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Vegetation along an altitudinal gradient in the Gremjachaya Valley, Barguzinskij Range, Eastern Siberia

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The vertical distribution of plant communities in the Gremjachaya Valley, Barguzinskij Range, was mapped. The research was focused on the study of changes of the vegetation under different climatic conditions. For comparison, the earlier published data from neighbouring valleys – Shumiliha, Boľshoj Chivyrkuj and Boľshaya Cheremshana (all at the lake-side of Lake Baikal) were chosen. Although the area studied, the Gremjachaya Valley is situated on the opposite side of the ridge, similar plant communities were found but they showed a different pattern in their vertical distribution. Along more than a thousand meter transect 14 types of plant communities (associations) were distinguished. In the upper zone communities of mountain tundra they were abruptly replaced by a mosaic of alpine grasslands and shrub communities. The middle part of this valley was characterised by transition of non-forest to forest vegetation with various ecotone situations. Forest vegetation showed the clearest dependence on altitude, although the relation to the moisture gradient and soil conditions was also very strong. The ecological peculiarities of all habitats are briefly described. Syntaxonomy of vegetation units corresponds with the current concept of classification of Siberian vegetation following the BRAUN-BLANQUET approach.

Key words: Russia, Eastern Siberia, plant communities, phytosociology, zonation.

Introduction

In August 1994, during a botanical expedition organised by Czech and Slovak naturalists into the Zabajkalskij National Park in Buryatia, the southern part of the Barguzinskij Range was visited (Fig. 1). The previous three expeditions were directed on the western slopes of mountain range. Our aim was to study the zonation of vegetation on the eastern slope of the Barguzinskij Range and make a comparison with all available vegetation data. The stages of this study were (1) to record the altitudinal ranges of all the described vegetation types (associations) and (2) to define the borders of different zones, to compare the sequence of zones and their altitudinal ranges with

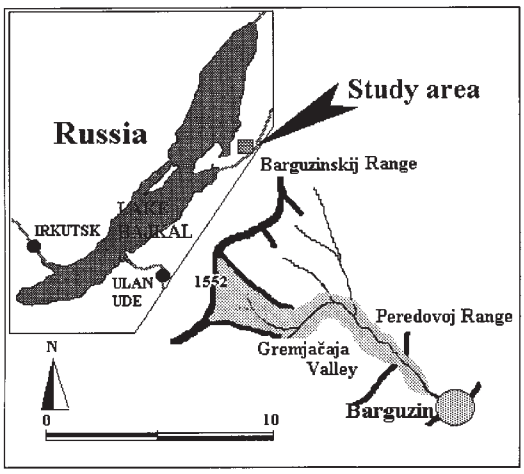

Fig. 1. Map of the Gremjachaya Valley.

the published data from neighbouring valleys on western slopes of the Barguzinskij Range, and other territories in Lake Baikal region. This paper extends the preliminary scheme of zonation of plant communities in the Gremjachaya Valley (Anenkhonov et al., 1999). The detailed vertical distribution of each recorded plant species was published by Anenkhonov et al. (2001).

The problems of altitudinal zonation of vegetation have been studied in Siberia in great detail and by numerous authors (cf. Zhitluhina, 1989). The different vegetation belts on the western and eastern coasts of Lake Baikal, and a higher number of vegetation belts on the southern part of the Barguzinskij Range have been discussed in papers by Tjulina (1967; 1981). Zonation in the valleys of the Barguzin River was studied by Buks & Ogureeva (1969). Together with papers by Chytrý et al. (1993, 1995) all these sources provided a good basis for comparison of zones and their altitudinal relations. For comparable interpretation with other parts of the Barguzinskij Range it was necessary to transform all association into a simplified model of vegetation types (Fig. 2). While other valleys, such as Shumilicha and Bolʹshoj Chivyrkuj, are exposed towards the West, the valley near Uljukchikan and the Gremjachaya Valley represent the opposite general slope – towards the East.

The main ecological factor responsible for vegetation zonation in the region of Lake Baikal was known to be the climate, which is very different on western and eastern coasts (Tjulina, 1967). According to our investigation the most sensitive zone is dark taiga with dominant *Abies sibirica*. While the fir forms a widespread zone in the western valleys, in the eastern parts the dark taiga is more or less confined to stream alluvia

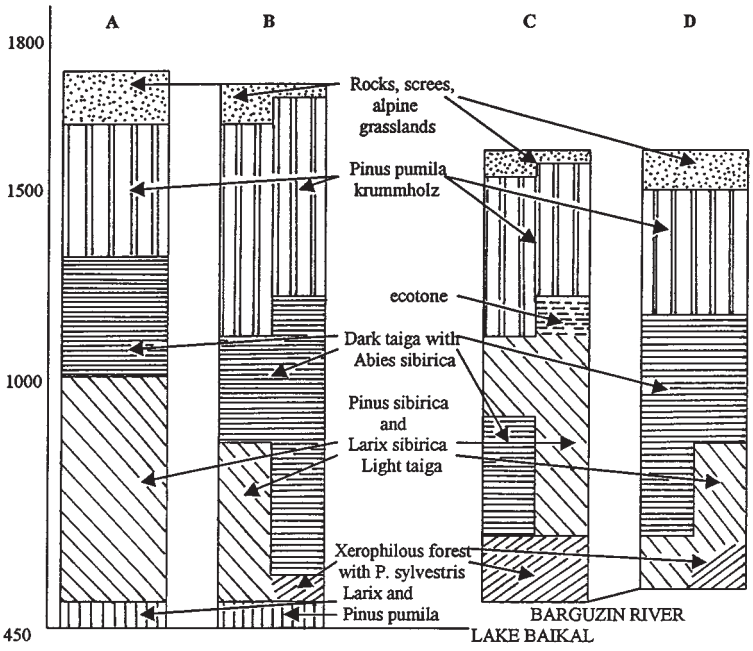

Fig. 2. Four examples of zonation of vegetation in the Barguzinskij Range. A – Shumilicha Valley (according Tjulina, 1967); B – Bolʹshoj Chivyrkuj Valley (Chytrý et al., 1993); C – Gremjachaya Valley (this paper); D – Uljukchikan (Buks & Ogureeva, 1969).

while the light taiga with larch is much more developed. The absence of a humid climate is also responsible for existence of xerophilous Scotch pine forest at lower altitudes (around 500 m). The other zones are more or less similar, only the altitudinal range is slightly different.

