site conditions. *R. songarica* generally indicates saline conditions, and the levels of soil-conductivity are indeed higher than in the previous sub-associations of the Calligono mongolici-Haloxyletum ammondendronis with a median around 1000 µS (see Fig. 2b). The occasional presence of salt-tolerant shrubs such as *Kalidium gracile* and *Nitraria sibirica* hints at the transitory character of the *Haloxylon* stands with respect to extra-zonal saline vegetation. The soil substrates are normally coarse, as most samples were taken along dry riverbeds at relatively low elevations. The height of the saxaul trees (>1 m) indicates a certain surplus of groundwater, whereas the surrounding pediments are often entirely bare of any vegetation corresponding to the low levels of precipitation (Fig. 2a).

4.6.6 Calligono mongolici-Haloxyletum ammondendronis, *Kalidium gracile* sub-association

Table 4, no. 13, Table 10, no. 19–24

In this sub-association we find in addition to *Reaumuria songarica* (often with a higher cover than in the other saxaul stands) other halophytic plants such as *Kalidium gracile* and *Nitraria sibirica*. The stands can be seen linking to the Nitrario sibiricae-Kalidietum gracilis mentioned by HILBIG (2000). However, due to the constant presence of *H. ammodendron* we place these relevés into the Calligono mongolici-Haloxyletum ammondendronis. The stands were found at comparativly high altitudes, but as we only sampled six relevés more material is needed to assess the ecology of this sub-association more closely.

4.7 *Reaumuria songarica-Nitraria sphaerocarpa* communities

4.7.1 *Reaumuria songarica-Nitraria sphaerocarpa* community

Table 4, no. 14; Table 11, no. 1–5

Together with *Salsola passerina*, *R. songarica* builds a widespread plant community on saline sites in less arid regions of the Mongolian Gobi (HILBIG 2000). In the eastern Transaltay, the *Reaumuria songarica-Nitraria sphaerocarpa* desert covers large areas (HILBIG 1995). *Salsola passerina* is absent from our data set for the Transaltay Gobi and was also rare in relevés from the neighbouring Inner Mongolian Alashan Gobi (KÜRSCHNER 2004), probably as a result of the overall aridity of the climate. WESCHE et al. (2005) gave samples of a similar community (yet with *Salsola passerina*) from the lower Gobi-Altay, where precipitation can be expected to be higher compared to the Transaltay. *Calligonum mongolicum* and *Haloxylon ammodendron* are absent, possibly as a consequence of the high levels of soil salinity. Fig. 2b shows high values of conductivity for the community. The stands can be best regarded as a species-poor association of the Reaumurio soongoricae-Salsolion passerinae (HILBIG 2000).

4.7.2 *Reaumuria songarica* community

Table 4, no. 15; Table 11, no. 6–13

On saline spots *R. songarica* (= *R. soongorica*) dominance stands are found; these are lacking other species beside *Sympegma regelii* and *R. songarica* themself (see Fig. 5). They show affinities to the Salsolo passerinae-Reaumurietum soongoricae KAŠAPOV et al. ex HILBIG 2000 recorded by HILBIG & TUNGALAG (2006) from the Galbyn and Borzongijn Gobi; however the name giving *Salsola* species is again missing in our relevés from the Great Gobi A. XU et al. (2006) emphasize the higher resistance of the *Reaumuria songarica* community to saline soils in comparison with *Haloxylon ammodendron* stands.

4.8 *Iljinia regelii* community

Table 4, no. 16; Table 11, no. 14–33

Where conditions get progressively drier, the dwarf shrub *Iljinia regelii* becomes increasingly common. It marks the driest sites still colonised by perennial plants in the Transaltay Gobi, and not surprisingly various transitional stages occur. The soil matrix is characterised by gypsum layers; levels of conductivity were somewhat lower than in other communities found at comparably low elevations (Fig. 2b). The soils were mostly deflated flat pediments; only one stand was sampled on shallow soils over rocky outcrops. On this site, *Iljinia regelii* occupied southern exposures, whilst the northern slope was covered by stands with *Sympegma regelii*. Some plots show a linkage to the *Haloxylon* stands, while others mediate to dry variants of the Anabasietum brevifoliae. However both the precipitation, that the sites receive (see Fig. 2a) and the vegetation structure with the overall low cover suggest that the stands can be classified as a separate unit with *Iljinia regelii* as a diagnostic species (HILBIG 2000). The overall lack of accompanying species (almost half of the plots contained only

Fig. 5
Reaumuria songarica stand, neighbouring *Tamarix* stands can be seen on the left; photo by W. HILBIG

Iljinia regelii) renders a placement of stands in the syntaxonomical system difficult, so the community has to remain rankless for the time being (HILBIG 2000).

4.9 *Halimodendron halodendron* community (not included in the tables)

North of the Atas Bogd, we found a stand with the shrub *Halimodendron halodendron*, which may be the easternmost record of this Turanic element. The stand had the following composition (relevé H23, 30% shrub layer, 0.5–1.5 m high):

Halimodendron halodendron	3
Reaumuria songarica	1
Calligonum mongolicum	1

HILBIG (1995) described a distinct community of *H. halodendron* scrub from the Dzungarian Gobi on alluvial habitats of the Bulgan-Gol. Comparable stands were found there by VON WEHRDEN et al. (subm.).

4.10 Ephemeral vegetation (not included in the tables)

The lowermost depression north of the Atas Bogd and the Tsagaan Bogd have a mean precipitation below 40 mm/a, and are practically bare of any vegetation (see Fig. 6 and Fig. 7). After occasional rains, some few specimen of *Micropeplis arachnoidea* and other annual Chenopodiaceae are found, but under the dry conditions of 2004 we drove a distance of 30 km without seeing any living plant.

Extrazonal plant communities

Within the Transaltay region, dense vegetation is restricted to oases and other extensive water catchment sites. Due to large drainage areas and aquifers some extrazonal plant communities are supported. Suchlike stands are described from other Gobi regions as well (HILBIG 1995; KÜRSCHNER 2004; WESCHE et al. 2005; VON WEHRDEN et al. subm.). Being surrounded by often barren dry vegetation these

Fig. 6
Extremely arid desert, shallow shrub-vegetation can be seen along drainage lines; photo by W. HILBIG

Fig. 7
Vegetationless desert north of the Atas Bogd; photo by H. v. WEHRDEN

Fig. 8
The oasis Shar-Khuls, which contains impressive extrazonal stands; a large reed-bed can be seen in front, with *Tamarix*-stands and a poplar forest in the background; photo by W. Hilbig

oases host a high biodiversity; the vegetation structure and open water attract a high number of animals, some of which depend on these locations (e.g. wild ass, wild camel, Gobi bear etc.). The vegetation zonation often follows a belt like zonation around oases, yet within valleys a linear zonation can be found as well (e.g. the oasis Shar-Khuls, see Fig. 8). Saline meadows and reed beds are often the innermost or wettest formations, spreading around locations that have a permanent water flow. Poplar- and *Tamarix*-stands are normally growing more distant from these sites. Other communities or associations link to the outer belts of the oases and often contain introgressive species from the zonal vegetation.

4.11 Phragmitetum communis

Table 5, no. 1; Table 12, no. 1–7

Tall dominance stands of reed are found in some few oases in the Transaltay Gobi; similar stands were also described from oases in the neighbouring western part of the Gobi Gurvan Saykhan Nationalpark (Wesche et al. 2005). They are strictly confined to open water bodies where *Phragmites australis* (= *P. communis*) can form extensive reed beds with 60–100% of vegetation cover (see Fig. 8). Few of these dense stands were found within the study area; the overall richness is relatively low compared to other vegetation types in the oases. Most relevés however represent a mixed species set. *Phragmites australis*, however, dominates the stands.

4.12 *Leymus* cf. *paboanus*-community

Table 5, no. 2; Table 12, no. 8–13

This plant community is found outside the main water bodies at the oases, yet within the transition zone characterised by a high conductivity. The presence of *L.* cf. *paboanus* is difficult to interpret, it might be due to disturbance, representing both trampling and grazing. However stands were observed at remote locations, pre-

Fig. 9
Dense Glycyrrhizo uralensis-Populetum euphraticae stand at the oasis Shar-Khuls; photo by W. HILBIG

sumably indicating natural grazing by wild camels and khulans. HILBIG (1995) described *Leymus paboanus* grassland from salt habitats of the Uvs-nuur lake in north-western Mongolia neighbouring *Achnatherum splendens* stands on salt marshes.

4.13 Glycyrrhizo uralensis-Populetum euphraticae ass. nov.

4.13.1 Glycyrrhizo uralensis-Populetum euphraticae ass. nov., typical sub-association

Table 5, no. 3; Table 12, no. 14–26

Populus euphratica (= *P. diversifolia*) forests are widely distributed in Middle and Central Asia. They are found in southern Mongolia (HILBIG 1995), in the Inner Mongolian Alashan Gobi (KÜRSCHNER 2004) but also in oases of the Taklamakan (BRUELHEIDE et al. 2003). The poplars require very moist conditions for germination, but can survive exceedingly long periods of dry conditions, providing the adult trees maintain access to the groundwater (BRUELHEIDE et al. 2003). As a consequence, remnant gallery forests with *P. euphratica* are found even in situations where the present groundwater table is well below the soil surface, a pattern often observed in the western Gobi Gurvan Saykhan National Park (WESCHE et al. 2005) and also in the Transaltay Gobi. Many stems are built by clonally formed root suckers and we never saw a poplar seedling. Trees were always below 10 metres in height; the crown layer can nevertheless be quite dense (see Fig. 9).

