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Plant communities of the summits of the Dund Saykhan mountain range (Southern Mongolia)

Henrik von Wehrden & Heike Zimmermann

Abstract

WEHRDEN, H. VON & H. ZIMMERMANN (2009). Plant communities of the summits of the Dund Saykhan mountain range (Southern Mongolia). *Candollea* 64: 49-67. In English, English and French abstracts.

The vegetation of the summits of the Dund Saykhan mountain range (Southern Mongolia) has been assessed. The existing literature is set in context to the randomly examined relevés, presenting a detailed description of the montane vegetation of one of the core zones of the Gobi Gurvan Saykhan National Park. Two new associations, *Junipero sabinae-Thalictetrum foetidii* and *Arenario meyeri-Festucetum valesiacae,* and one regional sub-association, *Papaver croceum-Artemisia pycnorrhiza,* are described. The ecology of all associations and communities is related to their occurrence in the study area and the accompanying surrounding environmental characteristics. The landscape is dominated by *Festuca valesiaca* Rchb. Steppes. The southern slopes are covered by large *Juniperus* L. patches and, at similarly disturbed sites, *Artemisia santolinifolia* Bess. dominance stands are common. In contrast, the northern exposures are covered by a mosaic of dense mats of *Kobresia* Willd. and *Festuca valesiaca* rock steppes.

Key-words

Mongolia – Mountain steppes – Phytosociology – Vegetation

Résumé

WEHRDEN, H. VON & H. ZIMMERMANN (2009). Les communautés végétales des sommets de la chaîne de montagne Dund Saykhan (Mongolie du Sud). *Candollea* 64: 49-67. En anglais, résumés anglais et français.

La végétation des sommets de la chaîne de montagnes Dund Saykhan (Mongolie du Sud) a été évaluée. La littérature existante est mise en rapport avec les relevés aléatoires examinés, en présentant une description détaillée de la végétation de montagne de l'une des zones centrales du Parc National de Gobi Gurvan Saykhan. Deux associations nouvelles, *Junipero sabinae-Thalictetrum foetidii* et *Arenario meyeri-Festucetum valesiacae,* et une sous-association régionale, *Papaver croceum-Artemisia pycnorrhiza,* sont décrites. L'écologie de toutes les associations et communautés a été mise en relation avec leur présence dans la zone étudiée et les caractéristiques des caractéristiques environnementales environnantes. Le paysage est dominé par des steppes de *Festuca valesiaca* Rchb. Les pentes exposées au sud sont couvertes de grandes parcelles de *Juniperus* L., et dans des zones similaires perturbées, la dominance d'*Artemisia santolinifolia* Bess. est commune. En revanche, les zones exposées au nord sont couverts d'une mosaïque de denses tapis de *Kobresia* Willd. et de steppes rocheuses composées de *Festuca valesiaca.*

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Introduction

The Gobi Gurvan Saykhan National Park encompasses some of the isolated mountain chains, which elongate the Mongolian Altay into the Gobi. These mountains were visited some 100 years ago by a Russian expedition (KOZLOFF, 1902), which expressed the richness of the pastures. The vegetation of the Gobi Gurvan Saykhan National Park was recently described by WESCHE & al. (2005a), who recorded the vegetation of the whole National Park, which was set into context to a nationwide description of the plant communities (HILBIG, 2000). A vegetation map (1:100000) was derived based on the same dataset (WEHRDEN & al., 2006); due to its limited resolution however only two vegetation units for the regions assessed were represented in that paper. A detailed account on the vegetation of the southern lower slopes of the middle chain of the Gobi Gurvan Saykhan – the Dund Saykhan – is available (WESCHE & RONNENBERG, 2004) and focuses on the montane *Juniperus sabina* and *Artemisia santolinifolia* stands south of the main peak. However some vegetation units (e.g. mats of *Kobresia* Willd.) are restricted to northern slopes within the Gobi Altay, and available descriptions are based on only a few relevés (WESCHE & al., 2005a). These ranges have the highest productivity in the Gobi desert (WEHRDEN & WESCHE, 2007a) and the highest biodiversity within all protected areas of the southern Mongolian Gobi, which taken together equal an area of almost 100000 km² (WEHRDEN & WESCHE, 2007b). The unique flora of the summit region of the Gobi Gurvan Saykhan mountain ranges is in stark contrast with that of the semi-desert surroundings (ANONYMOUS, 1990; WEHRDEN & al., 2006) and hosts many elements that are not found elsewhere in the Gobi (JÄGER, 2005). Only some few endemics are found in Mongolia (GRUBOV, 1989), yet most of these are restricted to suchlike montane environments (GUBANOV, 1996; GRUBOV, 2001; WESCHE & al., 2005b). We therefore believe that the differentiation of the vegetation of these summit regions need to be examined with a higher sampling density (especially on the northern slopes), and the syntaxonomic placement of the vegetation types needs to be clarified.

Our focus area -the Dund Saykhan- is one of the core zones of the Gobi Gurvan Saykhan National Park, which incorporates grazing grounds for several nomadic families (BEDUNAH & SCHMIDT, 2004). Within this paper we attempt to provide a comprehensive description of the plant communities of one of the central peaks of the region (> 2500 m) as well as an interpretation of the environmental background and a review of the available vegetation descriptions (ANONYMOUS, 1990; HILBIG, 1990, 1995, 2000; WESCHE & RONNENBERG, 2004; WESCHE & al., 2005a).

Material and methods

Studied area

The Gobi Gurvan Saykhan mountain range represents the easternmost outpost of the Altay. The relief of the mountains is predominantly characterized by metamorphic rocks; physical erosion results in steep slopes and shallow soils, which are at initial stages of the pedogenesis.

Reaching almost 3000 m, the montane region gains twice as much rain as the surrounding semi-desert (RETZER, 2004; WEHRDEN & WESCHE, 2007a). The cold winters contrast with hot summers, which is typical for this highly continental area (WEISCHET & ENDLICHER, 2000). Precipitation is mainly restricted to the vegetation period and snow is a rare phenomenon (see HIJMANS & al., 2005). However, mould damage on juniper stands indicates accumulation of drifting snow (WESCHE & al., 2005a).

Another important ecological factor are the pronounced differences within mountain sites due to aspect, which is known as one of the most important influences governing vegetation distribution in our study area (KOZLOFF, 1902; OPGENOORTH & al., 2005).

Methods

In order to sample a representative set of relevés a randomized design was chosen, since subjectively selected plots are known to introduce biases (CHYTRY, 2001): 100 plots were placed within the 2 × 2 km summit region (Fig. 1) by using the Hawth-tools plug-in within the Arc-map environment (Version 8.2).

Plot setting was corrected for the slope based on SRTM-data (JARVIS & al., 2006) to cover the actual surface of this montane environment. Sampling was based on a modified Braun-Blanquet approach. All plots were 3 × 3 metres in size, which is sufficient within this montane environment (DIERSCHKE, 1994). All higher plants were recorded with percentage accuracy. Plant determination and nomenclature was based on two standard flora volumes (GRUBOV, 2001), with modifications and revised determination keys inferred from GUBANOV (1996), FRIESEN (1995) and GRUBOV (2000) (e.g. merging *Poa attenuata & P. stepposa).* Standard environmental parameters were taken according to MUCINA & al. (2000).

The primary data table was compiled in Tabwin and imported into the Juice-package (TICHY, 2002). Initial data organization was aided by a cluster-analysis (Wards method, see LEGENDRE & LEGENDRE, 1998) using the Pcord-link; our final sorting did however slightly differ from this automated classification, as some plots were rather heterogeneous in the context of the complete dataset.