The study area

The famous Siberian Lake Baikal lies in a deep continental rift zone and it is encircled by numerous mountain ranges. One of them, the Barguzinskij Range rims the lake along north-eastern shore, stretching more than 300 km (Buks & Ogureeva, 1969). The typical water-shed ranges with outright N-S orientation reach with highest peaks around 2 500 m a.s.l. (Barguzin Alps, see Tjulina, 1967). The general climate in the Barguzinskij Range varies according to general slope. On the west-facing slopes the climate is under direct influence of Lake Baikal. The comparable climate data are from the Shumiliha Valley near Sosnovka Bay, where the annual temperature range is −4.5 ℃ (min. −23 ℃; max. +12 ℃), and summer precipitation is quite frequent (see Tjulina, l.c.). Also during the winter the snow is present for longer time due to thick snow cover. Moisture enables common occurrence of dark taiga forests ranging from the lake shore up to the subalpine zone. For comparison, the climate on the western shore of Lake Baikal is much more continental, dry, and the occurrence of forest-steppe vegetation is quite common. The dark taiga is very rare there (Tjulina, 1967).

The study area of the Gremjachaya Valley, is situated in the southern part of the Barguzinskij Range on the leeward slope of Lake Baikal. Generally it faces towards the East. A mouth of the valley lies in montane belt (around 500 m a.s.l.) near the settlement of Barguzin. The ridge reaches to the alpine and subalpine belts at about 1500 to 1700 m a.s.l. The valley is about 13 km long and vegetation was studied along this whole distance (ca. 1000 m altitudinal range). The relief of the valley is flat, while surrounding mountain branches are ornamented by separate rock cliffs built of grained granite. The whole Gremjachaya Valley is filled with granite screes and block-deposits.

The climate in east-facing Gremjachaya Valley is summer-warm and influences the existence of a continental forest-steppe belt (see Buks & Ogureeva, 1969). The mean annual temperature in the settlement of Barguzin – 3 km to the NE from the Gremjachaya Valley mouth (about 500 m a.s.l.) is 2.8 ℃, the annual precipitation 267 mm (Tatarnikov, 1993). The mean annual temperature around the saddle (1550 m a.s.l.) can reach −12.8 ℃ , the mean annual precipitation can be about 600 mm.

Material and methods

A total of 105 relevés were made using traditional methods of the Zürich-Montpellier school (Braun-Blanquet, 1964). Field sampling was carried out using 9-grade scale of abundance and dominance (Westhoff & van der Maarel, 1978). The aim of the investigation was to cover all vegetation types, generally across the whole area, and in more detail along an altitudinal gradient with 100 m intervals. For this aim the initial altitude was taken 1520 m a.s.l. in the saddle between Gremjachaya and Malyj Chivyrkuj Valleys. Afterwards every hundred altitudinal meters the various vegetation types and floristic data were recorded. The elevation was measured with altitude gauge Altiplus D2.

85 relevés were classified using the divisive polythetic classification program TWINSPAN (Hill, 1979). The resulting dendrogram was used to define ecologically and floristically homogeneous groups of non-forest and forest plant communities respectively (see Tabs 1, 2). The rest of the 20 relevés represent less frequent plant communities, e.g. pioneer vegetation on rocks and screes, or ruderal vegetation. These are described in the text without numerical treatment.

Nomenclature of vascular plants generally follows Cherepanov (1995) and Marhold (1998), that of lichens Pišút (1998) and Poelt (1969) and that of mosses Kubínska & Janovicová (1998).

There were serious problems with the nomenclature of syntaxa, because of invalidly published names of plant communities in older Russian manuscripts. We accepted a similar key as Chytrý et al. (1993), Danihelka & Chytrý (1995), and recent detailed syntaxonomical studies dealing with nomenclature published by Anenkhonov & Chytrý (1998) and Ermakov et al. (2000a).

Results and discussion

Survey of plant communities in the Gremjachaya Valley

***Betuletea rotundifoliae* Mirkin ex Chytrý, Pešout et Anenkhonov 1993**

***Dryadion oxydontae* Zhitluhina et Onishchenko ex Chytrý, Pešout et Anenkhonov 1993**

Alectorio ochroleucae-Patrinietum sibiricae Chytrý, Pešout et Anenkhonov 1993

***Empetro-Betulion rotundifoliae* Zhitluhina et Onishchenko ex Chytrý, Pešout et Anenkhonov 1993**

Cladino stellaris-Betuletum exilis Chytrý, Pešout et Anenkhonov 1993

***Anemonastro sibiricae-Festucion ovinae* Chytrý, Pešout et Anenkhonov 1993**

Anemonastro sibiricae-Festucetum ovinae Chytrý, **Pešout** et Anenkhonov 1993 var. *Rhododendon aureum*

***Mulgedio-Aconitetea* Hadač et Klika in Klika et Hadač 1944**

***Trollio-Crepidetalia sibiricae* Guinochet ex Chytrý, Pešout et Anenkhonov 1993**

***Trollio asiaticae-Crepidion sibiricae* Guinochet ex Chytrý, Pešout et Anenkhonov 1993**

Geranio albiflori-Pedicularietum uncinatae Chytrý, Anenkhonov et Danihelka 1995

Rubo-Cardaminetum macrophyllae Guinochet 1982

Carex pediformis-Pteridium aquilinum community

***Cleistogenetea squarrosae* Mirkin et al. 1986**

Saxifrago bronchialis-Phlojodicarpetum baicalensis Chytrý, Pešout et Anenkhonov 1993

Woodsia ilvensis-Borodinia tilingii community

Selaginella rupestris community

***Vaccinio-Piceetea* Br.-Bl. in Br.-Bl- et al. 1939**

***Vaccinio-Pinetalia sibiricae* Zhitluhina et Alimbekova** 1987

***Aconito rubicundi-Abietion sibiricae* Anenkhonov et Chytrý 1998**

Cardamino macrophyllae-Abietetum sibiricae Chytrý, Anenkhonov et Valachovič 1998

Equiseto hyemalis-Abietetum sibiricae Chytrý, Anenkhonov, Danihelka et Ünal 1998

Aconitum rubicundum-Duschekia fruticosa community

***Pino sibiricae-Laricion sibiricae* Guinocet ex Dostálek et al. 1988**

Calamagrostio obtusatae-Laricetum sibiricae Chytrý, Anenkhonov, Danihelka, Ünal et Valachovič 1998