Soils of poplar stands show an equally large range of grain sizes as those of the *Tamarix ramosissima* community. Some stands grow within dry sayrs, others among sand dunes. At one location, dunes moved over the stands and buried whole groups of trees. An interesting environmental pattern is the January minimum temperature of the stands, which apparently never drops below −20 °C. The annual precipitation of the sites is usually below 50 mm/a, but

Fig. 10
Open *Populus euphratica* stand nearby Bayantoroy; photo by W. HILBIG

a hydrological analysis of their drainage basin (using Arc Map 9.0) shows that most sites have a catchment yielding water surplus equivalent to 300 mm of annual precipitation, or even more. As we were unable to include information on geological structures of the aquifer in the model, this figure might be overestimated, but nonetheless it nicely demonstrates the importance of groundwater accumulation. We describe these *Populus euphratica* forests as the new association Glycyrrhizo uralensis-Populetum euphraticae within the class Populetea euphraticae. The type relevé is H 46a (Table 12, no. 16).

Phragmites australis, Achnatherum splendens, Lactuca tatarica, Lepidium latifolium and *Glycyrrhiza uralensis* are typical species of sites with high groundwater tables, and of saline habitats mentioned by HILBIG (1995). In some oases we found dense poplar stands with dominating *P. australis*. At other locations, especially at the border of the Great Gobi A. Strictly Protected Area we found very sparse stands (see Fig. 10), which were in contact with stands of *Achnatherum splendens*; these stands replace logged poplar stands (HILBIG 1995). The relationship to the *Tamarix* community is indicated by the presence of *Tamarix ramosissima* in half of the poplar stands in the Great Gobi A.

4.13.2 Glycyrrhizo uralensis-Populetum euphraticae, *Reaumuria songarica* sub-association

Table 5, no. 4; Table 12, no. 27–39

Beside the typical sub-association, a *Reaumuria songarica* sub-association exists. The presence of the differential species *R. songarica* indicates the high salinity as well but also transitions to the zonal vegetation. Poplars have no root suckers at these sites; whether this is due to grazing and browsing or to the higher salinity remains unclear. However, several other salt-adapted species were found.

4.14 Sophoro alopecuroidis-Populetum euphraticae (KÜRSCHNER 2004) ass. nov.

Table 5, no. 5; Table 12, no. 40, 41

Two samples of poplar stands with a dense herb layer of *Sophora alopecuroides* accompanied by *Peganum nigellastrum* were recorded in Ekhiyn Gol (see Fig. 11); the oasis is strongly depredated since it is a permanent settlement with large plantations and a high number of livestock. The same *Populus euphratica* vegetation was already described by KÜRSCHNER (2004) for the Inner Mongolian Alashan Gobi. There, the species poor forest stands (often only 3 species) were up to 8–15 m in height; the herb layer often contained unpalatable plants such as *Sophora alopecuroides*, *Peganum nigellastrum* and *Glycyrrhiza uralensis*. KÜRSCHNER (2004) found also *Tamarix ramosissima* in these *Populus euphratica* forests. We consider the stands of the Sophoro alopecuroidis-Populetum euphraticae association as a long time overgrazed and impoverished form of poplar forests; these stands replace the Glycyrrhizo uralensis-Populetum euphraticae in oases, which are strongly influenced by man. We raise the community to the association rank within the Populion euphraticae and show relevé no. 3/table 9 (field number 34) from KÜRSCHNER (2004, p. 197) as type. Here again the species composition of this stand:

Populus euphratica	2b
Sophora alopecuroides	3
Tamarix ramosissima	2
Peganum multisectum (= *P. harmala*)	1

The structure and appearance of the forest stand seems to be the same in both Outer and Inner Mongolia (see Fig. 11 in comparison with Fig. 9 of KÜRSCHNER 2004).

4.15 Glycyrrhizo uralensis-Achnatheretum splendentis

Table 5, no. 6; Table 12, no. 42–46

In southern Mongolia semi-deserts floodplains and depression are often found; in their transition zones the Deris-community (the Mongolian name for *Achnatherum splendens*) is widely distributed. In the Inner Mongolian Alashan Gobi this community was described by KÜRSCHNER (2004), and in the Great Gobi A some stands were found as well. Stands of the association were sampled in the oasis Bogd-Tsagaan-Deris, the name hints at the abundance of the tall bunch grass. The sandy soils showed salt efflorescences indicating a high salinisation as mentioned by HILBIG (1995) for the semi-desert region. Stands were dominated by *A. splendens* and *Phragmites australis*, which often covered more than 70%; other characteristic plants of the Deris-community were found as well, such as *Glycyrrhiza uralensis, Lactuca tatarica* and *Nitraria roborovskii*.

4.16 *Tamarix ramosissima* community

Table 5, no. 7; Table 13

Dominance stands of *Tamarix* shrubs are widespread in central Asian desert regions and are regarded as a separate albeit rankless community by both HILBIG (2000) and KÜRSCHNER (2004). Stands in the Gobi Gurvan Saykhan Nationalpark are also often monospecific (WESCHE et al. 2005), but more open in contrast to locations in the Transaltay Gobi which contain a number of companions from neighbouring vegetation types. Stands are restricted to drainage lines and species like *Sympegma regelii*, *Ephedra przewalskii* and *Haloxylon ammodendron* take advantage of the relatively high groundwater levels (see Fig. 5 and Fig. 8). Not surprisingly, about half of the samples are from the outer belts of oases, forming dense stands with 60–90% of shrub cover. Basal parts of shrubs trap inblown soil material, and are hence often surrounded by Nebkahs (the windblown sand trapped by the vegetation). The soils are built of various grain sizes, and some spots have a very high salt content (see Fig. 2b). XU et al. (2006) describe a similar preference to moist soils for this community from the Tienshan region. We found other *Tamarix* species such as *T. arceutoides* as well, but relevés were combined into one group as habitat requirements appear to be similar (see Fig. 12). To guarantee a uniform classification with respect to the high *Tamarix* cover we include all relevés in the here presented community. As in other plant communities of the area, *Reaumuria songarica* forms a distinct sub-association at more saline sites (XU et al. 2006), which is shown in Table 13 (16–22).

Fig. 11
Stand of the Sophoro alopecuroidis-Populetum euphraticae in the oasis Ekhiyn Gol; photo by W. Hilbig

4.17 Blysmetum rufi

Table 5, no. 8; Table 14

Three relevés of saline meadows were sampled within the Transaltay region. One stand was found north of the Tsagaan Bogd (Table 14, 1 and 2), another stand in the vicinity of the Ekhiyn Gol oasis (Table 14, 3); therefore we can conclude that salt meadows show no altitudinal variation. The stands grow on clayey soils with a permanent supply of fresh water at least during the growing season. A set of shared species including the character species *Halerpestes salsuginosa* and *Triglochin maritimum* supports the placement within the Halerpestion salsuginosae. However, stands are rather small compared to our standardised plot size of 10 × 10 m. This explains why on some

Fig. 12
Tamarix ramosissima stand with *Tamarix arceutoides*; photo by W. HILBIG

places character species of different associations, i.e. the Halerpesto-Hordetum brevisubulati, Blysmetum rufi, and even Salicornietum europaeae occur together in one relevé.

5 Syntaxonomical overview

Within this chapter we give a syntaxonomical overview of the vegetation units described in the text, which shows their phytosociological relations based on the current standard of knowledge (after HILBIG 2000, C = class; O = order; L = alliance; A = association; communities and associations in bold letters).

C Phragmitetea communis R.TX. & PRSG. 1942
  O Phragmitetalia communis (W.KOCH 1926) R. TX. & PRSG. 1942
    L Phragmition communis W.KOCH 1926
      A **Phragmitetum communis** (GAMS 1927) SCHMALE 1939 (Table 12)
      ? ***Leymus* cf. *paboanus*** community (unclear position) (Table 12)
C Achnatheretea splendentis (MIRKIN in KAŠAPOV et al. 1987) MIRKIN et al. 1988
  O Achnatheretalia splendentis (MIRKIN in KAŠAPOV et al. 1987) MIRKIN et al. 1988
    L Achnatherion splendentis MIRKIN et al. ex HILBIG 2000
      A **Glycyrrhizo-Achnatheretum splendentis** HILBIG (1987) 1990 (Table 12)
C Asteretea tripolium WESTH. & BEEFTINK in BEEFTINK 1965
  O Halerpestetalia salsuginosae MIRKIN et al. ex GOLUB 1994
    L Halerpestion salsuginosae MIRKIN et al. ex GOLUB 1994
      A Blysmetum rufi DU RIETZ 1925 (Table 14)

C Stipetea glareosae-gobicae HILBIG 2000
O Allietalia polyrrhizi HILBIG 2000
L Allion polyrrhizi HILBIG 2000
A **Stipo glareosae-Anabasietum brevifoliae** HILBIG (1987) 1990
typical sub-association (HILBIG 1990) (Table 7)
***Reaumuria songarica* sub-association** (HILBIG 1990) (Table 7)
***Ephedra przewalskii* sub-association** (Table 7)
O Reaumurio soongoricae-Salsoletalia passerinae (MIRKIN in KAŠAPOV et al. 1988) MIRKIN et al. 1988 em. HILBIG 2000
L Reaumurio soongoricae-Salsolion passerinae (KAŠAPOV et al. 1988) MIRKIN et al. 1988 em. HILBIG 2000
Reaumuria songarica-Nitraria sphaerocarpa community (Table 11)
Reaumuria songarica community (Table 11)
Iljinia regelii community (Table 11)
O Zygophyllo xanthoxyli-Brachanthemetalia gobici (MIRKIN in KAŠAPOV et al. 1988) MIRKIN et al. 1988
L Zygophyllo xanthoxyli-Brachanthemion gobici (MIRKIN in KAŠAPOV et al. 1988) MIRKIN et al. 1988
A **Eurotio ceratoidis-Zygophylletum xanthoxyli** HILBIG (1987) 1990 (Table 6)
A **Calligono mongolici–Haloxyletum ammodendronis** HILBIG (1987) 1990
typical sub-association (Table 9, 10)
***Ephedra przewalskii* sub-association** (Table 9)
***Reaumuria soongorica* sub-association** (Table 10)
***Nitraria sphaerocarpa* sub-association** (Table 10)
***Kalidium gracile* sub-association** (Table 10)
***Ephedra przewalskii* community** (Table 8)
L Caraganion leucophloeae HILBIG 2000
A Sympegmo regelii-Caraganetum leucophloeae ass. nov. hoc loco (Table 6)
***Convolvulus gortschakovii* community** (Table 8)
C Populetea euphraticae ZOHARY 1962
O Populetalia euphraticae ZOHARY 1962
V Populion euphraticae EIG 1938
A Glycyrrhizo uralensis-Populetum euphraticae ass. nov. hoc loco (Table 12)
typical sub-association (Table 12)
***Reaumuria songarica* sub-association** (Table 12)
A Sophoro alopecuroidis-Populetum euphraticae (KÜRSCHNER 2004) ass. nov. hoc loco (Table 12)

C ?Salicetea purpureae MOOR 1958
O Salicetalia miyabeanae HILBIG 2000
L Salicion viminalis MIRKIN et al. ex HILBIG 2000
***Tamarix ramosissima* community (**unclear position) (Table 13)

6 Concluding remarks on communities' ecology

The Transaltay Gobi is clearly the driest of the Mongolian floristic regions (GUBANOV 1996; GRUBOV 2001), and wide, vegetationless deserts are hardly found anywhere else in the southern Mongolian Gobi.