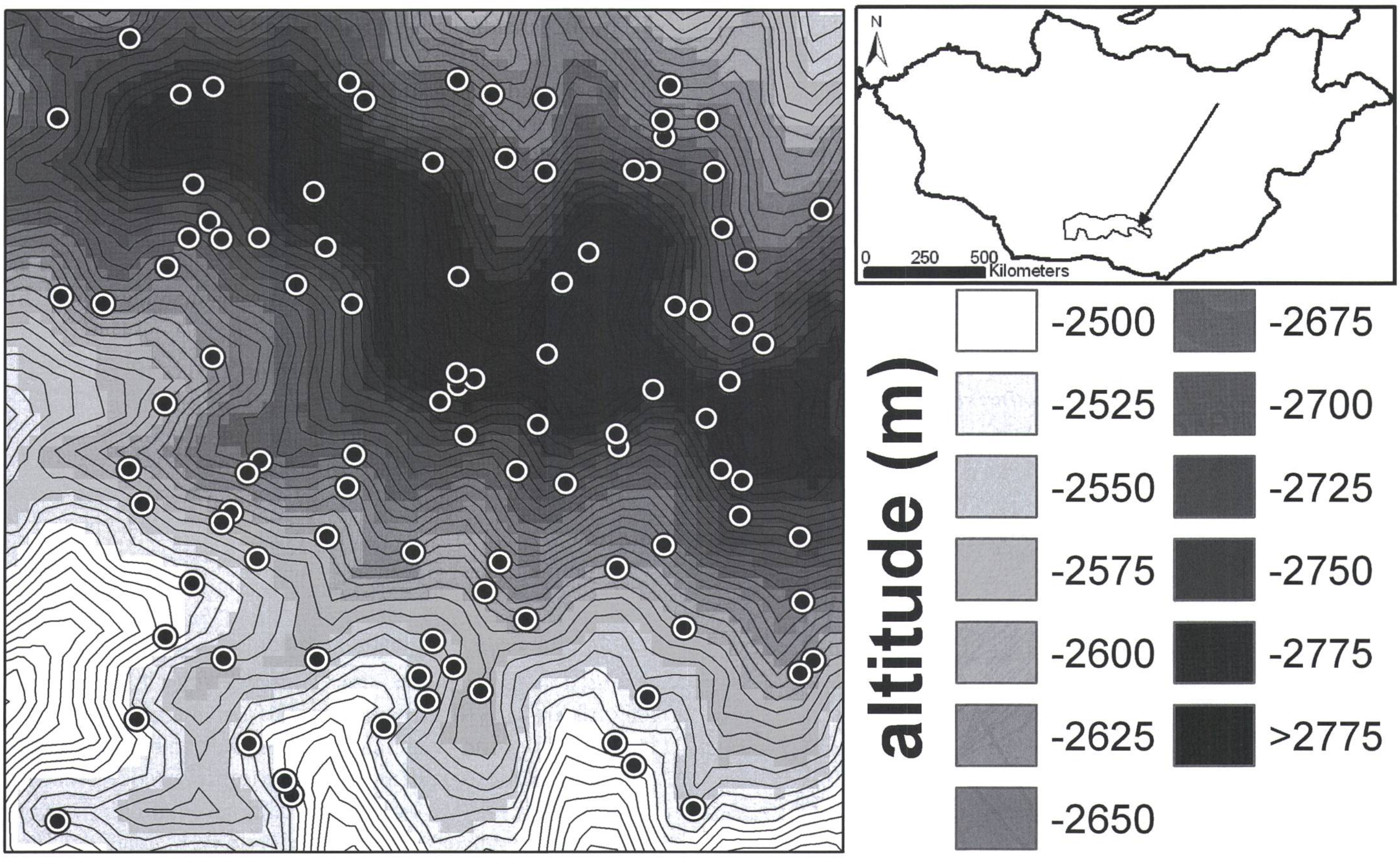

Fig. 1. – Location of the studied area (arrow) in southern Mongolia and overview of the working area. Altitude was obtained from SRTM-data, each circle indicates a plot.

The environment of the plant communities was described by Box & Whisker plots. Species-area curves were computed in order to quantify the plant biodiversity of the communities. All plots were made using the R software (R DEVELOPMENT CORE TEAM, 2008).

Results and discussion

Introduction

Due to a differing nomenclature (ZEMMRICH, 2005) and the use of both physiognomic and phytosociological terms, a short note on the general labelling of the vegetation seems necessary. The Russian literature names the vegetation of these mountains "moderate dry steppes" (ANONYMOUS, 1990), which is somewhat confusing without further knowledge on drier or moister vegetation. Thus, either "mountain steppes" or "desert steppes" seems more appropriate; the latter term may however contain a slight contradiction (see EITEN, 1992) since "desert" would refer to contracted vegetation typical for lower elevation within the region (WEHRDEN & al., 2006). "Alpine steppes" is abundantly used, but is misleading and should be restricted to the *Kobresia*-due to the middle-European origin of the term "alpine", which is derived for description of the vegetation of the Alps. The stands of *Juniperus* can be consequently named "montane scrubland". We have therefore named the grass/herb dominated vegetation "mountain steppes", while the vegetation dominated by woody species is referred to as "montane scrublands".

Description of plant communities

All the species observed may be found in Table 1. A phytosociological conspectus follows, with the plant communities described and presented (C: class; O: order; L: alliance; A: association)

C: *Juniperetea pseudosabinae* Mirkin & al. 1986
- O: *Juniperetalia pseudosabinae* Mirkin & al. 1986
  - L: *Juniperion pseudosabinae* Mirkin & al. 1986
    - **A: 1. *Junipero sabinae-Thalictetrum foetidii***
    - **2. *Artemisia santolinifolia* communities** (placement unclear)
      - **3. *Festuca valesiaca* sub-community** of the *A. santolinifolia* community dominance stands

C: *Carici rupestris-Kobresietea bellardii* Ohba 1974
- O: *Kobresietalia myosuroidis* Mirkin & al. (1983) 1986
  - L: *Kobresion myosuroidis* Mirkin & al. 1983 em. Hilbig 2000
    - **A: 4. *Kobresietum myosuroidis*** Hilbig 2000
      - **4. *Papaver croceum-Artemisia pycnorrhiza***

C: *Agropyretea cristati* Hilbig & Koroljuk 2000
- O: *Stipetalia krylovii* Kononov, Gogoleva & Mironova 1985
  - L: *Stipion krylovii* Kononov, Gogoleva & Mironova 1985
    - A: *Hedysaro pumili-Stipetum krylovii* Hilbig (1987) 1990 corr. 1995
    - **A: 5. *Arenario meyeri-Festucetum valesiacae, Papaver croceum-Artemisia pycnorrhiza* variant** (placement unclear)
    - **A: 6. *Arenario meyeri-Festucetum valesiacae*** (including the *Stellaria petraea* sub-association of the *Hedysaro-Stipetum* (Hilbig, 2000; Wesche & al., 2005a)

C: *Nepeto sibiricae-Urticetea cannabinae* Hilbig 2000
- O: *Nepeto sibiricae-Urticetalia cannabinae* Hilbig 2000
  - L *Nepeto sibiricae-Urticion cannabinae* Hilbig 2000
    - **A: 7. Nepeto sibiricae-Urticetum cannabinae** Hilbig (1987) 1990

1. *Junipero sabinae-Thalictetrum foetidii,* ass. nov. hoc loco (Table 2; unit 1 in Fig. 2 & Fig. 3)

Juniper builds impressive stands which diverge from the surrounding mountain steppes due to their high shrub cover. Stands are distributed throughout a lower belt within the working area (see Fig. 2 & 3A), since snow may limit the plant at the higher elevations (Wesche & al., 2005a).

These clonally growing patches (Wesche & al., 2005c) are mainly restricted to southern exposures (Fig. 3C), where they generally occur on steeper slopes (Fig. 3B). The litter accumulation results in high calcium and potassium values (Wesche & Ronnenberg, 2004). Since *Juniperus* dominates these montane scrublands, and the number of species is comparably low (Fig. 3G), the high cover values of the shrub layer (median = 55%) lead to even lower Shannon index values (Fig. 3H). The most prominent accompanying species is *Artemisia santolinifolia* while other abundant species indicate the montane habitat parameters of the stands (e.g. *Agropyron cristatum, Artemisia frigida, Polygonum alpinum). Thalictrum foetidum* occurs within all our relevés, and was likewise recorded as an abundant companion by Wesche & Ronnenberg (2004) and Wesche & al. (2005a). Although it is found in the surrounding vegetation as well, it can be judged as a regional character species of the Juniperetum described by Hilbig (2000). We suggest a regional association *(Junipero sabinae-Thalictetrum foetidii),* with *Juniperus sabina* and *Thalictrum foetidum* as character species. For the time being these stands will be included into the *Juniperion pseudosabinae,* although a systematic revision and more data may lead to the designation of an individual alliance. The type relevé is running no. 3 within Table 2.

2. *Artemisia santolinifolia* dominance stands (Table 3, running number 1-21; unit 2 in Fig. 2 & Fig. 3)

Two communities dominated by *Artemisia santolinifolia* can be distinguished within our working area (Fig. 2). The first one *(A. santolinifolia* dominance stands) is, like the previous association, mainly restricted to southern slopes (Fig. 3C); however with a lower inclination (Fig. 3B) yet at higher altitudes than the juniper stands. Although Wesche & Ronnenberg (2004) underlined the comparable habitat of both shrubs, our data suggests *A. santolinifolia* stands are more open compared to the juniper stands (see Fig. 3F). *Artemisia santolinifolia* is a typical disturbance indicator within High and Central Asia (Miehe & al., 2002), thus it is often associated with small mammal burrows (Wesche & al., 2007). Comparable stands are described for the Ikh Bogd located at a distance of some 250 km (Hilbig, 1990).

Table 1. – List of all the plant species observed in the studied area.