Pinus pumila-Populus tremula community

***Vaccinio-Pinetalia pumilae* Suzuki**

***Vacinio-Pinion pumilae* Suzuki 1964**

Pleurozio schreberi-Betuletum divaricatae Anenkhonov, Chytrý, Danihelka, Valachovič et Ünal 1998

Pleurozio schreberi-Pinetum pumilae Chytrý, Anenkhonov et Danihelka 1995

Festuco ovinae-Pinetum pumilae Anenkhonov, Valachovič et Chytrý 1998

Bergenia crassifolia-Juniperus sibirica community

***Rhytidio rugosi-Laricetea sibiricae* I. Korotkov et Ermakov 1999**

***Festuco ovinae-Laricetalia sibiricae* I. Korotkov et Ermakov 1999**

Festuco altaicae-Laricion sibiricae I. Korotkov et Ermakov ex Ermakov, Dring et Rodwell 2000

Scorzonero radiatae-Pinetum sylvestris Anenkhonov et Ünal in Anenkhonov et Chytrý 1998

1. zone: Alpine tundra ("golcy")

Alpine tundra is represented by vegetation of avens mats on wind-exposed slopes and plateaus, which are replaced by dwarf tundra scrubs in shallow wet depressions. Some azonal communities depending more on climate and soil conditions complete the picture of alpine zone.

1a) windswept stripes (Tab. 1, rels. 16–50): The most frequently occurring on extreme wind-exposed peaks is the association *Alectorio ochroleucae-Patrinietum sibiricae* belonging to the alliance *Dryadion oxydontae*. It forms long stripes in the direction of predominant winds. The soil is shallow and stony and the snow cover during winter is often blown away. The average height of plants is 3–5 cm. Lichens play an important role by fastening small pebbles. Mosses are nearly absent. This type was observed at altitudes 1520–1630 m a.s.l. and it was clearly separated in TWINSPAN classification (Fig. 3, cluster 1a).

Chamaephytes and low hemicryptophytes, e.g. *Patrinia sibirica, Minuartia arctica, Borodinia tilingii, Hierochloë alpina* are the typical life forms. The layer of various lichens, such as *Alectoria ochroleuca, A. nigricans, Asahinea chrysantha, Thamnolia vermicularis, Cladonia* sp. div., *Cetraria* sp. div. and *Parmelia* sp. div., is species rich. Only in this type of vegetation the species such as *Artemisia furcata, Silene jenisseensis, Dryas punctata* were found. The floristic composition and structure of this association accords with those described from the alpine belt of Svjatoj Nos Peninsula (Chytrý et al., 1993).

By contrast, wet stands called "dresva" with dominating *Dryas punctata* were observed very rarely. The community is documented by one relevé: (rel. 48), 1570 m a.s.l., aspect N, slope 5, area 8 m^2, cover E_1: 35 %, E_0: 90 %, 1994/08/09: E_1: *Dryas punctata* 2b, *Oxytropis alpicola* 2a, *Hierochloë alpina* 1, *Aconogonon ochreatum* +, *Anemonastrum sibiricum* +, *Minuartia arctica* +, *Patrinia sibirica* +, *Selaginella rupestris* +, *Silene chamarensis* +, *Vaccinium vitis-idaea* +;

E_0: *Cladonia arbuscula* 3, *Stereocaulon alpinum* 3, *Polytrichum piliferum* 2a, *Rhytidium rugosum* 2a, *Alectoria nigricans* 2b, *A. ochroleuca* 1, *Polytrichum strictum* 1, *Cladonia amaurocraea* +, *Cetraria islandica* +, *C. nivalis* +, *Thamnolia vermicularis* +.

Ecologically similar stands are known from the Western Sajany Mts. as the association *Dryadetum oxydontae* Zhitluhina et Onishchenko 1987. Similarly from the Barguzinskij Range Tjulina (1967) noted the dryas tundra predominantly from carbonate rocks.

Other rare plant communities: At the same altitudes the *Selaginella rupestris* community was found very rarely. It grows in shallow soil accumulated in the rocky bowls: (rel. 38), 1576 m a.s.l., –,–, 0.4 m^2, E_1: 50%, E_0: 70%, 1994/08/08: E_1: *Selaginella rupestris* 3, *Hierochloë alpina* 2a, *Anemonastrum sibiricum* r; E_0: *Cladonia stricta* 2a, *C. arbuscula subsp. mitis* 1, *Cladonia* sp. +, *Cetraria nivalis* 1, *C. erecta* 2a, *Cornicularia divergens* +, *Parmelia omphalodes* +, *Hypnum cupressiforme* +, *Polytrichum piliferum* +, *Racomitrium sudeticum* +.

1b) dwarf tundra scrub: The plant communities classified in the alliance *Empetro-Betulion rotundifoliae* occur on a plateau around springs and shallow wet depressions between dwarf pine and dwarf willows (krummholz). Another habitat is in more wind-protected places (near the boulders and twisty krummholz). The dwarf shrubs are represented by *Ledum decumbens* as a dominant species, commonly growing with dwarf ericoids (*Empetrum subholarcticum, Rhododendron aureum, Vaccinium uliginosum, V. vitis-idaea*),birches (*Betula divaricata, B. exilis*) and *Salix krylovii.* A well developed layer of cryptogams with hygrophilous mosses, such as *Sphagnum girgensohnii*, *Aulacomnium turgidum, Pleurozium schreberi, Polytrichum strictum* and a dense carpet of lichens such as *Cladonia stellaris, Stereocaulon alpinum* and other species, is a characteristic feature of these habitats. In the Gremjachaya Valley we observed only small patches of *Cladino stellaris-Betuletum exilis* association, that are much better developed on the west facing slopes of the Bolshoj Chivyrkuj Valley (Chytrý et al., 1995). Some vegetation with a successional relation to the next stands may be found in rels. 20–21 (see Tab. 1).

2. zone: Subalpine grasslands and krummholz (pod-golcy)

The slopes of the subalpine belt are covered by the mosaic of grasslands and krummholz (Fig. 3, clusters 2a–b). The rocky towers and boulders as well as open talus debris are overgrown with poor vegetation. They are very typical for the subalpine landscape in the Gremjachaya Valley.