Overall, the plant communities and associations we found in the Transaltay Gobi correspond well to previously described units (HILBIG 1995), but the special site conditions required some syntaxonomic amendments. The desert steppes described at the beginning of our account are generally impoverished regional variants of those described by other authors

(HILBIG 1995; KÜRSCHNER 2004; WESCHE et al. 2005). Not only is the species richness lower on the plot level, but also the overall number of species recorded in the table is conspicuously low.

The distribution of *Anabasis brevifolia* exemplifies these ecological differences; it is exceedingly widespread in semi-deserts of the Dzungarian Gobi and the Gobi Gurvan Saykhan (WESCHE et al. 2005; VON WEHRDEN et al. subm.), but restricted to somewhat moister sites at the upper pediments in the Transaltay region. Instead, the *Ephedra przewalskii* community seems to be rather typical for similar sites in the Transaltay; although its syntoxonomic status remains uncertain it is doubtless characteristic for the vast pediment regions.

Other semi-desert communities can be compared to the neighbouring regions as well; again the overall low number (and abundance) of species exemplifies the aridity. Characteristic and very widespread in the Transaltay is *Sympegma regelii* as a typical species of central Asian drylands. The *Iljinia regelii* community is a regional speciality occurring nowhere else in Mongolia (see GRUBOV 2000 for the distribution map of the species).

In seeming contrast to the general dryness is the presence of riparian or other extrazonal vegetation types. Oases and similar habitats occur in all parts of the Gobi, but nowhere else is the difference between zonal and extra-zonal vegetation more obvious. The water catchment areas are sparsely vegetated and often contain not more than a handful of species, yet ground water accumulates over hundreds of square kilometres. The aquifers finally reach the surface, and at least at eight locations this allows for the rather luxurious growth found in oases.

7 Implications for nature conservation

Land use in the region is extremely limited. The low vegetation cover and the low productivity of the grazing grounds support only a small number of animals, compared to other protected areas within the Gobi region. Thus, the Transaltay Gobi offers the last refuges for extremely rare species such as the wild camel and the Gobi bear (ZEVEGMID & DAWAA 1973); other endangered mammals living or at least passing through the region include the asiatic wild ass (Khulan) and gazella species. Hence possible threats to the ecosystem would be of high relevance for nature conservation.

Due to the site conditions, livestock numbers are low and probably will remain low, so anthropo-zoogenic impact should not become a widespread problem. However, the oasis of Ekhiyn Gol was cultivated over the last decades, leading to tremendous changes in the ecosystem (PANKOVA et al. 2004). Several replacement communities were observed, and grazing might affect the regrowth of the occurring poplar forests. Moreover, in the vicinity of the oasis hunting increased at least locally.

Since the protected area is situated alongside the border of China, one threat can be assumed from the south. More intense grazing was seen (pers. obs. VON WEHRDEN) in 2005 in the eastern Alashan Gobi, which contains comparable plant communities. KÜRSCHNER (2004) describes intense human land use for the adjacent area towards the south in Inner Mongolia. There, grazing of the montane communities seems to be strong; the grazing pressure on some semi-desert communities is equally high, and the impact on the riparian ecosystems is described to be “drastic”. Thus, land use in the neighbouring part of Inner Mongolia is apparently much more intense (KÜRSCHNER 2004) and has led to pronounced changes even in the zonal vegetation. Towards the north-east of the working area the grazing levels increase again with increasing moisture, and mining activity has also commenced. Thus, the drylands of the Transaltay are surrounded by regions of intensifying human land use. Whether or not these will eventually affect the Great Gobi A Strictly Protected Area remains an open question.

Yet, large-scale changes influence the almost natural ecosystem already. Climate change is expected to change the vegetation of Central Asia (CHRISTENSEN 2001; DAGVADORJ et al. 2001; ELLIS et al. 2001; CHRISTENSEN et al. 2004); although the precipitation might remain stable, the temperatures are expected to rise. Thus, evaporation may change gradually, leading to an overall loss of moisture. This may have affected some ecosystems such as the riparian woodlands that depend on permanent water surplus. Such sites are threatened by higher evapotranspiration, and even the zonal desert steppes may be transformed into drier vegetation types. At present, these considerations fortunately remain theoretical, but some kind of monitoring is needed to ensure possible changes in the important refuges of the Transaltay Gobi do not go unnoticed.

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References

ANONYMOUS 1990: Atlas of Mongolia. – Ulaanbaatar.

BARTHEL, H. 1983: Die regionale und jahreszeitliche Differenzierung des Klimas in der Mongolischen Volksrepublik. – Studia Geographica **34**: 3–91.

BATKHISHIG, O. & LEHMKUHL, F. 2003: Degradation und Desertifikation in der Mongolei. – Petermanns Geogr. Mitt. **147**: 48–49.

BEDUNAH, D. & SCHMIDT, S. M. 2000: Rangeland of Gobi Gurvan Saikhan National Conservation Park, Mongolia. – Rangelands **22**: 18–24.

BOBROVSKAJA, N. I. 1985: Wasserhaushalt der Wüsten- und Wüstensteppenpflanzen in der Nord- und der Trans-Altai-Gobi. – Feddes Repert. **96**: 425–432.

BRUELHEIDE, H.; JANDT, U.; GRIES, D.; THOMAS, F. M.; FOETZKI, A.; BUERKERT, A.; GANG, W.; XIMING, Z. & RUNGE, M. 2003: Vegetation changes in a river oasis on the southern rim of the Taklamakan Desert in China between 1956 and 2000. – Phytocoenologia **33**: 801–818.

CHRISTENSEN, L. 2001: Simulation of vegetation change due to grazing and climate change on the typical steppe. – In: T. CHULUUN & D. OJIMA (eds.): Change and sustainability of pastoral land use systems in temperate and central Asia. – Ulanbataar.

CHRISTENSEN, L.; COUGHENOUR, M. B.; ELLIS, J. E. & ZUO, Z. C. 2004: Vulnerability of the Asian typical steppe to grazing and climatic change. – Climatic Change **63**: 351–368.

DAGVADORJ, D.; BATIMA, B. & NATSAGDORJ, L. 2001: Climate change and its impacts on ecosystems of Mongolia. – In: T. CHULUUN & D. OJIMA (eds.): Change and sustainability of pastoral land use systems in temperate and central Asia. – Ulaanbataar.

DIERSCHKE, H. 1994: Pflanzensoziologie. – Stuttgart.

ELLIS, J. E.; PRICE, K.; BOONE, R.; YU, F.; CHULUUN, T. & YU, M. 2001: Integrated assessment of climate change effects on vegetation in Mongolia and Inner Mongolia. – In: T. CHULUUN & D. OJIMA (eds.): Fundamental issues affecting sustainability of the Mongolian steppe. – Ulaanbataar.

FERNANDEZ-GIMENEZ, M. E. 1999: Sustaining the steppes: a geographical history of pastoral land use in Mongolia. – Geogr. Rev. **89**: 315–342.

FRIESEN, N. 1995: The genus *Allium* L. in the flora of Mongolia. – Feddes Repert. **106**: 59–81.

GRUBOV, V. I. 1989: Endemismus in der Flora der Mongolei. – Erforsch. biol. Ress. MVR **6**: 87–90.

GRUBOV, V. I. 2000ff: Plants of Central Asia. – Enfield.

GRUBOV, V. I. 2001: Key to the vascular plants of Mongolia. Volume I & II. – Plymouth.

GUBANOV, I. A. 1996: Konspekt flory vneshney Mongolii (sosudistye rasteniya). – Moskva.

GUNIN, P. D.; VOSTOKOVA, E. A.; DOROFEYUK, N. I.; TARASOV, P. E. & BLACK, C. C. 1999: Vegetation dynamics of Mongolia. – Dordrecht, Boston, London.

HANELT, P. & DAVAŽAMC, S. 1965: Beitrag zur Kenntnis der Flora der Mongolischen Volksrepublik, insbesondere des Gobi-Altai, des Transaltai- und Alašan-Gobi-Bezirks. – Feddes Repert. **70**: 7–68.

HELMECKE, K. & SCHAMSRAN, Z. 1979: Ergebnisse ökologischer Untersuchungen in der Gobi der Mongolischen Volksrepublik. 1. Untersuchungsgebiet, Vegetationseinheiten und Ergebnisse der mikroklimatischen Untersuchungen. – Arch. Naturschutz u. Landschaftsforsch. **19**: 1–22.

HIJMANS, R. J.; CAMERON, S. E.; PARRA, J. L.; JONES, P. G. & JARVIS, A. 2005: Very high resolution interpolated climate surfaces for global land areas. – Int. J. Climatol. **25**: 1965–1978.