Achnatherum inebrians (Hance) Keng	*Crepis flexuosa* C. B. Clarke	*Poa altaica* Trin.
Agropyron cristatum (L.) Gaertn.	*Dontostemon integrifolius* Ledeb.	*P. attenuata* Trin.
Ajania achilleoides Grubov	*Dracocephalum foetidum* Bunge	*P. botryoides* Bess.
A. fruticulosa (Ledeb.) Poljakov	*Elymus sp.* L.	*Polygonum alpinum* All.
Allium altaicum Pall.	*Ephedra monosperma* C. A. Mey.	*P. angustifolium* Pall.
A. eduardii Stearn	*Eritrichium pauciflorum* DC.	*P. aviculare* L.
A. prostratum Maxim.	*Festuca lenensis* Drobow	*Potentilla bifurca* L.
A. tenuisissimum Habl.	*F. ovina* L.	*P. conferta* Bunge
Amblynotis rupestris (Pall.) Popov	*F. valesiaca* Rchb.	*P. ikonnikovii* Juz.
Androsace dasyphylla Bunge	*Galium verum* L.	*P. multifida* L.
A. maxima L.	*Gentiana barbata* Froel.	*P. nivea* L.
A. septentrionalis L.	*G. decumbens* L. f.	*P. sericea* L.
A. incana Lam.	*Hedysarum gmelinii* H. C. Fu	*Potentilla sp.*
Arabis rupicola Krylov	*Helictotrichon schellianum* (Korsh.) Kitag.	*Primula sp.*
Arenaria meyeri Edgew. & Hook. f.	*Heteropappus altaicus* Novopokrov.	*Ptilotrichum canescens* (DC.) C. A. Mey.
Arnebia fimbriata Maxim.	Iris potaninii Maxim.	*Ranuculus pedatifidus* Sm.
Artemisia dolosa Krasch.	*Iris sp.*	*Rheum undulatum* L.
A. frigida Willd.	*Isatis costata* C. A. Mey.	*Rhinactinidia eremophila* Botsch.
A. phaeolepis Krasch.	*Juniperus sabina* L.	*Salsola collina* Pall.
A. pycnorrhiza Ledeb.	*Kobresia humilis* (Trautv.) Serg.	*Saussurea pricei* N. D. Simpson
A. rutifolia Spreng.	*K. myosurioides* Fiori & Paoletti	*S. saichanensis* Lipsch.
A. santolinifolia Bess.	*Koeleria altaica* (Domin) Krylov	*S. lipschitzii* Filat.
Artemisia sp.	*K. cristata* Pers.	*Saxifraga sibirica* L.
A. tanacetifolia L.	*K. macrantha* (Ledeb.) Schult.	*Sedum aizoon* L.
Aster alpinus L.	*Lagotis integrifolia* (Willd.) Schischk.	*Senecio dubitabilis* C. Jeffrey & Y. L. Chen
Astragalus brachybotrys Bunge	*Leontopodium ochroleucum* Beauverd	*Seseli eriocarpum* B. Fedtsch.
A. brevifolius Ledeb.	*Limonium flexuosum* Kuntze	*Seseli sp.*
A. miniatus Bunge	*Lonicera microphylla* Schult.	*Sibbaldianthe adpressa* (Bunge) Juz.
Astragalus sp.	*Lophanthus chinensis* Benth.	*Silene jenisseensis* Willd.
Axyris hybrida L.	*Melandrium brachyopetalum* (Hornem.) Fenzl	*S. repens* Patrin
A. prostrata L.	*Nepeta sibirica* L.	*Smelovskia alba* B. Fedtsch
Bupleurum bicaule Helm	*Orobanche coerulescens* Stephan	*Stellaria cherleria* F. N.Williams
B. pusillum Krylov	*Orostachys spinosa* Sweet	*S. dichotoma* L.
Carex korshinskyi Kom.	*Oxytropis bungei* Komarov	*S. gypsophiloides* Fenzl
C. pediformis C. A. Mey.	*O. chionophylla* Royle	*S. petraea* Bunge
C. stenophylla Boott	*O. gebleri* Bunge	*Stipa krylovii* Roshev.
Cerastium arvense L.	*O. pumila* Ledeb.	*Taraxacum dissectum* Ledeb.
Chamaerhodos sabulosa Bunge	*O. tragacanthoides* DC.	*Taraxacum sp.*
Chenopodium "album" L.	*Papaver croceum* Ledeb.	*Thalictrum foetidum* L.
C. hybridum L.	*Pedicularis abrotanifolia* Steven	*Thymus gobicus* Tscherneva
C. prostratum Moq.	*P. flava* Pall.	*Vicia costata* Ledeb.
C. vulvaria L.	*Peucedanum hystrix* Bunge	*V. multicaulis* Ledeb.
Clausia aprica Trotzky	*Phleum sp.*	*Youngia tenuicaulis* (Babc. & Stebbins) Czerep.
Clematis sp.	*Phlojodicarpus sibiricus* Koso-Pol.	*Y. tenuifolia* (Willd.) Babc. & Stebbins
Crepis crocea Rchb.	*Plantago depressa* Willd.	

Table 2. – *Juniperetum sabinae-Thalictetrum foetidii* ("r" = rare; "+" = less than 1 %; "1" = 1-4 %; "2" = 5-24 %; "3" = 25-49 %; "4" = 50-74 %; "5" = 75-100 %).

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Relevé number	**54**	**28**	**79**	**67**	**2**	**55**	**50**
Juniperus sabina	2	4	5	4	+	4	1
Thalictrum foetidum	+	1	+	+	+	2	+
Artemisia santolinifolia	2	2	1	2	+	2	+
Agropyron cristatum	+	2	+	1	+	+	1
Stipa krylovii	–	–	–	–	+	–	–
Artemisia frigida	–	+	–	–	+	–	+
Arenaria meyeri	–	–	–	–	+	–	2
Ptilotrichum canescens	+	–	–	–	–	–	r
Lophanthus chinensis	–	+	–	–	+	–	–
Polygonum alpinum	–	–	–	+	r	r	r
Chenopodium prostratum	–	–	–	+	r	r	–
Rheum undulatum	–	–	–	–	r	r	–
Allium tenuisissimum	–	–	–	–	–	+	r
Thymus gobicus	–	–	–	–	+	–	r
Festuca valesiaca	–	–	–	–	–	–	r

ad 1: *Ajania fruticulosa, Lonicera microphylla*
ad 4: *Arabis rupicola, Axyris prostrata, Artemisia rutifolia*
ad 5: *Aster alpinus, Axyris hybrida, Chamaerhodos sabulosa, Galium verum, Potentilla multifida, Limonium flexuosum, Orostachys spinosa, Saussurea pricei, Youngia tenuifolia*
ad 6: *Allium altaicum, Chenopodium vulvaria, Silene repens*
ad 7: *Bupleurum bicaule, Ephedra monosperma, Iris sp., Oxytropis pumila, Phlojodicarpus sibiricus, Poa attenuata, Potentilla sericea*

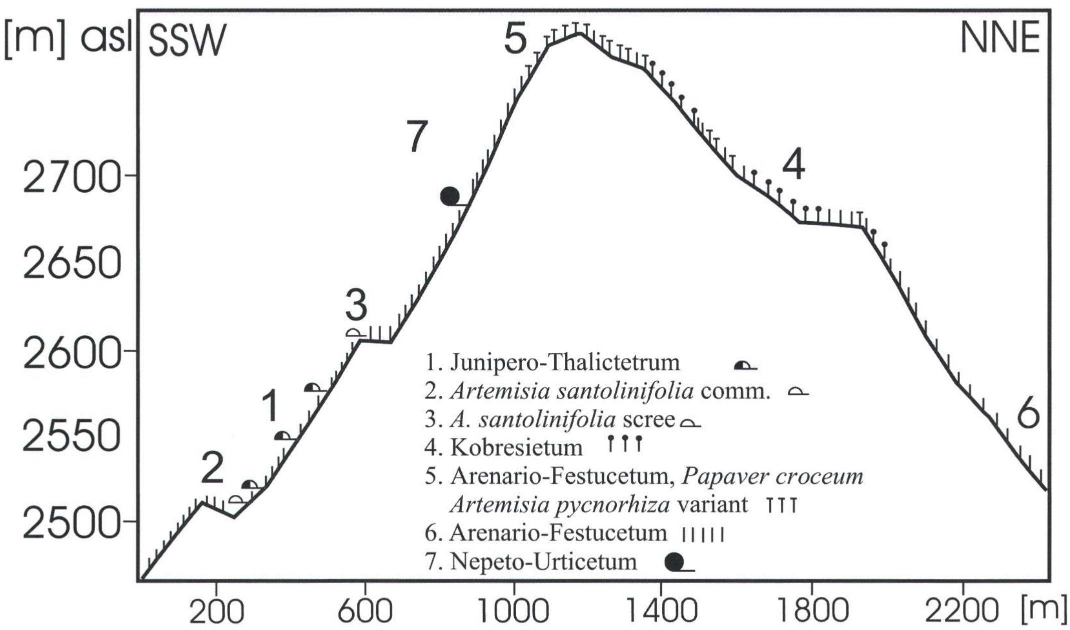

Fig. 2. – Profile of the Dund Saykhan peak region and the distribution of the vegetation. Numbers refer to the 'units' described in the text.