2a) (sub-) alpine grasslands (Tab. 1, rels. 2–11): Widely distributed alpine grasslands form a mosaic vegetation with krummholz. While the floristic composition of vegetation types in this belt is similar, the differences are in dominance of some species, and presence or absence of mixed brushes, represented here mostly by *Rhododendron aureum* or juniper scrub of *Juniperus sibirica*.

More hygrophilous species, such as *Veratrum lobelianum, Bupleurum triradiatum* and sedges *Carex aterrima* and *C. ericetorum*, are concentrated in habitats with relatively deeper soils, e.g. in the depressions and snow-patches, where snow cover persists longer than in neighbouring habitats. Dominant species, such as *Anemonastrum sibiricum, Festuca ovina* agg. give name to the association *Anemonastro sibiricae-Festucetum ovinae.* The association belongs to the alliance *Anemonastro sibiricae-Festucion ovinae* and it was recognised from Svjatoj Nos Peninsula as well as from the upper part of the Bolshaya Cheremshana Valley (Danihelka & Chytrý, 1995). A less frequent community with dominant *Rhododendron aureum* is usually developed on gentle slopes with convex relief and along margins of snow-runs. This type was not recorded in the western part of the Barguzinskij Range. Much litter and broad leaves of *Bergenia crassifolia* cover the soil and prevent growth of other herbs. Only some grasses such as *Calamagrostis purpurea* agg., *Festuca ovina* agg. and creeping *Diphasiastrum alpinum* are more common between branches of rhododendron. The remaining floristic composition is similar to *Anemonastro-Festucetum* and we propose for this type a status of variant with *Rhododendon aureum* (Tab. 1, rels. 8–11).

2b) *Pinus pumila*-krummholz (Tab. 1, 9–46): In the Gremjachaya Valley dwarf mountain pine scrubs occur between 1300–1600 m a.s.l. However, *Pinus pumila* extends to the lower part of the valley (ca. 700 m a.s.l.), where it accompanies the species of shrub layer of forest communities. Using our data two main types were recognised. The type with rich moss and lichen layer was described such as *Pleurozio schreberi-Pinetum pumilae.* In the cryptogam layer *Pleurozium schreberi* and *Cladonia* sp. div. are very common. In the Gremjachaya Valley, the differences between communities such as *Pleurozio-Pinetum* and *Pleurozio*

Headings of relevés of Table 1. (continued)

Relevé nr.	Area m^2	Aspect	Slope °	Altit. m	Cover E_3 %	Cover E_2 %	Cover E_1 %	Cover E_0 %	Date 1994
41	25	SE	40	1570	0	0	70	30	8.8.
24	30	S	20	1425	0	0	70	15	7.8.
28	20	S	15	1375	0	0	80	10	7.8.
8	25	S	15	1530	0	0	70	60	3.8.
10	50	E	15	1545	0	0	75	60	4.8.
11	100	NE	30	1550	0	0	75	70	4.8.
Pleurozio schreberi-Betuletum									
21	50	W	5	1550	0	30	70	100	6.8.
20	100	WNW	5	1540	0	70	60	100	6.8.
Pleurozio schreberi-Pinetum									
9	100	W	5	1520	0	80	10	30	3.8.
12	100	NNE	15	1550	0	60	50	100	4.8.
19	100	NW	5	1520	0	70	70	80	6.8.
60	100	SW	25	1230	0	70	15	3	7.8.
61	100	SE	10	1130	30	40	75	5	10.8.
22	100	W	5	1530	0	35	30	95	6.8.
Festuco ovinae-Pinetum pumilae									
56	100	W	15	1430	0	60	10	15	7.8.
59	100	–	–	1330	0	45	20	30	7.8.
58	100	SW	15	1330	10	65	25	15	7.8.
25	100	S	25	1422	0	55	40	25	7.8.
26	100	SSW	30	1425	0	40	20	10	7.8.
27	100	S	30	1390	0	70	50	25	7.8.
29	100	SE	10	1326	0	50	35	20	7.8.
32	100	E	30	1240	0	80	25	20	7.8.
46	100	SE	30	1510	0	60	25	3	8.8.
***Bergenia crassifolia-Juniperus sibirica* community**									
45	75	SE	20	1515	0	90	30	30	8.8.
47	100	E	35	1500	0	95	35	40	8.8.
51	100	SW	5	1660	0	90	60	60	9.8.
52	100	SW	10	1655	0	80	65	30	9.8.

schreberi-Betuletum divaricatae (known from the western slopes of the Barguzinskij Range) are very often obliterated due to several intermediate types (see Tab. 1). A more generalised picture was obtained using richer phytosociological material (Anenkhonov & Chytrý, 1998).

In drier habitats with the skeletal substratum the *Festuco ovinae-Pinetum pumilae* predominantly occurs. Accompanying species in the shrub layer are *Betula divaricata* and *Duschekia fruticosa*, both fast growing shrubs typical for places deforested owing to forest fire. In the herb layer, species such as *Festuca ovina* agg., *Bergenia crassifolia, Anemonastrum sibiricum, Aconogonon ochreatum, Hieracium ganeschinii, Solidago dahurica,* and shrubs such as cranberries and blueberries are constant.

The *Bergenia crassifolia-Juniperus sibirica* community (Tab. 1, rels. 45–52) forms dense juniper scrub in contact with the above mentioned units. The species composition is poor and this community should be classified as a degradation phase or post-fire succession stage of the *Festuco ovinae-Pinetum pumilae* krummholz on eroded slopes and burnt land.

Rare plant communities: In the subalpine zone, open screes and patches with eroded soil are frequent. They are overgrown by sparse vegetation with *Saxifraga bronchialis, Allium splendens, Calamagrostis korotkyi* and endemic *Borodinia tilingii.* A similar community was recorded in the Svjatoj Nos Peninsula and it was described as association *Saxifrago bronchialis-Phlojodicarpetum baicalensis.* Its classification into the montane steppe class *Cleistogenetea squarrosae* remains provisional (see also Chytrý et al., 1993). Three relevés (rels. 32a, 33, 44) document the structure of this community: Gremjachaya Valley, left side, 1260 m a.s.l./1265 m a.s.l./1510 m a.s.l., W/W/SE, 3/40/35, 100 m^2/25 m^2/100