HILBIG, W. 1990: Pflanzengesellschaften der Mongolei. – Erforsch. biol. Ress. MVR **8**: 5–146.

HILBIG, W. 1995: The vegetation of Mongolia. – Amsterdam.

HILBIG, W. 2000: Kommentierte Übersicht über die Pflanzengesellschaften und ihre höheren Syntaxa in der Mongolei. – Feddes Repert. **111**: 75–120.

HILBIG, W. & OPP, C. 2005: The effects of anthropogenic impact on plant and soil cover in Mongolia. – Erforsch. biol. Ress. Mongolei **9**: 163–178.

HILBIG, W. & TUNGALAG, R. 2006: Vegetationskundliche Untersuchungen in der Borzongijn– und Galbyn-Gobi (Ömnögov Aimak, Mongolei). – Feddes Repert. **117**: 339–433.

JÄGER, E. J. 2005: The occurrence of forest plants in the desert mountains of Mongolia and their bearing on the history of the climate. – Erforsch. biol. Ress. Mongolei **9**: 237–245.

JIRNOV, L. V. & ILINSKIY, V. O. 1985: Bolshoy Gobiyskiy Zapovednik – Ubejishche redkikh jivotnykh pustyn tsentralnoy Azii. – Moskva.

KASHAPOV, R. SH.; MIRKIN, B.M.; ALIMBEKOVA, L. M. & ONISHCHENKO, L. J. 1988: K sintaksonomii stepey i pustyn MNR. III. Pustyni severnoy Gobi. – Depon. Ms. VINITI No 138–V88, 34 p. – Moskva.

KAZANTSERA, T. J.; GUNIN, P. D.; SLEVMNEV, N. N. 2003: Saksaulovye soobshchestva ravnin Gobi (Mongoliya). – Bot. Zh. **88** (4): 1–16.

KÜRSCHNER, H. 2004: Phytosociological studies in the Alashan Gobi – a contribution to the flora and vegetation of Inner Mongolia (NW China). – Phytocoenologia **34**: 169–224.

LEHMKUHL, F. 2000: Alluvial fans and pediments in Western Mongolia and their implications for neotectonic envets and climatic change. – Berliner Geowiss. Abh. A **205**: 2–8.

LICHTENEGGER, E.; KUTSCHERA, L.; SOBOTIK, M. & HAAS, D. 1997: Bewurzelung von Pflanzen in der Mongolei. – In: Bewurzelung von Pflanzen in verschiedenen Lebensräumen. Band 5 der Wurzelatlas-Reihe. Spezieller Teil. – Stapfia **49**: 296–318.

MEUSEL, H. & JÄGER, E. 1992: Vergleichende Chorologie der zentraleuropäischen Flora. Bd. III Text und Kartenband. – Jena, Stuttgart.

MIX, H. M.; READING, R. P.; BLUMER, E. S. & BADAMJAVIIN, L. 2002: Status and distribution of Wild Bactrian camels in Mongolia. – In: R. READING; E. DULAMTSERENGIIN & G. TUVDENDORJIIN (eds.): Ecology and conservation of Wild Bactrian Camels: 39–48. – Ulaanbaatar.

MUELLER–DOMBOIS, D. & ELLENBERG, H. 1974: Aims and methods of vegetation ecology. – New York, London, Sydney, Toronto.

NATIONAL STATISTIC OFFICE OF MONGOLIA 2001: Mongolian Statistical Yearbook 2000. – Ulaanbaatar.

NATIONAL STATISTIC OFFICE OF MONGOLIA 2003: Mongolian Statistical Yearbook 2002. – Ulaanbaatar.

OPP, C. & HILBIG, W. 2003: The impact of overgrazing on natural pastures in Mongolia and Tyva. – Berliner Paläobiol. Abh. **2**: 96–98.

PANKOVA, Y. I.; GOLOVANOV, D. L. & MANDAKHBAYAR, J. 2004: Monitoring of the soil salinity in Ekhiyn-Gol oasis within the Gobi desert at local level. – Aridnye Ekosistemy **10**: 149–161.

RACHKOVSKAYA, E. I. 1993: Rastitelnost gobiyskikh pustyn Mongolii. – Biol. Res. prir. Uslov Mongolii **36**: 1–135.

RACHKOVSKAYA, E. I. & VOLKOVA, E. A. 1977: Rastitelnost Zaaltayskoy Gobi. – Biol. Res. prir. Uslov MNR **7**: 46–74.

READING, R. P.; AMGALANBAATAR, S. & LHAGVASUREN, L. 1999: Biological Assessment of Three Beauties of the Gobi National Conservation Park, Mongolia. – Biodiversity and Conservation **8**: 1115–1137.

RETZER, V. 2004: Carrying capacity and forage competition between livestock and a small mammal, the Mongolian Pika (*Ochotona pallasi*), in a non-equilibrium ecosystem, South-Gobi, Mongolia. – Univ. Marburg, Fac. Geogr., Ph. D. thesis.

RETZER, V.; NADROWSKI, K. & MIEHE, G. 2006: Variation of precipitation and its effect on phytomass production and consumption by livestock and large wild herbivores along an altitudinal gradient during a drought, South Gobi, Mongolia. – J. Arid Environ. **66**: 135–150.

SAMJAA, R.; ZÖPHEL, U. & PETERSON, J. 2000: The impact of the vole *Microtus brandtii* on Mongolian Steppe Ecosystems. – Marburger Geogr. Schr. **135**: 346–360.

SCHALLER, G. B. 2000: Wildlife of the Tibetan Steppe. – Chicago.

STUMPP, M.; WESCHE, K.; RETZER, V. & MIEHE, G. 2005: Impact of grazing livestock and distance from water points on soil fertility in southern Mongolia. – Mountain Research and Development **25**: 244–251.

VON WEHRDEN, H. & WESCHE, K. in press: Mapping Khulan habitats – a GIS-based approach. – Erforsch. biol. Ress. Mongolei **10**.

VON WEHRDEN, H.; WESCHE, K.; REUDENBACH, C. & MIEHE, G. in press: Mapping of large-scale vegetation pattern in southern Mongolian semi-deserts – an application of LANDSAT 7 data. – Erdkunde.

VON WEHRDEN, H.; WESCHE, K. & TUNGALAG, R. subm.: Plant communities of the Great Gobi B Strictly Protected Area. – Mongolian J. Biol. Sciences.

WALTER, H. 1974: Die Vegetation Osteuropas, Nord- und Zentralasiens. – Stuttgart.

WEISCHET, W. & ENDLICHER, W. 2000: Regionale Klimatologie. Teil 2. Die Alte Welt. – Stuttgart, Leipzig.

WESCHE, K.; MIEHE, S. & MIEHE, G. 2005: Plant communities of the Gobi Gurvan Sayhan National Park (South Gobi Aymak, Mongolia). – Candollea **60**: 149–205.

XU, L. H.; LIU, H. Y.; CHU, X. Z. & SU, K. 2006: Desert vegetation patterns at the northern foot of Tianshan Mountains: The role of soil conditions. – Flora **201**: 44–50.

YUNATOV, A. A. 1954: Kormovye rasteniya pastbishch i senokosov Mongolskoy Narodnoy Respubliki. – Moskva-Leningrad.

ZEMMRICH, A. 2005: Die Steppengliederung der Mongolei aus Sicht der russischen und mongolischen Geobotanik. – Arch. Naturschutz Landschaftsforsch. **1**: 17–35.

ZEVEGMID, D. & DAWAA, N. 1973: Die seltenen Großsäuger der Mongolischen Volksrepublik und ihr Schutz. – Arch. Naturschutz Landschaftsforsch. **2**: 87–106.

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Table 4
Constancy table of widespread communities in the Great Gobi A Strictly Protected Area. Diagnostic species are indicated: CC = class-level character species; OC = order-level character species; LC = alliance-level character species; AC = association-level character species, rC = regional character species, D = differential species (after HILBIG 2000). If more than 5 relevés were present in a given community, frequency is given as constancy classes ("r" = present in <5% of all relevés of that community; "+" = 5–10%; "I" = 11–20%; "II" = 21–40%; "III" = 41–60%; "IV" = 61–80%; "V" = 81–100%). For full community names refer to the text. Note that the number of relevés in the individual tables (tab. 6-14) is sometimes lower than the number of relevés used for the synoptic tables (see text)

	Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**12**	**13**	**14**	**15**	**16**
	Number of relevés	11	28	32	11	13	5	46	16	42	11	9	35	6	5	8	20
CC – STIPETEA GLAREOSAE GOBICAE																	
	Stipa glareosa	IV	V	IV	V	V	IV	II	I	I	I	.	I	I	I	.	.
	Ajania achilleoides	V	V	IV	III	III	.	III	II	I	+	III	.	I	.	.	.
	Allium mongolicum	+	r	II	.	II	.	r	.	r	.	I	.	.	.	.	.
	Lagochilus ilicifolius	.	.	r	+	I	.	.	.	.	.	.	.	.	.	.	.
	Arnebia guttata	+	+	I	II	I	.	I	+	r	.	.	r	.	.	.	+
	Arnebia fimbriata	.	r	+	.	.	.	r	+	+	.	II	r	.	.	.	.
	Artemisia scoparia	.	I	.	.	II	.	+	+	I	+	I	.	.	.	.	I
	Artemisia demissa	+	.	I	+	+	.	I	I	II	I	II	+	.	II	.	.
	Stipa gobica	I	.	.	.	+	.	r	.	.	.	.	.	.	.	.	.
	Scorzonera pseudodivaricata	.	r	r	.	+	.	+	+	.	.	.	.	.	.	.	.
	Ptilotrichum canescens	.	r	I	.	+	.	.	.	+	+	.	.	.	I	.	.
OC – ALLIETALIA POLYRRHIZI																	
	Allium polyrrhizum	I	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.
	Anabasis brevifolia	+	II	V	V	V	I	II	.	I	.	.	I	.	I	.	I
	Dontostemon senilis	III	III	II	III	II	.	I	.	r	.	.	.	.	.	.	.
	Rheum nanum	II	+	II	II	+	I	+	.	r	.	.	r	.	.	.	.
	Ptilagrostis pelliotii	I	I	II	III	II	.	.	.	.	.	.	.	.	.	.	.
OC – REAUMURIO SOONGORICAE-SALSOLETALIA PASSERINAE AND LC REAUMURIO SOONGORICAE-SALSOLION PASSERINAE																	
	Reaumuria songarica	III	I	.	.	V	.	.	V	.	.	.	V	V	IV	V	I
	Kalidium gracile	.	.	.	.	.	.	.	.	.	.	.	.	V	.	.	.
	Salsola arbuscula	.	.	.	.	+	I	+	.	r	II	II	+	I	1	.	.
OC – ZYGOPHYLLO XANTHOXYLI-BRACHANTHEMETALIA GOBICI AND LC ZYGOPHYLLO XANTHOXYLI-BRACHANTHEMION GOBICI																	
D	*Zygophyllum xanthoxylon*	II	III	I	II	II	IV	IV	III	r	II	I	+	I	I	.	+
D	*Artemisia xanthochroa*	+	r	r	.	+	.	.	.	.	.	.	.	.	.	.	r
AC – EUROTIO CERATOIDIS-ZYGOPHYLLETUM XANTHOXYLI																	
	Krascheninnikovia ceratoides	V	III	II	+	II	.	I	+	+	I	.	+	I	I	.	.
	Asterothamnus centrali-asiaticus	+	III	+	+	.	.	I	+	.	.	I	.	.	.	.	.

Table 4 (continued)

	Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**12**	**13**	**14**	**15**	**16**
AC – CALLIGONO MONGOLICI-HALOXYLETUM AMMODENDRONIS																	
	Haloxylon ammodendron	.	.	.	.	.	.	.	.	V	V	V	V	V	.	I	II
	Calligonum mongolicum	+	.	.	.	.	I	+	II	+	I	II	I	I	.	.	I
LC – CARAGANION LEUCOPHLOEAE																	
	Caragana leucophloea	.	V	.	.	.	.	r	.	.	+	.	.	.	.	.	.
	Atraphaxis pungens	.	+	.	.	.	.	r	+	.	.	.	.	.	.	.	.
C – *CONVOLVULUS GORTSCHAKOVII* COMMUNITY																	
	Convolvulus gortschakovii	.	r	r	+	I	V	+	.	.	.	.	+	.	.	.	.
	Oxytropis aciphylla	+	.	.	.	.	II	r	.	.	.	.	r	.	.	.	.
C – *EPHEDRA PRZEWALSKII* COMMUNITY																	
D	*Ephedra przewalskii*	+	III	.	V	III	.	V	V	r	V	II	II	.	.	I	I
C – *ILJINIA REGELII* COMMUNITY																	
	Iljinia regelii	.	r	r	.	.	.	.	.	I	.	.	.	.	.	.	V
D – *REAUMURIA SONGARICA-NITRARIA SPHAEROCARPA*-COMMUNITY																	
	Nitraria sphaerocarpa	.	.	.	.	.	.	r	I	.	.	V	I	.	IV	.	.
D – SYMPEGMO REGELII-CARAGANETUM LEUCOPLOEAE																	
	Sympegma regelii	IV	IV	IV	III	IV	I	IV	II	II	II	II	I	III	I	III	I
COMPANIONS																	
	Cancrinia discoidea	+	.	+	I	+	.	.	.	r	.	.	.	.	.	.	I
	Bassia dasyphylla	+	r	r	.	.	.	I	+	II	+	I	I	.	I	.	+
	Peganum nigellastrum	II	I	r	.	+	.	r	+	.	.	.	.	.	.	.	.
	Nitraria sibirica	.	.	.	.	.	.	.	+	+	.	.	+	I	.	.	.
	Tamarix ramosissima	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
	Stipa orientalis	II	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.
	Astragalus brachybotrys	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.
	Astragalus grubovii	+	.	+	+	.	.	r	.	.	+	II	r	.	.	.	.
	Dontostemon crassifolius	II	I	r	.	+	.	I	+	.	.	.	.	.	.	.	.
	Dontostemon elegans	.	.	+	.	+	.	r	.	r	I	I	.	.	.	.	.
	Amygdalus pedunculata	.	r	.	.	+	.	.	.	.	.	.	.	.	.	.	.
	Enneapogon borealis	.	.	.	.	.	.	r	.	r	.	.	.	.	.	.	.
	Ephedra glauca	+	r	+	+	.	.	r	.	.	.	.	.	.	.	.	.
	Zygophyllum pterocarpum	.	.	+	+	.	.	r	.	.	.	.	.	.	.	.	r
	Kaschgaria komarovii	.	r	r	.	.	.	.	.	r	+	.	.	.	.	.	.
	Limonium aureum	.	.	+	.	+	.	r	.	.	.	.	.	.	.	.	.

Micropeplis arachnoidea	+	r	.	.	.	I	r	.	I	+	II	I	.	.	.	+
Nitraria roborovskii	.	.	.	.	.	.	r	I	.	.	.	.	.	.	.	.
Salsola collina	.	I	r	II	.	I	.	.	r	+	I	.	.	.	.	.
Zygophyllum gobicum	.	r	+	+	+	.	+	.	r	+	.	.	.	.	II	.
Zygophyllum potaninii	+	.	I	I	+	.	r	.	+	+	.	+	.	.	.	.
Schizonepeta annua	.	.	+	.	+	.	r	.	.	.	.	.	.	.	.	.
Artemisia xerophytica	.	.	.	.	.	.	.	.	r	I	I	+	.	.	.	.
Corispermum mongolicum	.	.	.	.	.	.	.	.	r	+	.	r	I	.	.	.
Lepidium densiflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	I	.	.
Halimodendron halodendron	.	.	.	.	.	.	.	.	.	.	.	+	IV	.	.	.
Potaninia mongolica	.	.	.	.	.	.	.	.	.	.	.	r	I	.	.	.

Additional:

ad 1: *Saussurea catarinae* (+), *Galitzkya potaninii* (+), *Echinops gmelinii* (r), *Elymus sibiricus* (r)
ad 2: *Stellaria dichotoma* (r), *Artemisia pectinata* (r), *Youngia tenuicaulis* (r)
ad 3: *Salsola passerina* (+), *Cleistogenes squarrosa* (+), *Astragalus monophylla* (r) *Carex stenophylla* (r), *Limonium tenellum* (r), *Chamaerhodos* sp. (r), *Tribulus terrestris* (r)
ad 4: *Setaria viridis* (+)
ad 5: *Lycium* sp. (+), *Dracocephalum foetidum* (+)
ad 7: *Chenopodium album* (r), *Artemisia dracunculus* (r), *Lappula stricta* (r), *Artemisia macrocephala* (r)
ad 9: *Artemisia macrocephala* (r), *Tribulus terrestris* (r)
ad 15: *Salsola tragus* (r)

Running no.:

1 — Eurotio ceratoidis-Zygophylletum xanthoxyli
2 — Sympegmo regelii-Caraganetum leucophloeae
3 — Stipo glareosae-Anabasietum brevifoliae, typical sub-association
4 — Stipo glareosase-Anabasietum brevifoliae, *Ephedra przewalskii* sub-association
5 — Stipo glareosase-Anabasietum brevifoliae, *Reaumuria songarica* sub-association
6 — *Convolvulus gortschakovii* community
7 — *Ephedra przewalskii* community, typical sub-community
8 — *Ephedra przewalskii* community, *Reaumuria songarica* sub-community
9 — Calligono mongolici-Haloxyletum ammondendronis, typical sub-association
10 — Calligono mongolici-Haloxyletum ammondendronis, *Ephedra przewalskii* sub-association
11 — Calligono mongolici-Haloxyletum ammondendronis, *Nitraria sphaerocarpa* sub-association
12 — Calligono mongolici-Haloxyletum ammondendronis, *Reaumuria songarica* sub-association
13 — Calligono mongolici-Haloxyletum ammondendronis, *Kalidium gracile* sub-association
14 — *Reaumuria songarica-Nitraria sphaerocarpa* community
15 — *Reaumuria songarica* community
16 — *Iljinia regelii* community

Table 5
Constancy table of extra-zonal communities. Diagnostic species are indicated, abbreviation similar as in Table 4

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of relevés	7	6	13	13	2	5	24	3
CC-PHRAGMITITEA COMMUNIS								
Phragmites australis	V	IV	IV	III	.	V	II	.
Bolboschoenus popovii	I	.	.	.	.	.	.	.
Scirpus sp.	I	.	.	.	.	.	.	.
CC-ACHNATHERETEA SPLENDENTIS								
Achnatherum splendens	.	.	I	II	.	V	r	.
Glycyrrhiza uralensis	.	.	III	I	.	IV	+	.
Lactuca tatarica	I	.	II	+	.	IV	r	.
CC-POPULETEA EUPHRATICAE								
Populus euphratica tree layer	.	.	V	V	2	.	.	.
Populus euphratica shrub layer	.	.	III	II	.	.	.	.
D-SOPHORO ALOPECUROIDIS-POPULETUM EUPHRATICAE								
Sophora alopecuroides	.	.	.	.	2	.	.	.
Peganum nigellastrum	.	.	.	.	2	.	+	.
D-*LEYMUS* CF. *POBOANUS* COMMUNITY								
Leymus cf.*paboanus*	.	V	.	.	.	.	.	.
Lepidium cordatum	.	III	.	.	.	.	.	.
D-TAMARIX RAMOSISSIMA COMMUNITY								
Tamarix ramosissima	.	.	IV	II	.	.	V	.
TYPICAL SPECIES OF SALINE AND DISTURBED HABITATS								
Nitraria sibirica	II	.	+	II	.	.	II	.
Nitraria roborovoskii	.	.	II	.	.	V	r	.
Reaumuria songarica	IV	.	.	V	.	II	II	.
Kalidium gracile	I	I	+	I	.	.	+	.
Kalidium foliatum	.	.	.	.	.	II	I	.
Lepidium latifolium	.	.	II	.	.	I	r	.
CC-ASTERETEA TRIPOLIUM								
Glaux maritima	.	II	.	.	.	.	r	3
Juncus gerardii	.	.	.	.	.	.	.	1
Potentilla anserina	.	I	.	.	.	.	.	3
Triglochin maritimum	I	.	.	.	.	.	r	2
Triglochin palustre	.	.	.	.	.	.	.	3
Halerpestes salsuginosa	.	.	.	.	.	.	.	3
Taraxacum dealbatum	.	.	.	.	.	.	.	2
Calamagrostis macilenta	.	.	.	.	.	.	.	2
Carex vesicata	.	.	.	.	.	.	.	2
Eleocharis spec.	.	.	.	.	.	.	.	3
Poa tibetica	.	.	.	.	.	.	.	1