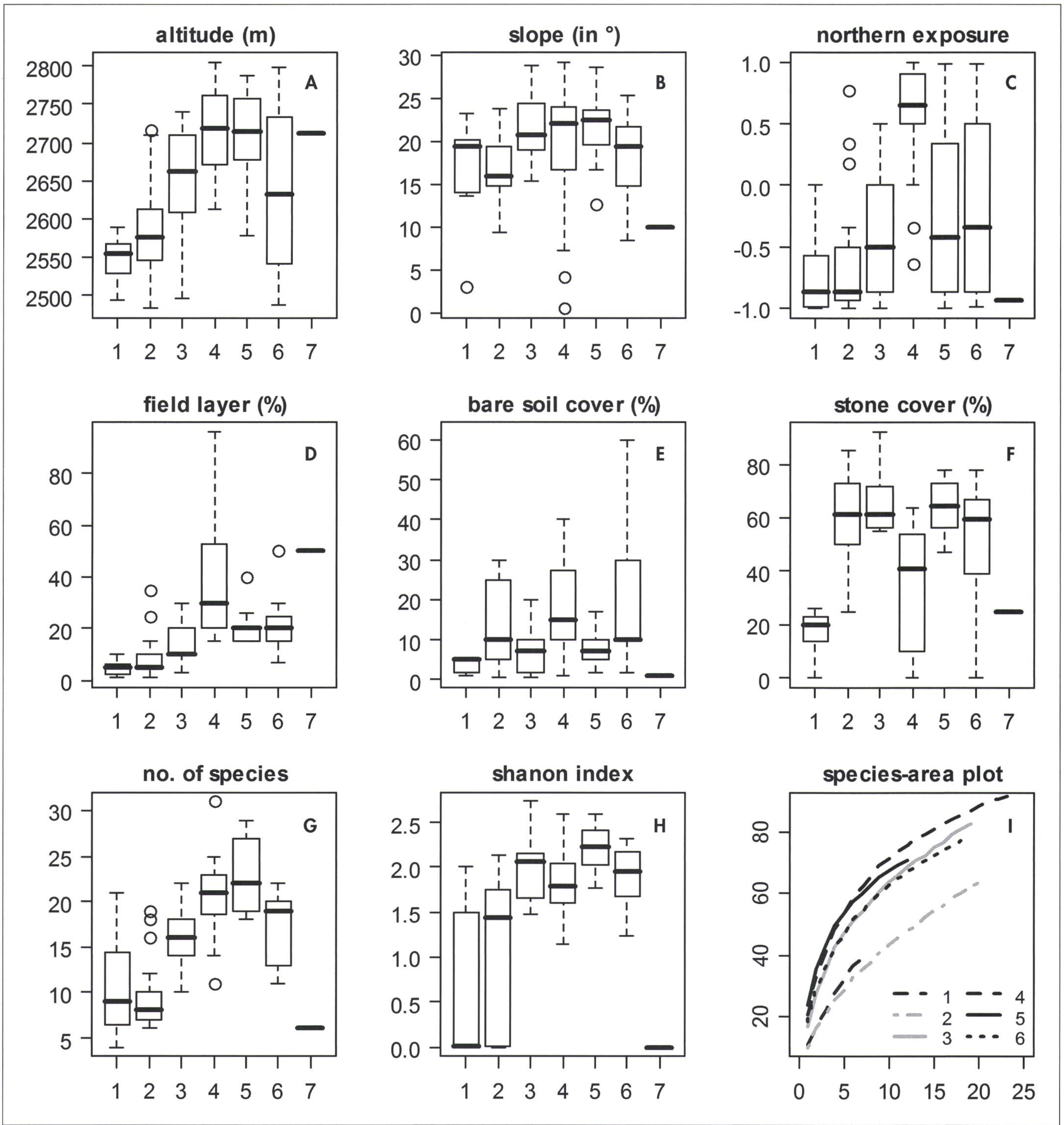

Fig. 3. – Boxplots summarising important environmental characteristics of the plant communities described in the text (boxes give the interquartile range, medians are indicated by a horizontal line). **A.** Altitude [m]; **B.** Slope [°]; **C.** Northern exposure, derived from the aspect by calculating the cosine; **D.** Cover of the field layer [%]; **E.** Cover of the bare soil [%]; **F.** Cover of the stone layer [%]; **G.** Number of species; **H.** Shannon index (fig. A-H: the x-axis enumeration refer to the vegetation units described in the text); **I.** Species area curves for the plant communities (unit 7 not included) (the x-axis gives the number of relevés; the number in the lower-right legend correspond to the vegetation units).

Table 3. – *Artemisia santolinifolia* dominance stands. Relevés 1-21 are the typical sub-community, relevés 22-36 are stands of the *Festuca valesiaca*

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Relevé number	**58**	**15**	**18**	**23**	**36**	**37**	**41**	**7**	**17**	**53**	**76**	**75**	**14**	**4**	**44**	**49**
Artemisia santolinifolia	+	2	2	1	2	2	1	+	+	2	2	2	2	1	2	2
Festuca valesiaca	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polygonum alpinum	–	–	–	–	–	–	–	–	–	–	–	r	r	+	+	1
Potentilla sericea	–	–	–	–	–	–	r	+	r	r	–	–	–	–	–	–
Poa attenuata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r
Limonium flexuosum	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Rhodiola rosea	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ephedra monosperma	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Clausia aprica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phlojodicarpus sibiricus	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Artemisia phaeolepis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rheum undulatum	r	–	–	–	–	–	–	–	–	–	–	–	–	2	–	+
Chenopodium prostratum	–	r	–	r	r	r	–	–	r	–	r	r	–	–	–	r
Thalictrum foetidum	–	–	–	–	–	–	r	–	r	–	–	+	+	–	–	+
Allium tenuisissimum	–	r	–	+	r	–	–	r	r	–	–	r	–	–	–	–
Agropyron cristatum	–	2	+	1	–	1	+	r	1	1	+	r	+	–	1	r
Arenaria meyeri	–	–	–	+	+	–	–	2	2	–	–	–	–	–	–	–
Stipa krylovii	–	–	r	–	–	+	–	2	2	1	r	–	–	–	+	–
Artemisia frigida	–	–	+	r	–	–	–	+	r	+	r	–	–	–	–	–
Ptilotrichum canescens	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Aster alpinus	r	–	–	–	r	–	–	–	r	–	–	–	–	–	–	r
Silene jenisseensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Koeleria macrantha	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thymus gobicus	+	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Orostachys spinosa	+	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–
Carex stenophylla	–	+	–	r	2	–	–	r	1	r	–	–	–	–	2	–
Oxytropis tragacanthoides	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vicia costata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Astragalus brachybotrys	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–
Lophanthus chinensis	–	r	–	–	–	–	1	–	–	–	–	–	–	–	–	r
Allium prostratum	–	–	–	+	–	–	–	–	r	–	–	r	–	–	r	–
Arnebia fimbriata	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–
Lonicera microphylla	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–
Silene repens	–	–	–	–	–	+	–	–	–	–	r	–	–	+	–	r
Axyris prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	r
Ajania achilleoides	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Pedicularis flava	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r
Koeleria altaica	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sibbaldianthe adpressa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Allium altaicum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r
Oxytropis pumila	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–
Vicia multicaulis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Crepis flexuosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Taraxacum dissectum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Potentilla ikonnikovii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Iris potaninii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Saussurea pricei	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Poa altaica	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

sub-community of the *A. santolinifolia* community (for explanation of cover abundance scale see table 2).

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
99	**31**	**6**	**93**	**35**	**82**	**21**	**62**	**25**	**70**	**65**	**66**	**34**	**33**	**94**	**91**	**13**	**60**	**45**	**98**
+	2	2	2	1	1	1	1	2	2	+	2	1	r	1	r	2	2	1	r
–	–	–	–	–	r	2	1	1	r	1	1	+	2	1	1	2	+	r	+
r	r	+	r	2	+	r	r	–	r	–	+	–	2	r	+	r	r	–	–
–	–	–	r	r	–	r	r	r	–	r	–	–	r	1	r	–	r	r	r
–	–	–	+	–	–	–	–	–	–	–	–	r	r	1	1	r	r	r	r
–	–	–	–	–	–	r	r	r	r	+	r	–	r	–	r	–	–	–	–
–	–	–	r	–	2	+	–	–	–	–	+	r	–	r	r	–	–	r	–
–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	r	–	–	r	+
–	–	–	–	–	r	–	r	r	–	–	–	–	r	–	–	–	–	–	–
–	–	–	–	–	–	r	r	–	–	–	–	r	–	–	r	–	–	–	–
–	–	r	–	–	–	–	r	–	–	r	–	–	–	r	r	–	–	–	–
–	–	+	r	r	1	r	+	r	r	–	+	–	–	–	–	–	r	–	–
–	r	–	–	r	–	r	–	–	1	r	–	–	–	r	–	–	r	–	–
+	1	r	+	–	r	r	–	+	r	+	r	r	–	r	r	r	+	–	–
–	–	r	r	r	–	r	r	–	r	r	–	–	–	+	+	r	–	r	r
–	+	+	–	r	+	+	1	r	2	2	+	+	2	–	–	+	–	+	–
–	–	–	+	–	–	+	2	–	–	2	r	+	+	+	+	+	–	+	+
–	+	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–
–	r	–	–	–	–	r	+	–	+	r	r	r	r	r	r	–	–	–	r
–	–	–	r	–	–	–	–	–	–	–	–	r	r	–	–	–	–	–	r
–	–	–	r	–	–	r	r	–	–	–	r	–	r	–	r	–	–	r	–
–	–	–	+	–	–	–	–	–	–	r	–	–	–	–	r	–	–	–	r
r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	r	–	r	1
–	–	–	–	–	–	–	–	–	–	r	–	r	–	–	r	–	–	r	r
–	–	–	–	2	–	–	–	–	–	+	–	–	–	1	–	–	–	–	–
–	–	–	r	–	–	–	–	–	–	–	–	r	r	–	–	–	r	r	r
–	–	1	–	–	r	–	–	–	–	r	r	–	–	–	r	–	r	–	r
–	–	r	–	–	–	–	–	–	–	–	r	–	r	–	r	–	–	–	–
r	–	–	–	r	–	–	–	1	r	–	–	–	–	–	–	–	1	–	–
–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r
–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r
–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	r	–	2	r	r	–	–	–	–	–	–	–	–	r	–	–	–	–
–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–
–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	r	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–
–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	r	–	–	–	r	–	–	–	–	–	–	–	r
–	–	–	r	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	r	r	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–
–	–	r	r	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–
–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–
–	–	–	–	–	r	–	r	–	–	–	–	–	–	r	–	–	–	–	–
–	–	–	–	–	–	r	–	–	–	–	–	r	–	–	–	–	r	–	–
–	–	–	–	–	r	–	–	–	–	–	r	–	–	–	–	–	–	–	–