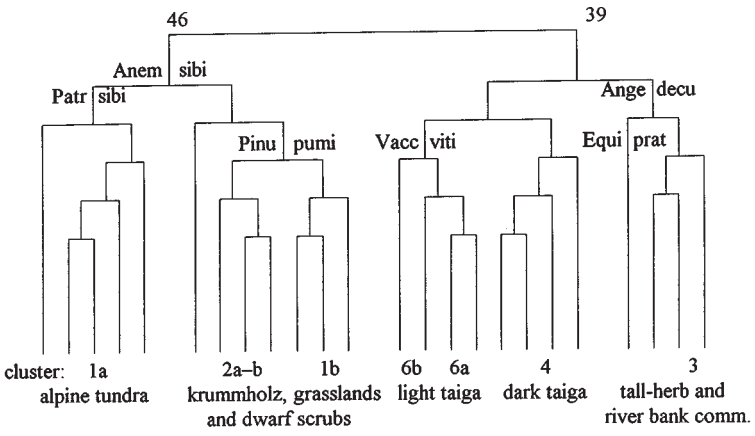

Fig. 3. Dendrogram based on TWINSPAN classification of 85 relevés. Clusters (1–6) corresponding with zones described in the text.

m^2, E_1: 3%/3%/3%, 1994/08/07–08: E_1: *Aconogonon ochreatum* +/+/+, *Saxifraga bronchialis* +/+/+, *Silene repens* +/+/–, *Thymus* cf. *mongolicus* +/+/–, *Calamagrostis korotkyi* +/r/–, *Allium splendens* r/r/–, *Borodinia tilingii* r/r/–, *Campanula rotundifolia* agg. +/–/+, *Pinus pumila* juv. +/–/+, *Vaccinium vitis-idaea* –/+/–, *Festuca ovina* agg. –/–/+, *Sibbaldia procumbens* –/–/+.

3. zone: Ecotone between krummholz and forest

A very narrow ecotone of the *Pinus pumila-Populus tremula* community between dwarf pine scrubs and low aspen and birch forest was observed at an altitude of ±1250 m a.s.l. These stands are floristically rich due to species from various types of vegetation – krummholz, taiga forests and wet meadows: (rel. 36), 1240 m a.s.l., E, 5, 30 m^2, E_3: 40%, E_2: 40%, E_1: 90%, E_0: 3%: 1994/08/07: E_3: *Populus tremula* 3, *Betula pubescens* 1, E_2: *B. pubescens* 2b, *Pinus pumila* 2a, E_1: *Bergenia crassifolia* 2b, *Calamagrostis purpurea* agg. 2a, *Geranium albiflorum* 2a, *Aegopodium alpestre* 1, *Thalictrum minus* agg. 1, *Trollius asiaticus* 1, *Aconitum rubicundum* +, *Calamagrostis obtusata* +, *Chamaenerion angustifolium* +, *Festuca ovina* agg. +, *Galium boreale* +, *Lathyrus humilis* +, *Lilium pilosiusculum* +, *Maianthemum bifolium* +, *Milium effusum* +, *Pedicularis uncinata* +, *Pleurospermum uralense* +, *Rosa acicularis* +, *Solidago dahurica* +, *Vaccinium vitis-idaea* +, *Veratrum lobelianum* +, *Vicia nervata* +, *Viola uniflora* +, *Pedicularis labradorica* r, *Populus tremula* juv. +, E_0: *Ptilium crista-castrensis* 1, *Polytrichum strictum* 1.

Rare communities: The belt around 1200 m a.s.l. is characterised by the first occurrence of wet meadows and tall-forb communities of the class *Mulgedio-Aconitetea*. Their occurrence along streams is due to permanent moisture of the soils. They are common in the upper part of the valley. According to Zhitluhina & Onishchenko (1987) the fragments of these communities occur secondarily on a deforested *Pinus pumila* zone and here they reach an altitude up to 2000 m a.s.l. Typical species are *Veratrum lobelianum, Geranium albiflorum, Trollius asiaticus* and other hygrophilous plants. In the Gremjachaya Valley, the community with *Geranium albiflorum, Cirsium helenioides, Aconitum rubicundum, Pedicularis uncinata,* and *Thalictrum minus* agg. known as *Geranio albiflori-pedicularietum uncinatae* is relatively frequent (Tab. 2, rels. 34–81; Fig. 3, cluster 3). On the other hand, stands with conspicuous *Cacalia hastata* (Chytrý et al., 1995) were recorded only rarely. The *Cacalio hastatae-Calamagrostidetum langsdorffii* Mirkin 1992 is probably similar to these stands. The basic character of the habitat – the mosaics of scrub of *Salix abscondita, S. caprea, Populus tremula* and alpine brush meadows with high abundance of *Calamagrostis purpurea* agg. and various tall-herbs and grasses, is similar too.

The tall-herb communities make a transition towards the springs and river bank communities. The narrow banks of rivulets are overgrown mainly with *Cardamine macrophylla.* A similar association *Rubo-Cardaminetum macrophyllae* Guinochet 1982 was described from the Sajan Mts. near the town of Irkutsk (Guinochet, 1982). The absence of *Rubus arcticus* and other species of this association gives no reason for proposal of a new community (Tab. 2, rels. 31–67). Until now the classification of spring plant communities analogous to the European class *Montio-*

Cardaminetea Br.-Bl. et R. Tx. ex Klika et Hadač 1944 [or to the larger proposed class *Aconito-Geranietea albiflori* Zhitluhina et Onishchenko 1987 (nom. nud.)] is more or less provisional in Siberia (cf. Ermakov et al., 2000b). The moisture and sufficient light are important for development of this vegetation. Therefore, these spring communities are missing in lower part of the valley in the zone of dark forest. Only some of hygrophilous and sciophilous plants are present here and they form a block of differential species of fir forest of the *Cardamino macrophyllae-Abietetum sibiricae*.

4. zone: Dark taiga forest

Cardamino macrophyllae-Abietetum sibiricae (Tab. 2, rels. 98–88; Fig. 3, cluster 4) forms narrow strips along creeks. Firs are sporadic in the plots, but the shade of trees in addition to periodical flooding is a very important ecological factor for the existence of the shade tolerant species such as *Chrysosplenium alternifolium, Caltha palustris* agg., *Saxifraga aestivalis* and several mosses. The association was also observed on the Svjatoj Nos Peninsula and syntaxonomically it belongs to the *Aconito rubicundi-Abietion sibiricae*, although in our community other trees such as *Betula pendula* and taller shrubs of *Duschekia fruticosa* sometimes substitute the fir. Similar units belonging to the easternmost range of the order *Fagetalia* were found in the Altaj, Sajan, and Alatau Mts (Ermakov et al., 2000a).