Table 5
(continued)

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of relevés	7	6	13	13	2	5	24	3
AC-BLYSMETUM RUFI								
Blysmus rufus	.	.	.	.	.	.	.	3
FURTHER SPECIES, INTROGRESSIVE OF NEIGHBOURING STANDS								
Lycium ruthenicum	.	.	II	.	.	.	.	.
Scorzonera mongolica	I	I	.	.	.	.	.	.
Ephedra przewalskii	.	.	.	.	.	.	III	.
Sympegma regelii	.	.	+	.	.	.	II	.
Zygophyllum xanthoxylon	.	.	.	+	.	.	+	.
Haloxylon ammodendron	.	.	+	I	.	.	I	.
Elymus sp.	.	.	+	II	.	.	I	.
Salicornia perennis	I	.	.	.	.	.	.	1
Scorzonera cf. *gobica*	.	.	.	.	.	II	.	.

ad 1: *Echinops gmelinii* (I), *Elymus sibiricus* (I), *Krascheninnikovia ceratoides* (I),
ad 2: *Carex enervis* (+), *Artemisia* sp. (+), *Potentilla dealbata* (I), *Oxytropis glabra* (I)
ad 3: Sphaerophy*sa salsula* (r), *Asparagus trichphyllus* (r), *Cynachum sibiricum* (r), *Acroptilon repens* (r), *Clematis glauca* (I), *Saussurea grubovii* (I)
ad 4: *Caragana leucophloea* (r), *Cistanche* sp. (r), *Micropeplis arachnoidea* (+)
ad 6: *Elymus* cf. *secalinus* (I), *Acroptilon repens* (I), *Asparagus trichophyllus* (I)
ad 7: *Ajania achilleoides* (+), *Rheum nanum* (r), *Artemisia xanthochroa* (+), *Dontostemon elegans* (r) *Nitraria sphaerocarpa* (+), *Lepidium densiflorum* (r), *Limonium aureum* (r), *Asterothamnus centrali-asiaticus* (r), *Puccinellia tenuifolia* (r), *Tamarix* sp. (r), *Artemisia dracunculus* (r), *Acroptilon repens* (r), *Micropeplis arachnoidea* (I), *Calligonum mongolicum* (I), *Artemisia scoparia* (I)
ad 8: *Panicum* sp. (1)

Running no.:

1 Phragmitetum communis
2 *Leymus* cf. *paboanus* community
3 Glycyrrhizo-Populetum euphraticae, typ. sub-association
4 Glycyrrhizo-Populetum euphraticae, *Reaumuria songarica* sub-association
5 Sophoro-Populetum euphraticae
6 Glycyrrhizo uralensis-Achnatheretum splendentis
7 *Tamarix ramosissima* community
8 Blysmetum rufi

Table 6
Eurotio ceratoidis-Zygophylletum xanthoxyli (running no. 1–11) and Sympegmo regelii-Caraganetum cover values of the species; the letter in the relevé no. indicates the person, who sampled the relevé

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	**15**
Relevé no.	W 4 7	H 2 1	W 5 6	W 6 0	W 1 0 8	W 2 6 9	W 2 7 7	W 6 1	W 5 3	W 5 4	W 5 5	W 1 7 7	W 1 7 1	W 4 9	W 5 2
Caragana leucophloea	.	.	.	.	.	.	.	.	.	.	.	2	1	1	1
Stipa glareosa	.	1	+	+	+	r	+	.	+	+	.	.	+	r	1
Ajania achilleoides	+	2	+	+	+	.	+	+	1	1	+	+	+	+	r
Krascheninnikovia ceratoides	+	+	1	+	.	+	2	+	1	1	1	.	.	1	1
Sympegma regelii	1	1	1	1	1	.	1	1	.	1	.	1	.	1	1
Dontostemon senilis	.	.	r	r	.	.	.	+	+	r	r	.	.	r	+
Zygophyllum xanthoxylon	+	+	.	.	.	+	1	.	.	.	.	.	.	.	.
Ephedra przewalskii	+	.	.	.	.	.	.	.	.	.	.	1	1	.	.
Anabasis brevifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Reaumuria songarica	1	+	+	+	+	.	.	.	.	.	.	.	.	.	.
Asterothamnus centrali-asiaticus	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.
Atraphaxis pungens	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Stipa orientalis	.	.	.	.	.	.	.	.	+	1	1	.	.	.	.
Allium polyrrhizum	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.
Rheum nanum	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.
Ptilagrostis pelliotii	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia scoparia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peganum nigellastrum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Arnebia guttata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dontostemon crassifolius	+	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Peganum nigellastrum	+	.	+	r	.	.	.	r	.	.	.	.	.	.	.
Stipa gobica	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.
Astragalus grubovii	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Ephedra glauca	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Salsola collina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micropeplis arachnoidea	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ephedra intermedia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia demissa	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Bassia dasyphylla	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.

Additional:

ad 3: *Cancrinia dioscoidea* (r)
ad 5: *Oxytropis aciphylla* (+), *Allium mongolicum* (r)
ad 6: *Echinops gmelini* (r), *Calligonum mongolicum* (+), *Artemisia sphaerocephala* (r)
ad 8: *Zygophyllum potaninii* (+)
ad 11: *Galitzkya potaninii* (r), *Elymus sibiricus* (r), *Saussurea catharinae* (r)
ad 14: *Iljinia regelii* (r)
ad 16: *Artemisia xantochroa* (r)
ad 17: *Arnebia fimbriata* (r)

leucophloeae (running no. 12–39). Within each individual table Arabian numbers represent Braun-Blanquet ('H'= W. HILBIG, 'W'= H. v. WEHRDEN)

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	H	H	H	H
2	1	1	1	5	1	1	1	2	2	1	2	1	1	1	1	1	1	1	4	2	5	5	5
8	7	6	7	9	6	5	1	8	7	6	7	6	7	5	8	2	7	6	8	8	2	2	3
0	4	7	3		1	0	9	1	9	9	1	3	2	9	7	4	5	5				a	a
+	1	1	+	1	+	+	1	1	+	+	+	+	+	1	1	+	+	+	1	4	3	3	3
1	+	+	+	+	1	.	+	+	+	+	+	1	1	+	.	+	+	1	+	r	2	2	2
1	+	1	1	+	+	+	1	+	+	1	+	+	+	+	.	+	+	.	+	.	1	1	.
+	.	.	.	1	1	.	.	1	1	+	.	1	.	1	.	.	.	.	+	3	.	.	.
.	1	1	+	1	1	1	.	.	+	1	+	+	+	+	1	.	1	1	1	2	2	2	1
r	.	.	.	r	.	.	.	+	r	r	r	.	.	r	.	.	.	.	r	.	.	.	.
.	.	.	.	1	1	+	+	+	1	+	1	.	.	+	+	1	.	.	+	+	.	.	.
.	.	.	.	.	.	1	1	.	.	.	+	1	+	1	1	.	+	.	.	2	+	+	.
.	.	.	.	.	.	.	.	.	+	+	+	+	+	+	1	+	.	.	.	.	.	.	.
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r	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
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ad 19: *Kaschgaria komarovii* (1), *Youngia tenuicaulis* (+)
ad 23: *Allium mongolicum* (+)
ad 24: *Ptilotrichum canescens* (+)
ad 25:*Amygdalus pedunculata* (+), *Artemisia pectinata* (+)
ad 26: *Stellaria dichotoma* (1)
ad 27: *Scorzonera pseudodivaricata* (+), *Zygophyllum gobicum* (+)
ad 31: *Convolvulus gortschakovii* (1)

Table 7
Stipo glareosae-Anabasietum brevifoliae: typical sub-association (running no. 1 – 16); *Ephedra przewalskii*

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Relevé no.	H 2 7 a	H 2 6	W 2	H 2 7 b	H 2 7 c	W 2 7 d	W 1 6 6	W 1 6 0	W 2 7 0	W 1 0 5	W 1 7 0	W 5 1	H 5 8 a	W 2 7 8	W 7 2	W 3 8
Anabasis brevifolia	1	+	1	+	+	+	1	1	+	+	1	r	2	1	+	r
Stipa glareosa	2	2	1	2	2	2	1	+	+	r	+	1	1	+	.	.
Ajania achilleoides	+	+	+	+	1	1	+	+	r	+	+	1	.	.	.	.
Dontostemon senilis	+	+	.	.	+	.	.	.	r	.	.	r	.	r	.	.
Ptilagrostis pelliotii	.	.	.	.	.	r	.	.	r	.	+	.	.	.	.	.
Sympegma regelii	.	.	1	+	+	+	+	+	+	+	1	1	.	.	1	1
Ephedra przewalskii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Convolvulus gortschakovii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Reaumuria songarica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Zygophyllum xanthoxylon	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Rheum nanum	+	.	.	.	.	+	.	r	+	.	.	.	+	.	.	.
Cancrinia discoidea	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Ptilotrichum canescens	.	.	.	.	.	.	.	.	.	.	.	r	1	.	.	.
Krascheninnikovia ceratoides	.	.	+	.	.	.	+	.	.	+	+	+	.	.	.	.
Zygophyllum gobicum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Zygophyllum potaninii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
Allium mongolicum	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.
Artemisia scoparia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salsola collina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia demissa	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.
Lagochilus ilicifolius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Arnebia guttata	.	.	.	.	.	.	.	r	.	.	.	.	+	.	.	.
Asterothamnus centrali-asiaticus	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.
Ephedra glauca	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Zygophyllum pterocarpum	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.
Astragalus grubovii	+	.	r	+	+	.	.	.	.	.	.	.	.	.	.	.
Schizonepeta annua	.	.	.	.	.	.	.	.	.	+	.	.	.	.	r	.
Dontostemon elegans	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Limonium aureum	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.
Allium polyrrhizum	.	.	.	.	.	.	.	.	.	.	r		.	.	.	.