Table 3 *(continuation)*

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Relevé number	**58**	**15**	**18**	**23**	**36**	**37**	**41**	**7**	**17**	**53**	**76**	**75**	**14**	**4**	**44**	**49**
Stellaria petraea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Allium eduardi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bupleurum pusillum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Iris sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r
Achnatherum inebrians	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–
Polygonum angustifolium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium hybridum	–	–	r	–	–	–	–	–	–	–	–	r	r	–	–	–
C. vulvaria	–	r	1	–	–	–	–	–	–	r	–	r	–	r	–	–

ad 1: *Artemisia rutifolia, Sedum aizoon*
ad 2: *Astragalus sp.*
ad 6: *Axyris hybrida*
ad 7: *Polygonum aviculare*
ad 8: *Amblynotis rupestris, Heteropappus altaicus, Rhinactinidia eremophila, Salsola collina*
ad 10: *Potentilla bifurca*
ad 16: *Stellaria dichotoma*
ad 17: *Arabis rupicola, Artemisia rutifolia*
ad 18: *Sausurea lipschitzii*

The number of species of these montane scrublands is low (Fig. 3G), yet the Shannon index is higher compared to the juniper stands (Fig. 3H), since the shrub cover of *A. santolinifolia* is overall lower (median = 7.5%).

The accompanying species include typical montane species (e.g. *Agropyron cristatum, Stipa krylovii, Polygonum alpinum)* and other disturbance indicators (e.g. *Carex stenophylla, Chenopodium prostratum, Rheum undulatum).* An exclusive co-abundant companion is however missing; thus we follow the suggestion made by Wesche & al. (2005a) and designate the stands as a rankless unit within the *Juniperion.* This placement reflects the possibility that the *Artemisia santolinifolia* stands may outcompete and thus replace the juniper patches under the current environmental conditions (Wesche & Ronnenberg, 2004; Wesche & al., 2005c).

3. *Festuca valesiaca-Artemisia santolinifolia* sub-community
(Table 3, running number 22-36; unit 3 in Fig. 2 & Fig. 3)

The second *Artemisia santolinifolia* sub-community replaces the previous unit at higher altitudes (see Fig. 3A). The shrub cover is lower (median = 4%), whereas the cover of the field layer is doubled (Fig. 3D). The sub-community is not restricted to southern slopes (Fig. 3C).

The combination of these environmental patterns probably reflects higher moisture availability; in addition, the relevés are more heterogeneous due to the rocky environments, thus several grasses and herb species may outcompete *A. santolinifolia* at rocky micro-sites. As such the biodiversity of this unit is higher (Fig. 3G), and the species-area relation suggests that the stands are more similar to the mountain steppes (Fig. 3I). Besides the typical montane elements of the Gobi Gurvan Saykhan *(Agropyron cristatum, Arenaria meyeri, Artemisia frigida and Polygonum alpinum)* the stands are accompanied by species typical of the higher and thus stonier slopes of the region (e.g. *Poa attenuata/stepposa, Rhodiola rosea, Potentilla sericea, Vicia costata).* This unit was not designated by previous studies (Wesche & Ronnenberg, 2004; Wesche & al., 2005a), but the syntaxonomic tables given within these publications indicate comparable stands. Potential differential species to the previous unit may be *Limonium flexuosum, Potentilla sericea* and *Ephedra monosperma,* all of which testify the more rocky environment (see Table 3). However a syntaxonomic placement within the nationwide context (Hilbig, 2000) is hampered due to the transitional nature of the respective stands; this unit can be placed together with the previous units *(= Juniperion)* or into the *Agropyretea cristati.* There the unit would certainly be included into the sub-association *Stellaria petraea* Hilbig 2000 of the *Hedysaro pumili-Stipetum krylovii* (Hilbig, 2000; Wesche & al., 2005a). Due to the physiognomy and the accompanying set of species, we would concur with suggestion placement into the *Juniperion*, yet more material is needed in order to clarify this designation.

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
99	31	6	93	35	82	21	62	25	70	65	66	34	33	94	91	13	60	45	98
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	r
–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	r
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	1
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	r
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–

4. ***Kobresietum myosuroidis* and *Papaver croceum-Artemisia pycnorrhiza*, subass. nov. hoc loco** (Table 4, running number 1-23; unit 4 in Fig. 2 & Fig. 3)

In Central and High Asia *Kobresia* mats are abundant alpine vegetation units, which in the Gobi Altay are restricted to only the highest montane sites (Wesche & al., 2005a). These climatic relics are almost completely limited to northern exposed slopes (see Fig. 2 & 3C), where evapotranspiration is lower and water availability is higher due to snow accumulation as well as fog. Thus, the cover of the field layer is comparably high (Fig. 3D), making this vegetation type a rich pasture, especially for yaks. Stands are normally characterized by a low stone cover, and due to disturbances by Yaks have a high bare soil cover (Fig. 3E). The stand characteristics and species set lead to a clear differentiation of the group.

The accompanying species set is rich (Fig 4I), and besides typical montane elements some species are almost completely restricted to these stands (e.g. *Potentilla nivea, Galium verum, Androsace dasyphylla, A. maxima). Papaver croceum* and *Artemisia pycnorrhiza* characterize these stands, based on the occurrence of these two species in combination with *Kobresia myosuroides* we suggest a local new sub-association *Papaver croceum-Artemisia pycnorrhiza,* which is included into the *Kobresietum myosuroidis* association proposed by Hilbig (2000). The type relevé is running no. 3 within Table 4 (relevés 17-23 indicate transitional stages to the following unit). Stands are described from other mountains of the Gobi Gurvan Saykhan as well (e.g. Zuun Saykhan, Sevrey Uul; Wesche, *pers. comm.).* The nearest comparable stands, apart from other peaks of the Gobi Gurvan Saykhan (Wesche & al., 2005a), are in the Ikh Bogd (ca. 250 km distant), although these have a somewhat different species composition (Hilbig, 1990). Stands are more common in the Mongolian Altay, the Changay (Hilbig, 2000) and in Northern Mongolia, thus illustrating the high-montane distribution of *Kobresia myosuroides* (Hilbig & al., 2004).

5. ***Arenario meyeri-Festucetum valesiacae* and *Papaver croceum-Artemisia pycnorrhiza* variant** (Table 4, running number 24-38; unit 5 in Fig. 2 & Fig. 3)

At southern exposures water availability is presumably not sufficient to support *Kobresia* mats, the previous community is therefore replaced by a less densely growing *Festuca valesiaca* steppe (Fig. 3D), which is more abundant on southern slopes (Fig. 2 & 3C). At lower altitudes comparable stands are found on more north facing slopes (Wesche & Ronnenberg, 2004), which indicates that at lower altitudes (< 2500m) northern slopes have a comparable moisture to stands within southern slopes at higher altitudes. These stands are often accompanied by *Papaver croceum* and *Artemisia pycnorrhiza,* thus pointing to a high montane vegetation aspect. The soils are more shallow and stony (Fig. 3E & 3F), and due to the heterogeneous site conditions the Shannon index is slightly higher compared to the *Kobresietum* (see Fig. 3H). This variant of

Table 4. – Stands of the *Kobresietum myosuroides* Hilbig 2000, running no. 1-23. Running no. 24-38 are montane steppes of the higher slopes (*Arenario*