In the Gremjachaya Valley the typical vegetation belt of dark taiga with conifers is not developed. Small stands occur on the flat floodplain terraces with wet soils. They are most probably analogous to the azonal association *Equiseto hyemalis-Abietetum sibiricae* (Tab. 2, rels. 80–78). Coniferous trees *Abies sibirica, Picea obovata* and *Pinus sibirica* reach a height of more than 20–25 m. Other trees such as *Betula divaricata, Populus tremula*, and *Sorbus sibirica* complete the species composition. The same plants build a shrub layer enriched by *Duschekia fruticosa, Sambucus sibirica, Ribes nigra,* and various *Salix* species. The herb layer is relatively diverse and *Equisetum pratense, E. hyemale* and *E. sylvaticum* are dominant species, while *E. scirpoides* is rather rare. The constant species are boreal forest elements (*Maianthemum bifolium, Linnaea borealis,* rarely *Goodyera repens, Carex globularis* and *Listera cordata*) and they were found only in this vegetation zone. The same habitats were recorded in the Boľshoj Chivyrkuj Valley.

Rare plant communities: As the younger stage of dark fir forest near swamps, scrub of *Aconitum rubicundum-Duschekia fruticosa* community was sporadically recorded (Tab. 2, rel. 95). Species such as *Carex loliacea* and *Galium uliginosum*, both characteristic of permanently wet places, were found.

On the other hand, heliophilous plants such as *Chamaenerion angustifolium* and *Thalictrum minus* agg. occur on treeless as well as on non-forested block deposits near the Gremjachaya River. The open block deposits in lateral debris streams with overflowing water are the typical habitat of the *Carex pediformis-Pteridium aquilinum* community. They are full of heliophilous over-topping herbs and juvenile poplar *Populus tremula* as well as various sedges and grasses: (rels. 74/82), Gremjachaya Valley, left side, 1075 m a.s.l./1085 m a.s.l., SWW/SW, 50/45, 25 m^2, /25 m^2, E_1: 95%/75%, both 1994/08/11: E_1: *Pteridium aquilinum* 4/3, *Rosa acicularis* 2b/+, *Thalictrum minus* agg. 2a/+, *Chamaenerion angustifolium* +/+, *Carex amgunensis* –/1, *C. pediformis* agg. 2b/2a, *Calamagrostis purpurea* agg. 2a/–, *C. epigejos* +/+, *Crepis sibica* 1/–, *Hieracium robustum* +/r, *H. krylovii* +/– , *Allium chamarense* +/+, *Populus tremula* juv. 1/1, *Astragalus propinquus* –/2a, *Spiraea media* 1/1, *Lilium pilosiusculum* +/r, *Melica nutans* +/+, *Campanula rotundifolia* agg. –/+, *Dendranthema zawadskii* –/+, *Dianthus speciosus* –/+, *Dracocephalum nutans* –/+, *Festuca ovina* agg. –/+, *Lamium album* +/–, *Poa botryoides* –/+, *Pulsatila flavescens* –/+, *Rubus saxatilis* +/–, *Silene repens* –/+, *Vicia nervata* +/–.

Similar stands are known also from other valleys of the Barguzinskij Range (Tjulina, 1981). From Boľshoj Chivyrkuj Valley, the *Pteridium aquilinum-Bergenia crassifolia* community, and from Boľshaya Cheremshana the *Pteridium aquilinum-Aconitum rubicundum* were described (Chytrý et al., 1993; 1995). Their definitive position in the classification system needs more phytosociological data.

The *Woodsia ilvensis-Borodinia tilingii* community should be considered as frequent azonal vegetation. It was found in granite rock fissures with dominant ferns *Woodsia ilvensis* and *Dryopteris fragrans.* The relevés were recorded on the main ridge (near 1550 m a.s.l.) as well as on rock outcrops and small towers situated inside the valley (under 1200 m a.s.l.). Some floristic features are evident from the Table 3.

Table 3. Plant communities of rock fissures

Number of relevés	49	30	43	45	76	7
altitude/m	1525	1575	1575	1560	1170	1160
aspect	SW	N	S	E	N	NE
slope/°	90	75	70	40	80	80
area/m^2	0.1	0.2	0.3	0.2	0.4	0.9
E_1/%	25	50	60	75	10	40
E_0/%	1	90	5	5	1	30
E_1:						
Woodsia ilvensis	2b	.	2a	.	.	.
Borodinia tilingii	+	3	+	3	2m	.
Poa attenuata	1	+	+	+	.	.
Dryopteris fragrans	.	.	.	.	.	2b
Aconogonon ochreatum	.	1	.	.	.	.
Calamagrostis korokyi	.	+	.	+	1	2a
Oxytropis alpicola	.	r	.	.	.	.
Gymnocarpium dryopteris	.	+	+	.	.	.
Dendranthema zawadskii	.	.	2b	2b	.	2a
Vaccinium vitis-idaea	.	.	2a	.	.	.
Pinus pumila juv.	.	.	+	.	r	.
Bergenia crassifolia	.	.	1	r	2a	2a
Saxifraga bronchialis	.	.	+	+	.	.
Selaginella rupestris	.	.	.	.	.	1
E_0						
Umbilicaria muehlenbergii	+	.	.	.	+	.
Polytrichum alpinum	.	2a	.	.	.	.
Hypnum cupressiforme	.	+	1	1	.	.
Racomitrium sudeticum	.	4	+	.	.	.
Cladonia stricta	.	+	.	.	.	.
Oncophorus virens	.	.	.	.	.	2b
Hypogymnia physodes	.	.	.	.	.	+
Pohlia cruda	.	.	.	.	.	+
Hedwigia ciliata	.	.	.	.	.	+
Thuidium abietinum	.	.	.	.	.	+

5. zone: Ecotone to light taiga forests

A *Pinus pumila-Populus tremula* community makes conspicuous strips also between subalpine krummholz and light taiga. The most typical habitats are slopes around 30 on both sides of the valley ranging between 1 000–1 100 m a.s.l. Aspen in the tree layer and shrubby cedar pine are physiognomically the most important species. Characteristic herbs are represented by *Pedicularis labradorica*, *Hieracium ganeschinii*, and a small assortment of subalpine plants.