Additional:

ad 14: *Artemisia xantochroa* (r)
ad 26: *Setaria viridis* (+)
ad 28: *Amygdalus pedunculata* (+), *Scorzonera pseudodivaricata* (+)
ad 29: *Salsola arbuscula* (+)

sub-association (running no. 17–27); *Reaumuria songarica* sub-association (running no. 28–38)

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
W274	W267	W114	W176	W116	W162	W272	W178	H10	W182	W117	W275	W259	W120	W258	W121	W122	W110	W57	W276	W50	H54
+	+	+	+	1	1	+	1	+	1	1	1	+	1	+	1	+	+	+	+	r	2
+	1	+	+	+	1	+	+	2	.	.	1	1	+	1	+	.	+	+	1	1	1
+	+	+	1	.	+	.	.	+	.	.	r	.	.	.	+	.	.	+	+	+	+
r	r	.	.	r	.	r	.	+	.	.	.	.	.	.	.	.	.	+	.	r	+
r	+	.	+	.	.	+	r	.	.	.	.	.	.	.	.	.	r	r	+	.	1
+	.	.	+	.	+	+	.	2	.	+	1	.	.	+	+	1	+	1	+	1	.
+	+	1	+	+	1	+	1	+	+	+	+	+	+	+	+	.	.	.	.	.	.
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+	+	.	.	.	+	+	.	.	.	.	.	1	+	.	.	.	.	.	+	.	.
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ad 30: *Dontostemon crassifolius* (r)
ad 31: *Lycium* sp. (1)
ad 35: *Stipa gobica* (+)
ad 37: *Peganum nigellastrum* (r), *Dracocephalum foetidum* (r)

Table 8
Ephedra przewalskii community, typical sub-community (running no. 1 – 21) and *Reaumuria songarica* sub-

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Relevé no.	W73	W107	W180	W273	W75	W74	W102	W44	W179	W157	W128	W183	W113	W35	W101	W233	W239
Ephedra przewalskii	+	r	1	1	1	+	+	1	1	1	+	1	+	1	+	1	1
Zygophyllum xanthoxylon	.	.	.	1	1	.	+	1	1	1	.	1	+	.	+	1	1
Ajania achilleoides	.	.	.	.	.	+	.	.	+	+	1	.	+	1	.	.	.
Stipa glareosa	.	.	.	1	+	.	.	.	.	.	.	.	r	.	.	.	.
Reaumuria songarica	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Anabasis brevifolia	+	+	r	+	+	+	.	.	.	.	.	.	.	.	.	.	.
Sympegma regelii	.	r	1	1	1	1	+	1	1	+	+	+	1	+	+	.	.
Asterothamnus centrali-asiaticus	.	.	+	.	.	.	.	.	.	.	1	+	.	.	.	.	.
Artemisia scoparia	.	.	.	r	.	.	.	.	.	+	.	.	.	.	.	.	.
Convolvulus gortschakovii	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Oxytropis aciphylla	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Calligonum mongolicum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Nitraria sphaerocarpa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+
Dontostemon crassifolius	.	.	.	.	.	.	.	.	+	+	+	+	+	.	.	.	.
Artemisia demissa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rheum nanum	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.
Nitraria roborovskii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Atraphaxis pungens	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Krascheninnikovia ceratoides	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Bassia dasyphylla	.	r	.	.	+	.	.	.	.	.	.	r	.	.	.	.	.
Arnebia guttata	.	.	r	.	.	.	.	.	.	.	.	r	.	.	.	.	.
Zygophyllum gobicum	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Peganum nigellastrum	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.
Scorzonera pseudodivaricata	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Zygophyllum potaninii	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.

Additional:

ad 2: *Zygophyllum pterocarpum* (+)
ad 3: *Allium mongolicum* (+)
ad 6: *Dontostemon senilis* (+)
ad 10: *Limonium aureum* (+)
ad 19: *Enneapogon borealis* (+)

community (running no. 22–37); *Convolvulus gortschakovii* community (running no. 38–42)

18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
W18	W71	W260	W228	W9	W229	W233	W232	W235	W118	W106	W76	W46	H25	H31	H50	W240	W245	H406	W23	W188	W264	W261	W263	W262
1	1	1	1	+	1	1	1	1	1	1	+	+	2	+	+	1	1	2	1	.	.	.	.	.
1	1	.	.	.	.	.	.	.	.	.	.	1	2	+	1	1	1	+	1	.	+	1	1	+
.	+	.	.	.	.	.	.	.	1	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.
.	+	+	.	.	.	.	.	.	+	.	.	.	.	+	1	.	.	.	.	.	+	1	1	+
.	.	.	.	1	1	1	+	+	1	+	2	1	+	+	+	+	+	2	1	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.
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ad 22: *Nitraria sibirica* (1), *Arnebia fimbriata* (r)
ad 31: *Kaschgaria komarovii* (+)
ad 38: *Micropeplis arachnoidea* (+), *Salsola collina* (+)
ad 39: *Salsola arbuscula* (+)

Table 9
Calligono mongolici-Haloxyletum ammondendronis: typical sub-association (running no. 1–20); running no. 1–5 indicate pure *Haloxylon*-stands; *Ephedra przewalskii* sub-association (running no. 21–28)

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Relevé no.	W 1 1	W 2 0 4	W 2 2 2	W 2 2 0	W 2 2 4	H 1 7	H 1 7 a	W 2 5 6	W 4	W 2 6	W 3 0	W 3 1	W 2 2 1	W 2 8	W 2 9	W 1 9 1	W 1 4 3	H 6 4 a	W 6 5	W 8 8	H 9	H 6 1 a	W 2 0 3	W 2 0 1	W 2 5 3	W 2 5 5	W 2 1 8	H 6 1
Haloxylon ammodendron	1	1	+	1	+	2	2	1	2	2	2	1	+	1	1	1	1	2	1	2	1	1	1	1	1	1	+	1
Ephedra przewalskii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	+	1	1	r	+	1
Nitraria sphaerocarpa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Calligonum mongolicum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.
Stipa glareosa	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.
Sympegma regelii	.	.	.	.	.	1	1	.	1	.	.	.	.	2	+	.	.	.	.	.	.	.	.	.	+	.	.	.
Krascheninnikovia ceratoides	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Ajania achilleoides	.	.	.	.	.	+	+	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Zygophyllum xanthoxylon	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.
Salsola arbuscula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	+	.	2
Nitraria sibirica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2	.	.	.	.	.	.	.	.
Artemisia xerophytica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	+
Artemisia scoparia	.	.	.	.	.	.	.	.	.	.	1	+	.	1	1	+	+	.	.	.	.	.	.	.	.	+	.	.
Artemisia demissa	.	.	.	.	.	+	+	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bassia dasyphylla	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.
Ptilotrichum canescens	.	.	.	.	.	.	.	+	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	+	.	.
Micropeplis arachnoidea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	1	.	.	.	.	.	1
Zygophyllum potaninii	.	.	.	.	.	.	.	.	.	+	.	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.

Additional:

ad 9: *Enneapogon borealis* (r)
ad 10: *Arnebia fimbriata* (r), *Astragalus brachybotrys* (r)
ad 14: *Arnebia guttata* (r)
ad 15: *Dontostemon senilis* (r)
ad 16: *Cancrinia discoidea* (+), *Rheum nanum* (+)
ad 18: *Allium mongolicum* (+)
ad 19: *Anabasis brevifolia* (+)
ad 21: *Corispermum mongolicum* (1)
ad 25: *Zygophyllum gobicum* (r)
ad 26: *Salsola collina* (+)

Table 10
Calligono mongolici-Haloxyletum ammondendronis: *Nitraria sphaerocarpa* sub-association (running no. 1–9); *Reaumuria songarica* sub-association (running no. 10–18); *Kalidium gracile* sub-association (running no. 19–24)

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Relevé no.	H39	W158	H49	W158	H63	W22	W219	W211	W13	W14	W140	W64	W32	W8	H12	H12a	W200	W43	W17	H34	H34a	H34e	H34d	H67
Haloxylon ammodendron	1	1	2	1	+	1	1	1	1	1	1	1	+	2	2	2	+	1	2	1	1	+	+	+
Reaumuria songarica	.	.	.	.	+	.	1	+	+	2	1	1	2	1	2	2	2	2	2	2	2	3	3	+
Ephedra przewalskii	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	+	.	.	.	.	.	.
Nitraria sphaerocarpa	+	+	+	+	2	1	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kalidium gracile	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	1	1	+
Calligonum mongolicum	+	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+	.
Stipa glareosa	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Sympegma regelii	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	.
Krascheninnikovia ceratoides	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Ajania achilleoides	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Anabasis brevifolia	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Zygophyllum xanthoxylon	1	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Potaninia mongolica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Salsola arbuscula	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Nitraria sibirica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	1	1	+	1	.
Artemisia demissa	+	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bassia dasyphylla	.	.	+	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	.
Arnebia fimbriata	+	+	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astragalus brachybotrys	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Astragalus grubovii	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micropeplis arachnoidea	.	.	.	r	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.