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Relevé number	**47**	**52**	**64**	**16**	**77**	**100**	**81**	**71**	**78**	**80**	**89**	**72**	**61**	**5**	**86**	**96**	**32**
Kobresia myosurioides	2	2	2	2	3	3	2	r	2	2	3	r	3	2	2	r	r
Papaver croceum	r	r	r	r	r	r	r	r	r	r	r	–	–	r	r	r	–
Artemisia pycnorrhiza	1	r	1	r	r	r	r	r	r	2	r	r	r	–	–	–	–
Festuca valesiaca	3	2	2	2	–	–	–	2	–	–	–	2	+	2	–	2	2
Astragalus brachybotrys	–	–	–	–	–	–	r	–	r	–	–	–	–	r	–	r	r
Silene jenisseensis	r	–	–	r	r	–	–	–	r	r	–	–	–	–	r	r	r
Thalictrum foetidum	–	–	–	–	–	–	–	r	r	–	–	–	–	r	r	r	–
Saussurea pricei	–	–	–	r	–	–	–	–	r	–	r	–	–	–	–	r	r
Potentilla sericea	–	r	–	r	r	–	–	r	r	r	r	r	–	r	r	r	r
Allium tenuisissimum	–	–	–	r	–	r	–	+	+	r	–	–	–	r	r	r	r
Poa attenuata	+	r	–	–	r	–	r	r	–	1	–	2	–	+	r	r	r
Cerastium arvense	r	–	r	r	r	r	r	–	–	–	r	2	–	–	r	–	–
Aster alpinus	+	r	r	r	r	–	r	r	r	–	r	–	–	r	–	r	–
Limonium flexuosum	–	r	–	r	–	–	r	–	r	r	r	–	–	r	–	r	r
Clausia aprica	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
Rhodiola rosea	–	–	–	r	–	–	–	r	r	–	r	–	–	r	–	r	r
Phlojodicarpus sibiricus	1	–	–	r	–	–	–	r	–	r	r	2	1	r	r	r	r
Polygonum alpinum	r	–	r	–	r	r	r	–	–	2	r	+	–	–	+	r	r
Agropyron cristatum	r	+	–	–	r	–	+	2	–	–	–	+	r	–	–	–	–
Arenaria meyeri	–	r	–	r	–	–	–	1	1	–	r	–	–	1	–	1	2
Artemisia frigida	–	–	–	2	–	–	–	r	+	–	–	–	–	–	r	r	–
Bupleurum pusillum	–	–	–	r	–	–	–	r	r	–	–	–	–	r	–	–	r
Artemisia phaeolepis	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	1
Amblynotus rupestris	–	–	–	+	r	–	r	–	2	–	r	–	–	r	–	r	r
Ptilotrichum canescens	–	r	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–
Koeleria macrantha	–	r	–	–	–	r	–	–	r	–	–	–	–	–	–	2	–
Artemisia santolinifolia	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	r	–
Thymus gobicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium prostratum	r	–	r	–	–	–	–	r	–	–	r	–	–	–	r	–	–
Orostachys spinosa	–	–	–	–	–	–	–	–	r	–	r	–	–	–	r	r	–
Carex stenophylla	r	–	2	–	–	–	1	r	–	–	–	3	–	–	r	–	–
Rheum undulatum	r	–	–	–	–	–	–	–	–	2	–	–	–	–	r	r	–
Oxytropis tragacanthoides	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	r
Iris potaninii	–	–	–	–	–	–	–	r	–	–	–	–	–	–	r	–	–
Ephedra monosperma	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
Allium eduardi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vicia costata	–	–	–	–	–	–	–	r	–	–	–	–	–	r	r	–	–
Galium verum	1	–	–	–	–	+	r	–	–	+	–	r	r	–	r	–	–
Allium prostratum	r	r	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–
Bupleurum bicaule	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–
Achnatherum inebrians	–	–	–	–	–	–	–	r	–	3	–	–	–	–	–	–	–
Silene repens	–	–	r	–	r	–	r	–	–	r	–	–	r	r	–	–	–
Poa altaica	r	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–
Chenopodium vulvaria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ajania achilleoides	–	–	–	r	–	–	–	–	–	–	–	–	–	2	–	–	1
Saussurea saichanensis	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–
Pedicularis flava	–	r	–	–	–	r	–	–	–	–	–	–	–	r	–	–	r
Androsace dasyphylla	–	–	–	r	–	–	–	–	r	–	–	r	–	r	–	–	r

meyeri-Festucetum valesiacae, Papaver croceum-Artemisia pycnorrhiza variant) (for explanation of cover abundance scale see table 2).

18	**19**	**20**	**16**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**
56	**22**	**8**	**84**	**40**	**69**	**39**	**88**	**74**	**63**	**97**	**11**	**59**	**43**	**46**	**26**	**19**	**68**	**57**	**87**	**83**
+	1	r	r	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	r	–	–	r	r	r	r	r	r	r	r	–	–	–	–	–	–	r
–	–	–	–	–	–	+	–	r	r	r	–	–	–	r	r	r	r	r	r	r
r	–	–	2	+	1	2	2	2	2	2	2	2	r	2	–	2	2	2	2	2
r	–	r	–	r	–	–	r	r	–	–	r	r	–	–	r	–	–	–	r	–
r	–	–	r	r	–	r	–	r	r	r	r	r	r	r	–	–	r	r	r	–
r	–	r	r	r	r	r	r	–	r	+	–	r	r	r	r	–	2	r	r	+
–	–	–	–	–	–	r	+	r	r	r	r	–	r	r	r	–	–	–	r	–
r	–	–	–	–	–	r	r	–	r	+	+	r	r	r	+	r	r	+	–	+
r	2	r	r	r	2	r	r	r	1	–	–	r	r	–	r	r	r	–	r	2
r	–	r	1	r	+	r	–	r	–	+	–	r	r	r	r	–	–	–	–	–
–	–	r	–	–	–	r	–	r	–	–	r	–	r	–	–	–	–	r	–	–
r	–	r	+	–	–	r	r	r	r	–	–	r	r	–	2	r	r	–	+	–
r	–	r	r	r	r	–	r	–	r	–	r	r	r	–	–	–	–	–	+	r
r	–	–	–	r	–	–	–	r	–	–	–	–	r	–	r	–	–	–	r	–
–	–	–	r	–	–	–	+	r	r	–	r	r	r	r	–	+	r	r	r	+
r	–	r	–	r	–	r	r	r	r	r	r	–	–	r	–	r	r	r	r	r
–	1	–	r	r	r	r	r	–	r	r	r	r	2	r	–	–	–	–	r	r
1	2	r	–	2	+	r	–	–	+	–	r	r	+	–	–	2	+	r	–	2
+	–	2	+	–	–	r	+	r	2	r	1	r	r	2	2	+	2	r	r	+
r	r	2	r	–	–	+	r	r	1	–	r	–	–	–	–	r	–	–	r	r
–	–	–	r	–	–	r	–	r	–	r	–	–	–	–	–	–	–	r	–	r
+	–	–	r	–	–	–	–	–	–	–	+	2	–	–	–	–	r	–	r	–
–	–	r	2	–	–	+	–	–	–	–	–	–	–	r	–	–	r	–	–	–
r	–	–	–	–	–	r	r	–	r	–	r	–	–	r	–	r	r	r	–	–
–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–
–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
–	–	–	–	–	–	–	–	r	–	–	–	r	–	r	r	r	–	r	–	r
–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–
r	–	–	r	–	–	–	r	–	–	–	–	r	–	r	–	–	r	–	–	–
–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	r	–	–	–	+	–
–	2	–	–	–	–	r	r	r	–	r	–	r	r	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	r	–	–	2	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	r	r	–	–	r
–	–	–	–	–	–	–	–	r	r	–	r	–	–	r	–	r	r	–	–	r
–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	2	2	–	+
–	–	–	–	–	r	–	–	r	–	r	–	r	–	–	–	–	–	r	r	r
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
r	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	r	r	–	r	–
–	–	r	–	r	–	–	–	–	r	–	+	–	–	1	r	r	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	r	–	–	–
–	–	r	–	–	r	r	–	–	+	r	–	–	–	–	–	–	–	–	r	–
–	–	–	–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	r	r	–
r	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	r	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–
–	–	–	–	–	–	r	–	r	–	–	r	r	–	–	–	–	–	–	–	r
–	–	–	r	–	–	r	–	–	–	–	–	r	–	–	–	–	–	–	–	–

Table 4 *(continuation)*

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Relevé number	**47**	**52**	**64**	**16**	**77**	**100**	**81**	**71**	**78**	**80**	**89**	**72**	**61**	**5**	**86**	**96**
Koeleria altaica	–	–	+	–	–	–	–	–	–	–	+	r	2	r	–	–
Ranuculus pedatifidus	–	–	r	–	–	r	r	–	–	–	–	–	–	–	–	–
Crepis crocea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxytropis pumila	–	–	–	–	r	–	r	–	1	–	2	r	–	–	–	r
Festuca lenensis	–	–	–	–	2	3	2	–	2	–	–	–	–	–	r	–
Heteropappus altaicus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r
Chenopodium hybridum	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–
Androsace maxima	–	r	–	–	r	–	–	–	r	–	–	r	r	–	–	r
Leontopodium ochroleucum	r	r	r	–	r	r	r	–	–	–	–	–	–	–	–	r
Koeleria cristata	–	–	–	–	–	2	+	–	–	–	–	–	–	–	–	–
Potentilla multifida	r	–	–	–	–	r	r	–	–	–	–	–	–	–	–	–
Crepis flexuosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Taraxacum dissectum	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–
Artemisia dolosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Eritrichium pauciflorum	–	r	–	r	–	–	r	–	–	–	r	–	–	–	–	–
Smelovskia alba	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxytropis bungei	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Polygonum angustifolium	–	–	r	–	–	–	–	–	–	–	–	–	r	–	–	–
Taraxacum sp.	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–
Saxifraga sibirica	r	r	–	–	r	–	–	–	–	–	–	–	–	–	–	r
Gentiana barbata	r	–	–	–	–	–	–	–	–	–	r	r	–	–	–	–
G. decumbens	–	r	–	–	–	r	–	–	–	–	–	r	–	–	–	r
Artemisia tanacetifolia	–	–	r	–	–	r	–	–	–	–	–	–	–	–	–	–
Phleum sp.	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
Potentilla nivea	–	–	–	–	–	r	r	–	r	–	r	–	–	–	–	r
Kobresia humilis	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–

ad 3: *Elymus sp., Orobanche coerulescens, Oxytropis gebleri, Potentilla sp.*
ad 4: *Artemisia sp., Carex pediformis*
ad 5: *Primula sp., Seseli sp.*
ad 6: *Hedysarum gmelinii*
ad 11: *Helictotrichon schellianum*
ad 12: *Melandrium brachyopetalum*
ad 13: *Androsace septentrionalis, Carex korshinskyi, Potentilla sp., Seseli eriocarpum, Stellaria gypsophiloides*
ad 15: *Lagotis integrifolia*
ad 16: *Potentilla sp.*
ad 18: *Axyris prostrata*