Populus tremula grows separately in the upper timberline and the poplar forests occur primarily on stone habitats, where the pine and spruce cannot grow. In lower part of the valley, poplar occupies mainly secondary habitats (e.g. burnt after fires) (Tab. 2, 63–65).

More stabilised blocks with the diameter of boulders about 1 m are overgrown with lichens and mosses and succession follows to young (5–8 m) poplar forests (see rel. 101 in Tab. 2).

6. zone: Light taiga forest *Calamagrostio obtusatae-Laricetum sibiricae* (Tab. 2, rels. 79–97; Fig. 3, cluster 6a) is one of the most common forest types covering mesic habitats on the slopes with deeper soil at lower altitudes between 600–1 000 m a.s.l. *Pinus sylvestris, P. sibirica, Larix sibirica,* and *Betula pendula* are dominating trees. Species such as *Atragene sibirica, Diphasiastrum complanatum*, and several representatives of Pyrolaceae and *Viola* sp. div., are characteristic of this vegetation in the Gremjachaya Valley.

Xerophilous light pine forest is represented by only 4 relevés from altitudes ranging from 500 to 750 m a.s.l. which can be considered as the association *Scorzonero radiatae-Pinetum sylvestris* (Tab. 2, rels. 100–93; Fig. 3, cluster 6b), originally described not far from the Barguzin Valley (Anenkhonov & Chytrý, 1998). The open pine forests dominated by *Pinus sylvestris* in the tree layer and *Rhododendron dauricum* in the shrub

layer make up the last zone on the alluvial deposits of the Barguzin River. The cover of the herb layer is about 30% with a dense carpet of *Vaccinium vitis-idaea.* A frequent occurrence of some Fabaceae species (*Astragalus suffruticosus, A. propinquus, Lathyrus humilis, Lupinaster pentaphyllus, Vicia nervata*) is conspicuous. The soils are shallow, dry and sandy, partly disturbed due to vicinity of villages. The vegetation shows human influences such as unruly cut timber or frequent traces of fires. The association marks a transition between ultracontinental xerophilous forests of the alliance *Festuco altaicae-Laricion* and light taiga forests of the *Vaccinio-Pinetalia sibiricae* due to species such us *Vaccinium vitis-idaea, Maianthemum bifolium, Betula pendula*, and others.

Rare plant communities: In the lower part of the valley trampled stands on sandy roads have been recorded. Two following relevés (rels. 99, 102) document the composition and structure of the community**:** Gremjachaya Valley, 744 m a.s.l./628 m a.s.l., 2.5 m^2/5 m^2, E_1: 65%/80%, both 1994/08/14: E_1: *Poa supina* 1/4, *Agrostis clavata* 3/1, *Amoria repens* 2b/2b, *Plantago major* 1/1, *Polygonum aviculare* agg. 1/+, *Sanguisorba officinalis* +/–, *Sagina procumbens* +/–, *Trifolium pratense* +/–, *Geum aleppicum* r/–, *Matricaria discoidea* –/+, *Ranunculus propinquus* –/r.

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Table 1. Plant communities of the alpine and subalpine belts – a result of TWINSPAN classification

Relevé number	135 1111414555	2422 11 22	11662 555222234	4455
	67573478952340	23563148801 10	929012 698567926	5712
Alectorio ochroleucae-Patrinietum sibiricae, Dryadion oxydontae				
Patrinia sibirica	a1+11+11+m1+++	....	....	....
Minuartia arctica	++1amm11ma1+1a	+.++..... ..	....	....
Borodinia baicalensis	.+1++++++m+1+.	....	....	....
Selaginella rupestris	+r.r+.1.1ma.+1	++111.r+... ..	....+.	....
Salix sphenophylla	...aaa+11.....	....	....	....
Calamagrostis korotkyi	...r+.+...+.++	....	....	....
Oxytropis alpicola	r......a1.a..3	....	....	....
Poa attenuata	.+..++...++.+1	....	....	....
Hierochloë alpina	.+.11...+++...	....	....	....
Androsace septentrionalis	..+r...+...+..	....	....	....
Silene chamarensis	+.......+....+	....	....	....
Artemisia furcata	........+....1	....	....	....
E0				
Alectoria ochroleuca	+1++++++++++m	.... +.	....	....
Asahinea chrysantha	+++1+++++1+1.+	....	....	....
Thamnolia vermicularis	++++..+++.++++	....	....	....
Cladonia coccifera	+.ar++++++.+..	....+..++rm ..	.+....	....
Parmelia stygia	..+1.aaaaaa13+	........1.. ..	....	....
Parmelia somloensis	11..b..+a+a...	....	....	....
Cladonia verticillata	1..++.+++.....	....	....	....
Umbilicaria mühlenbergii	+r..+r+.r+....	....	....	....
Alectoria nigricans	...a.+11+1...1	....	....	....
Cetraria nivalis	1+.....+....+	....	....	....
Anemonastro sibiricae-Festucetum ovinae				
Anthoxanthum alpinum	..............+++++1111+.	.. ..	1..+.1...	..11
Carex aterrima	..............++1+.+1111+	.. ..	....	....
Solidago dahurica	..............++++++r++1.	.. ...+.	.+.++++.+	.+++
*Veratrum *lobelianum*	.............r+..rba+a.	.. +..+.	....	..+.
Diphasiastrum alpinum	.............b+..a...1bb	.. ....r	....	...a
Sanguisorba officinalis	.............+.+.+.a+...	.. ..	...r.+...	....
Sibbaldia procumbens	.............+++++....1.	.. ..	....	....
Bupleurum triradiatum	.............+++++++....	.. ..	...+.....	..++
Cladonia uncialis E0	.............++..+++....	.. ....+	....	....
var. with Rhododendron aureum				
Rhododendron aureum	.............+........444	.. 1+..3	....	....
Polytrichum juniperinum E0	.........1+....+1..1...a+b	.. ..	..+.....	....
Pleurozio schreberi-Betuletum E2				
Betula divaricata	....	13 +.b.ab	.ab3b33aa	....
Salix krylovii	....	a+	....	....
E1				
*Ledum *decumbens*	....	4a .a....	....	....
Vaccinium uliginosum	....	bb .a1...	....	....
Carex iljinii	....+..11	b3 +.a.1+	....	...1
E0				
Sphagnum girgensohnii	....	31	....	....
Aulacomnium turgidum	....	b+	....	....
Peltigera aphthosa	....	+a	....	....
Cladonia amaurocraea	....	++	....	....
Hylocomium splendens	....	++	....	....
Pleurozio schreberi-Pinetum				
E2				
Pinus pumila	....	1a 4b443a	333babb43	++++
*Betula *exilis*	....	.. +3....	....	....
E1				
Linnaea borealis	....	.1 .aa...	....	....