Additional:

ad 2: *Allium mongolicum* (+)
ad 3: *Asterothamnus centrali-asiaticus* (+)
ad 12: *Halimodendron halodendron* (1)
ad 14: *Arnebia guttata* (r)
ad 18: *Zygophyllum potaninii* (r)
ad 24: *Corispermum mongolicum* (1)

Table 11
Reaumuria songarica-Nitraria sphaerocarpa community (running no. 1–5); *Reaumuria songarica*

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13
Relevé no.	H63a	W237	H63	W24	W25	H40	H40a	W126	W149	W125	W34	H6d	H6e
Nitraria sphaerocarpa	2	1	2	1	1	.	.	.	.	.	.	.	.
Reaumuria songarica	+	+	+	2	1	2	2	1	1	1	1	2	1
Iljinia regelii	.	.	.	.	.	.	.	.	.	.	.	.	.
Haloxylon ammodendron	+	.	.	.	.	.	.	.	.	.	+	.	.
Ephedra przewalskii	.	.	.	.	.	+	.	.	.	.	.	.	.
Anabasis brevifolia	+	.	+	.	.	.	.	.	.	.	.	.	.
Calligonum mongolicum	.	.	.	.	.	.	.	.	.	.	.	.	.
Sympegma regelii	.	.	.	.	2	.	.	.	1	+	1	+	.
Zygophyllum xanthoxylon	+	.	+	.	.	.	.	.	.	.	.	.	.
Artemisia scoparia	.	.	.	.	.	.	.	.	.	.	.	.	.
Cancrinia discoidea	.	.	.	.	.	.	.	.	.	.	.	.	.
Micropeplis arachnoidea	.	.	+	.	.	.	.	.	.	.	.	.	.
Bassia dasyphylla	.	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia demissa	+	.	+	+	r	.	.	.	.	.	.	.	.

Additional:

ad 1: *Krascheninnikovia ceratoides* (1), *Salsola arbuscula* (1), *Stipa glareosa* (+)
ad 3: *Salsola arbuscula* (1), *Krascheninnikovia ceratoides* (1), *Stipa glareosa* (+), *Carex* sp. (+)
ad 5: *Lepidium densiflorum* (+)
ad 12: *Zygophyllum gobicum* (r), *Salsola tragus* (+)
ad 13: *Zygophyllum gobicum* (+), *Zygophyllum rosovii* (+)
ad 18: *Arnebia guttata* (r)
ad 24: *Zygophyllum pterocarpum* (r)
ad 31: *Tribulus terrestris* (1), *Salsola collina* (+)

dominance stands (running no. 6–13); *Iljinia regelii* community (running no. 13–33)

14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
W226	W99	W213	W227	W146	W67	W137	W135	W215	W82	W136	W100	W80	W139	W216	W217	W137	W144	W131	W132
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Table 12
Phragmitetum communis (running no. 1–7); *Leymus* cf. *paboanus* community (running no. 8–13); *songarica* sub-association (running no. 27–39); Sophoro alopecuroidis-Populetum euphraticae (running

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Relevé no.	W86	W20	H6b	H6c	W1	H6a	W85	H8	H57	H38a	H35	H35a	H8a	W206	H46	H46a	H46b	H46c	W96
Phragmites australis	4	2	2	2	1	2	3	+	.	+	1	1	1	.	2	3	3	2	.
Reaumuria songarica	.	.	1	2	2	2	.	+	.	.	.	.	.	.	.	.	.	.	.
Leymus cf. *paboanus*	.	.	.	.	.	.	.	2	3	2	4	4	2	.	.	.	.	.	.
Populus euphratica-tree layer	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	4	3	3	4
Populus euphratica-shrub layer	.	.	+	.	.	.	.	.	.	.	.	.	.	2	1	+	.	+	.
Glycyrrhiza uralensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	1	2	.
Tamarix ramosissima	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	1	.
Nitraria sibirica	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kalidium gracile	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.
Achnatherum splendens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Elymus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.
Lycium ruthenicum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	2	.
Lactuca tatarica	.	r	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	.
Saussurea grubovii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.
Lepidium latifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Nitraria roborovskii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	.
Clematis glauca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	.
Haloxylon ammodendron	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sophora alopecuroides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peganum nigellastrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lepidium cordatum	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.
Glaux maritima	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.
Kalidium foliatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Additonal:

ad 1: *Scorzonera mongolica* (r), *Elymus sibiricus* (3)
ad 4: *Echinops gmelinii* (r)
ad 7: *Triglochin maritimum* (1), *Salicornia europaea* (1), *Bolboschoenus popovii* (1), *Scirpus* sp.(1)
ad 9: *Potentilla anserina* (+), *Oxytropis glabra* (1), *Carex enervis* (3), *Potentilla dealbata* (3), *Artemisia* sp. (+)
ad 15: *Sphaerophysa salsula* (2)
ad 18: *Acroptilon repens* (+), *Sympegma regelii* (+)
ad 25: *Artemisia xanthochroa* (+), *Kalidium foliatum* (+)

Glycyrrhizo uralensis-Populetum euphraticae, typical sub-association (running no. 14–26) and *Reaumuria* no. 40 + 41); Glycyrrhizo uralensis-Achnatheretum splendentis (running no. 42–46)

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
W	W	W	W	W	H	H	W	W	H	H	H	W	W	W	W	W	W	W	W	H	H	H	H	H	H	H
2	1	9	1	2	4	4	1	2	7	7	7	1	1	8	9	8	1	1	9	6	6	3	3	3	3	3
1	3	3	9	0	7	7	4	1		a	b	9	4	4	2	3	9	9	1	0	0	3	3	3	3	3
2	0		6	7		a	2					9	7				5	8		a	b		a	b	c	d
2	2	3	.	.	2	3	2	1	2	2	2	.	3	.	.	.	.	.	.	.	.	2	3	3	3	4
.	.	.	.	.	.	.	+	2	+	+	1	1	1	+	1	+	+	+	1	.	.	+	.	+	.	.
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4	3	3	5	1	3	2	1	2	2	1	2	3	3	5	3	3	5	5	3	3	4	.	.	.	.	.
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ad 26: *Asparagus trichophyllus* (1), *Cynanchum sibiricum* (2)
ad 28: *Caragana leucophloea* (1)
ad 32: *Zygopyllum xanthoxylon* (+), *Micropeplis arachnoidea* (+)
ad 39: *Cistance* sp. (+)
ad 42: *Elymus* cf. *secalinus* (+)
ad 45: *Acroptilon repens* (+), *Scorzonera* cf. *gobica* (+)
ad 46: *Asparagus trichophyllus* (+), *Scorzonera* cf. *gobica* (+)

Table 13
Tamarix ramosissima community; typical sub-community (1–15), *Reaumuria songarica* sub-community (16–22)

Running no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Relevé no.	H 4	H 4 c	W 2 3 6	W 1 0 3	W 1 9 4	W 8 7	W 2 0 8	H 3 7	H 3 7 a	H 4 5	W 2 0 5	W 1 0 4	H 7	W 3 7	W 1 9 3	H 4 1	H 1 3	H 1 3 a	H 1 3 b	H 3 7 b	W 9 5	W 1 5
Tamarix ramosissima	5	5	2	5	1	5	4	4	4	5	1	2	2	1	1	4	3	3	2	4	3	3
Reaumuria songarica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	+	+	+	+	2	1
Ephedra przewalskii	.	.	1	+	.	.	.	.	.	.	+	+	1	1	.	.	+	+	+	.	1	.
Sympegma regelii	.	.	+	.	.	.	.	.	.	.	.	1	1	+	.	.	1	+	1	.	.	.
Atraphaxis pungens	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Ajania achilleoides	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.
Rheum nanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Zygophyllum xanthoxylon	.	.	1	r	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Artemisia scoparia	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Calligonum mongolicum	.	.	2	.	.	.	.	.	.	.	1	.	.	.	.	.	+	+	+	.	.	.
Nitraria sphaerocarpa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Kalidium foliatum	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	1	+	.	.	.
Peganum nigellastrum	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Nitraria sibirica	2	+	.	.	.	.	.	1	2	.	+	.	.	.	.	1	.	.	.	1	.	.
Phragmites australis	.	.	.	.	.	.	.	2	1	+	.	.	.	.	.	.	.	.	.	2	.	2
Kalidium gracile	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Haloxylon ammodendron	.	.	.	.	.	1	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	.
Artemisia xanthochroa	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.
Micropeplis arachnoidea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.
Elymus sp.	1	1	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Glycyrrhiza uralensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1

Additional:

ad 2: *Dontostemon elegans* (+)
ad 4: *Artemisia dracunculus* (+)
ad 10: *Lepidium latifolium* (+), *Acroptilon repens* (+)
ad 12: *Lepidium densiflorum* (+), *Lactuca tatarica* (+), *Asterothamnus centrali-asiaticus* (+)
ad 16: *Limonium aureum* (+), *Achnatherum splendens* (+), *Lycium ruthenicum* (1), *Tamarix* sp. (1)

Table 14
Blysmetum rufi

Running no.	1	2	3
Relevé no.	H 5 6	H 5 6 a	W 1 9 7
Blysmus rufus	2	1	3
Potentilla anserina	1	2	2
Glaux maritima	1	2	2
Triglochin maritima	1	1	.
Triglochin palustre	+	1	+
Halerpestes salsuginosa	1	1	2
Taraxacum dealbatum	+	+	.
Carex vesicata	1	2	.
Calamagrostis macilenta	1	1	.
Juncus gerardii	.	1	.
Poa tibetica	.	1	.
Panicum sp.	.	.	2
Salicornia perennis	.	.	1
Eleocharis sp.	4	4	2