18	19	20	16	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
56	22	8	84	40	69	39	88	74	63	97	11	59	43	46	26	19	68	57	87	83
–	–	–	r	–	–	r	–	r	–	–	–	r	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
r	–	r	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–
–	–	r	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–
–	–	–	r	–	–	1	–	–	r	–	1	r	–	–	–	–	–	–	–	–
r	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–
–	–	–	–	r	–	r	–	–	–	–	–	–	r	–	–	–	–	–	–	–
–	r	–	r	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	r	r	–	–	–	–	–	–	r	–	r	–	–	–	r	–
–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–
–	–	–	–	–	–	–	–	r	–	–	–	–	–	r	–	–	–	–	–	–
–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	r	–	–	–	–	–
–	–	–	–	–	–	–	–	r	r	r	+	–	–	–	–	–	–	–	–	r
–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	r	r	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	r	–	–	–	–
–	–	–	–	–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	–	–
–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	r	–	–	–	–	r	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

the *Arenario-Festucetum* (below described) contains the highest biodiversity within the upper Dund Saykhan region (see Fig 4G), with a median even slightly higher than within the *Kobresietum*. Typical montane elements are prominently found, however, a large set of species are bound to rather stony and rocky habitat of this variant (e.g. *Arenaria meyeri, Silene jenisseensis, Rhodiola rosea, Potentilla sericea, Ephedra monosperma)*. In contrast to the previous unit *Kobresia* is completely absent. The precise syntaxonomic designation of this unit is difficult, yet it is characterized by both *Papaver croceum* and *Artemisia pycnorrhiza*. We suggest that these stands be regarded as a scree variant of the following unit, which is mainly restricted to rocky and stony sites within our working area.

6. *Arenario meyeri-Festucetum valesiacae*, ass. nov. hoc loco (Table 5; unit 6 in Fig. 2 & Fig. 3)

At lower elevations stands appear to gain progressively less moisture, as such the two high mountain species of the previous unit *(Papaver croceum* and *Artemisia pycnorrhiza)* are no longer found, as well as other species sharing their habitat. These *Festuca valesiaca* stands are the drier matrix vegetation of the working area; they can be found at all exposures (Fig. 2 & 3C) and elevations (Fig. 3A), they do however appear less abundant compared to the other mountain steppe vegetation (Fig. 3G). Surface characteristics are variable (Fig. 3E), yet the habitat of the stands indicates the gentle, and therefore less rocky, stands of the lower elevations. Wesche & al. (2005a) described these stands and the previous unit, yet summarized both into one unit *(F. valesiaca* variant of the *Stellaria petraea* sub-association of the *Hedysaro pumili-Stipetum krylovii)*. We refrain from putting these stands to the status of a local sub-association as suggested by Wesche & al. (2005a), given that *Hedysarum fruticosum* was not sampled by us at all *(Hedysaro fruticosi-Stipetum krylovii*, see Hilbig, 2000), and almost all other abundant species characterize the class *(Agropyron cristatum* and *Poa attenuata/stepposa)* the order *(Artemisia frigida* and *Stipa krylovii)* or are abundant within the other vegetation types as well *(Allium tenuissimum, Phlojodicarpus sibiricus, Polygonum alpinum, Thalictrum foetidum, Aster alpinus, Potentilla sericea)*. We therefore suggest a new association based on *Festuca valesiaca* and *Arenaria meyeri* as character species, which should be labelled *Arenario meyeri-Festucetum valesiacae*. Only

Table 5. – Stands of the montane *Arenario meyeri-Festucetum valesiacae* (for explanation of cover abundance scale see table 2).

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Relevé number	**48**	**51**	**73**	**90**	**92**	**27**	**9**	**10**	**1**	**24**	**29**	**95**	**3**	**38**	**42**	**85**	**30**	**12**
Festuca valesiaca	2	2	r	2	2	-	-	3	-	r	2	2	r	r	r	r	2	2
Agropyron cristatum	-	r	r	-	-	r	2	r	r	r	-	-	+	2	-	-	2	r
Arenaria meyeri	2	2	1	+	2	1	1	+	r	r	+	+	r	2	r	r	+	2
Artemisia frigida	1	r	+	+	r	r	r	+	2	r	-	-	-	-	-	-	-	-
Stipa krylovii	-	-	r	-	-	1	r	-	r	-	-	-	2	r	2	-	-	-
Allium tenuisissimum	-	r	-	r	r	-	+	r	-	-	1	r	-	+	-	r	r	r
Phlojodicarpus sibiricus	r	r	r	r	r	-	-	r	-	r	r	r	-	r	r	-	-	-
Polygonum alpinum	-	r	-	r	r	r	-	r	-	-	r	r	-	-	-	r	-	r
Silene jenisseensis	r	r	-	r	r	-	-	-	-	-	r	r	-	-	r	r	r	-
Rhodiola rosea	r	-	-	-	r	-	-	r	r	-	-	-	-	-	-	-	-	-
Artemisia phaeolepis	1	+	r	+	-	-	-	-	-	-	r	+	-	-	-	-	-	-
Bupleurum pusillum	-	r	r	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-
Limonium flexuosum	r	r	-	-	r	r	-	r	-	-	r	-	-	r	r	1	r	r
Clausia aprica	r	-	-	-	-	-	-	-	r	-	r	-	-	-	r	-	r	-
Ptilotrichum canescens	-	-	r	-	-	-	-	r	r	-	-	-	1	-	-	-	r	-
Thalictrum foetidum	-	-	r	r	r	-	-	-	r	r	r	r	-	-	-	r	r	r
Aster alpinus	r	-	-	r	-	-	-	+	-	2	1	-	-	-	-	r	r	r
Koeleria macrantha	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	r	-
Thymus gobicus	-	-	-	-	-	-	-	-	r	-	-	-	r	-	-	-	-	-
Saussurea pricei	-	-	r	r	-	-	-	r	+	-	-	-	r	-	-	-	r	-
Cerastium arvense	r	r	-	r	-	-	-	-	-	-	-	r	-	-	-	-	-	-
Potentilla sericea	r	r	r	r	+	-	-	-	-	r	-	r	-	-	-	-	r	r
Poa attenuata	r	r	r	r	-	-	-	r	-	-	r	+	-	r	-	-	-	r
Chenopodium prostratum	-	r	r	-	-	r	r	-	-	-	-	r	-	-	r	r	-	-

Table 5 *(continuation)*

Running no.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Relevé number	**48**	**51**	**73**	**90**	**92**	**27**	**9**	**10**	**1**	**24**	**29**	**95**	**3**	**38**	**42**	**85**	**30**	**12**
Orostachys spinosa	-	1	r	r	r	-	-	-	r	-	-	-	-	-	-	-	-	-
Carex stenophylla	r	r	-	r	-	-	-	+	-	-	r	r	-	r	-	-	-	-
Rheum undulatum	-	-	-	-	-	-	-	-	-	-	-	r	-	-	-	r	-	-
Oxytropis tragacanthoides	-	-	-	-	-	-	-	-	+	-	-	r	r	-	-	-	r	-
Iris potaninii	-	-	-	-	-	-	-	-	r	r	-	r	-	-	-	-	-	-
Ephedra monosperma	r	-	-	-	r	-	r	-	r	-	-	-	-	-	-	-	r	-
Allium eduardi	-	r	2	-	-	-	-	-	+	1	-	-	-	2	r	-	-	-
Vicia costata	-	-	-	r	-	-	-	-	-	-	r	-	-	-	-	-	-	r
Astragalus miniatus	r	r	-	-	-	-	-	-	-	-	-	r	-	r	-	-	-	-
Lophanthus chinensis	-	-	r	-	-	-	-	-	r	-	-	-	-	r	-	-	-	-
Allium prostratum	-	-	r	-	r	-	r	1	-	r	-	-	1	-	-	-	-	-
Bupleurum bicaule	+	-	-	-	-	r	-	-	-	r	r	-	1	-	-	-	r	-
Amblynotus rupestris	r	r	r	-	-	-	-	-	-	r	r	-	r	-	-	-	-	-
Silene repens	-	-	-	-	-	-	-	r	-	-	-	-	-	-	-	r	-	-
Poa altaica	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	r	-
Chenopodium vulvaria	-	-	-	-	-	+	-	-	-	-	-	-	-	r	-	-	-	-
Pedicularis flava	-	-	-	-	-	-	-	-	-	-	1	r	-	-	-	-	-	-
Crepis crocea	-	r	r	r	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oxytropis pumila	-	-	r	-	-	-	-	-	-	r	-	-	-	r	-	-	-	-
Koeleria cristata	-	-	-	-	-	r	r	-	-	r	-	-	-	-	-	-	-	-
Vicia multicaulis	-	-	-	-	r	-	-	-	r	-	-	-	-	-	-	-	-	-
Crepis flexuosa	r	-	-	-	-	r	-	-	-	-	r	-	r	-	-	-	-	r
Artemisia dolosa	-	-	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	r
Stellaria petraea	-	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	r	-

ad 1: *Saussurea saichanensis*
ad 5: *Taraxacum dissectum*
ad 6: *Axyris prostrata, Oxytropis bungei*
ad 7: *Carex korshinskyi*
ad 8: *Artemisia sp., Eritrichium pauciflorum, Oxytropis chionophylla*
ad 9: *Dracocephalum foetidum, Peucedanum hystrix, Potentilla multifida, Stellaria dichotoma, Youngia tenuicaulis*
ad 10: *Leontopodium ochroleucum*
ad 11: *Koeleria altaica, Potentilla ikonnikovii*
ad 12: *Isatis costata*
ad 13: *Arnebia fimbriata, Astragalus brevifolius, Potentilla conferta*
ad 14: *Axyris hybrida*
ad 15: *Achnatherum inebrians, Clematis sp., Nepeta sibirica, Salsola collina*
ad 17: *Iris sp., Polygonum angustifolium*

a comparison with a wider geographic focus might enable an analysis of the relation with the *Hedysaro fruticosi-Stipetum krylovii*. Our suggestion would be supported by the relevés given by WESCHE & RONNENBERG (2004), which labelled a comparable unit as *"Festuca valesiaca* rock steppes": these were set in context to a "rock steppe" described from the mountain surroundings of the Uvs-Nuur basin (HILBIG, 2003). The type relevé is running no. 2 within Table 5.

7. ***Nepeto sibiricae-Urticion cannabinae*** (Table 6; unit 7 in Fig. 2 & Fig. 3)

One stand which was dominated by *Nepeta sibirica* was recorded at the bottom of a ravine. The vegetation cover was around 50%, and other disturbance indicators such as *Chenopodium prostratum* and *C. hybridum* were present. The stand belongs to the *Nepeto sibiricae-Urticion cannabinae* (HILBIG, 2000) and testifies to the rare occurrence of these stands on heavily disturbed sites in the south-eastern Gobi-Altay mountains.

Table 6. – Disturbed relevé (*Nepeto-Urticion* Hilbig (1987) 1990)) of an eroded valley (for explanation of cover abundance scale see table 2).

Running no.	20
Nepeta sibirica	4
Polygonum alpinum	r
Chenopodium hybridum	r
Silene repens	r
Poa sp. (attenuata/stepposa)	r
Chenopodium prostratum	r

Conclusion

Methodological note

The randomized sampling approach of our study is rather untypical among phytosociological studies, as vegetation-ecologists often prefer a deliberate sampling. By choosing an objective approach one also has to accept a greater logistic challenge, since the localisation of plots with a GPS in a montane environment is certainly more time consuming. Other studies (Hilbig, 1990, 1995, 2000; Wesche & Ronnenberg, 2004; Wesche & al., 2005a) did not designate stands of the *Arenario meyeri-Festucetum valesiacae,* which indicates the random approach as rather superior, at least on this fine scale. However this should not be overestimated, since previous studies had a lower sampling density (Wesche & al., 2005a) or only partly overlapped with our working area (Wesche & Ronnenberg, 2004). Spatially small-spread vegetation types may (e.g. disturbed or replacement communities) remain unrecorded within a randomized sampling. However, since our approach apparently sampled all spatially widespread units described in the literature, and added substantial new insights to existing knowledge, we would recommend a suchlike design for other studies as well.

Flora and vegetation

The character species of the montane slopes of the Dund Saykhan (and likewise all mountains of the Gobi Gurvan Saykhan) are *Stipa krylovii, Agropyron cristatum, Arenaria meyeri, Allium tenuissimum* and *Polygonum alpinum.* The two *Gramineae* are however more frequent at lower altitudes, whilst at higher and more stony slopes *Festuca valesiaca* becomes more abundant. The scree slopes are more heterogeneous and in this respect host a higher biodiversity. The most restricted relics are found at these spots and the northern slopes, where they benefit from micro-sites with high moisture availability.

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References

Anonymous (1990). *Atlas of Mongolia.* Ulaan Baatar.

Bedunah, D. & S. M. Schmidt (2004). Pastoralism and protected area management in Mongolia`s Gobi Gurvansaikhan National Park. *Developm. & Change* 31: 167-191.

Chytry, M. (2001). Phytosociological data give biased estimates of species richness. *J. Veg. Sci.* 12: 439-444.

Dierschke, H. (1994). *Pflanzensoziologie: Grundlagen und Methoden.* Ulmer.

Eiten, G. (1992). How names are used for vegetation. *J. Veg. Sci.* 3: 419-424.

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. Ressource Mongolei* 6: 87-90.

Grubov, V. I. (2000). *Plants of Central Asia.* Science Publishers.

Grubov, V. I. (2001). *Key to the vascular plants of Mongolia.* Volume I & II. Science Publishers.

Gubanov, I. A. (1996). *Conspectus of the flora of Outer Mongolia (Vascular Plants).* Valang Publishers.

Hijmans, R. J., S. E. Cameron, J. L. Parra, P. G. Jones & A. Jarvis (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. Ressource Mongolei* 8: 5-146.

Hilbig, W. (1995). *The vegetation of Mongolia.* SPB Academic Publishing.

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

HILBIG, W. (2003). The distribution of the vegetation in the Uvs-nuur basin and its surrounding mountain ranges. *Feddes Repert.* 114: 540-558.

HILBIG, W., E. J. JÄGER & H. D. KNAPP (2004). Die Vegetation des Bogd-uul bei Ulaanbaatar (Mongolei) – Standortsbindung und pflanzengeographische Stellung. *Feddes Repert.* 115: 265-342.

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. Ressource Mongolei* 9: 237-245.

JARVIS, A., H. I. REUTER, A. NELSON & E. GUEVARA (2006). Hole-filled SRTM for the globe Version 3. [http://www.srtm.csi.cgiar.org].

KOZLOFF, P. K. (1902). The Russian Tibet Expedition, 1899-1901. *Geogr. J. (London)* 19: 576-598.

LEGENDRE, P. & L. LEGENDRE (1998). *Numerical Ecology.* Elsevier.

MIEHE, S., G. MIEHE & F. SCHLÜTZ (2002). Vegetationskundliche und palynologische Befunde aus dem Muktinath-Tal (Tibetischer Himalaya, Nepal). *Erdkunde* 56: 268-285.

MUCINA, L., J. H. J. SCHAMINEE & J. S. RODWELL (2000). Common data standards for recording releves in field surveys for vegetation classification. *J. Veg. Sci.* 11: 769-772.

OPGENOORTH, L., J. CERMAK, G. MIEHE & W. SCHOCH (2005). Isolated birch and willow forests in the Gobi Gurvan Saykhan National Park. *Erforsch. Biol. Ressource Mongolei* 9: 247-260.

R DEVELOPMENT CORE TEAM (2008). *R: A language and environment for statistical computing* [http://cran.r-project.org/doc/manuals/refman.pdf].

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.* Görich & Weiershäuser Verlag.

TICHY, L. (2002). JUICE, software for vegetation classification. *J. Veg. Sci.* 13: 451-453.

WEHRDEN, H. VON & K. WESCHE (2007a). Relationships between climate, productivity and vegetation in southern Mongolian drylands. *Basic Appl. Dryland Res.* 1: 100-120.

WEHRDEN, H. VON & K. WESCHE (2007b). Conservation of Equus hemionus in southern Mongolia: a GIS approach. *Erforsch. Biol. Ressource Mongolei* 10: 391-406.

WEHRDEN, H. VON, K. WESCHE, C. REUDENBACH & G. MIEHE (2006). Vegetation mapping in Central Asian dry eco-Systems using Landsat ETM+. *Erdkunde* 60: 261-272.

WEISCHET, W. & W. ENDLICHER (2000). *Regionale Klimatologie. Teil 2: Die Alte Welt.* Teubner.

WESCHE, K. & K. RONNENBERG (2004). Phytosociological affinities and habitat preferences of Juniperus sabina L. and Artemisia santolinifolia TURCZ. ex BESS. in mountain sites of the south-eastern Gobi Altay, Mongolia. *Feddes Repert.* 115: 585-600.

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

WESCHE, K., E. J. JÄGER, H. VON WEHRDEN & R. UNDRAKH (2005b). Status and distribution of four endemic vascular plants in the Gobi Altai. *Mongolian J. Biol. Sci.* 3: 3-11.

WESCHE, K., K. RONNENBERG & I. HENSEN (2005c). Lack of sexual reproduction within mountain steppe populations of the clonal shrub Juniperus sabina L. in semi-arid southern Mongolia. *J. Arid Environm.* 63: 390-405.

WESCHE, K., K. NADROWSKI & V. RETZER (2007). Habitat engineering under dry conditions: The impact of pikas (Ochotona pallasi) on vegetation and site condition in southern Mongolian steppes. *J. Veg. Sci.* 18: 665-674.

ZEMMRICH, A. (2005). Die Steppengliederung der Mongolei aus Sicht der russischen und mongolischen Geobotanik. *Arch. Naturschutz Landschaftsf.* 44: 17-35.