Table 1. (continued)

E0						
Pleurozium schreberi	.....	.....a+	34	+1311+	.....+..	.1bb
Cladonia stellaris	...+.....	.....	1+	b31+.3	a+.....+.	...+
Polytrichum commune	.....	.....	b1	.3a.+1	.....	....
Dicranum polysetum	.....	.....	++	.4b.+.	..+.....	....
Festuco ovinae-Pinetum pumilae						
Duschekia fruticosa E2	.....	.....	+.	+..a..	**aab.++111**	....
Hieracium ganeschinii	.....	.....	..	.....	**r.r+.++++**	....
Astragalus trigonocarpus	.....	.....	..	.....	**+....1+.r**	....
Antennaria dioica	.....	..r.++.....	..	.....	**...1++.++**	....
Cladonia gracilis E0	.....	....1.....	..	.....	**...+++++.**	..+.
Bergenia crassifolia-Juniperus sibirica community						
Juniperus sibirica E2	.....	r.....	..	.....	.....	5555
Vaccinio-Pinion pumilae						
Festuca ovina agg.	.....	1ab3bba+aaa	..	...+1+	.a11+ab11	ba33
Bergenia crassifolia	.....	bb3313333aa	..	+.4.4+	.1b1.a+++	abab
Vaccinium myrtillus	.....	3bbabbab+1.	..	..1.a+	.11a1a+.+	1111
Campanula rotundifolia agg.	.+.....r.....	+++++++....	..	+...+.	+++++++r+	++.+
Pinus pumila	+.....	+++++++r+++	+.	.1..++	..+++1+++	+.++
E0						
Cetraria islandica	.+.....	3bb3b+..334	..	+1+..3	...a.+...	bb3a
Cladonia rangiferina	.....	31..1+.....	..	aa.+++	+.+..111.	...+
Cladonia arbuscula	.....	.a++.+...+.	1.	...++1	1.1.+1...	....
Cladonia pleurota	.....	.+1+1a++.+.	..	.+....	...1.+.+.	++++
Vaccinio-Piceetea						
Anemonastrum sibiricum	++.+..+++r+.ra	aa1a1a1+11+	..	+.+..r	+..1+1+.1	++11
Polygonum baicalense	++++++++++1+++	+++++++++..	..	+..+..	+1++.++++	....
Vaccinium vitis-idaea	a+...r++.....	1.+.+++.11a	1a	a11+1+	1+++++1ba	++++
E0						
Polytrichum piliferum	1.+amamm11+1++	aa334bba11b	..	...+.+	13aaa11a+	1+aa
*Cladonia *mitis*	++.+.....b	13.1+...+++	++	.a...1	...+..11.	...+
Stereocaulon paschale	++1+..r.....b	a1.+b...+..	..	1..++3	++11+++++	..11
Others						
E3						
Pinus sylvestris	.....	.....	..	...1..	.....	....
Betula pendula	.....	.....	..	....3.	..a.....	....
E1						
*Dianthus *alpestris*	.....	+.++.+++...	..	.....	..+..++.+	++++
Carex ericetorum	.....	...1..++...	..	.....	...1.++++	.+++
Calamagrosis purpurea agg.	.....	.....a+a+.	..	....a.	.+..+.1..	.+..
Betula divaricata	.....	....r.....	+1	..+...	.....+..	..+.
Populus tremula juv.	.....	.....	..	...++.	....b..+.	....
Chamerion angustifolium	.....	.....	..	...+1.	+.....	....
Carex pediformis	.....	.....	..	...+..	.++.....	....
Luzula sibirica	.....r.....+	..	.....	...+.....	....	.
Pulsatilla flavescens	.....	..r.....	..	.....	.+.....r	....
*Betula *exilis* juv.	.....r.....	.....	..	.a....	.....	..1.
Carex kirilowii	.....	....+.....	..	.....	.....	1+..
Maianthemum bifolium	.....	.....	..	....a.	...+.....	....
Arctostaphylos uva-ursi	.....	.....	..	...a..	.....+.	....
Carex rupestris	.....+...b	.....	..	.....	.....	....
Saxifraga bronchialis	.++.....	.....	..	.....	.....	....
Festuca sp.	..+.....r.....	.....	..	.....	.....	....
Youngia tenuifolia	.....r..+.	.....	..	.....	.....	....
Calamagrostis lapponica	.....	.....+.....	+.	.....	.....	....
*Carex *ensifolia*	.....	......+1...	..	.....	.....	....
Viola sp.	.....	.....r+	..	.....	.....	....
Silene repens	.....	.....	..	...++.	.....	....
Abies sibirica E2	.....	.....	..	.....	.....++.	....

Table 1. (continued)

Poa sibirica	.....	.....	..	.....	.....	++..
E0									
Pohlia nutans	.....	.....++.+.	+.	.....	.....	++..
Polytrichum strictum	....1.....	.....	11	.....+	.....+a..	....
Cetraria cucullata	...++.....	.....	+.	.1...+	.....	....
Dicranum congestum	.....	.....+..	..	..+..+	.....	..++
Stereocaulon alpinum	.....++.....	.....a.	..	.....	.....	....
Parmelia ompalodes	.....a++....	.....	..	.....	.....	....
Ophioparma ventosa	.....r.r+....	.....	..	.....	.....	....
Cornicularia odontella	...+...+.....	.....	..	.....	.....	....
Rhizocarpon geographicum	.....r..r....	.....	..	.....	.....	....
Cladonia carneola	.....	+..+.....	..	.....	.....+.	....
Ceratodon purpureus	.....	.....+..+.	..	.....	.....	....
Cladonia macrophyllodes	.....	..+.....	..	.....	.....+...	....
Cladonia multiformis	.....	.....+.....	..	.....	....+....	....
Sphagnum rubellum	.....	.....	.+	.1....	.....	....
Peltigera scabrosa	.....	.....	.+	.+....	.....	....
Aulacomnium palustre	.....	.....	.1	.+....	.....	....
Cladonia sulphurina	.....	.....+	..	.....	....+.+..	....
Bryum sp.	.....	.....	..	...+..	..+.....	....

In one relevé only: E_2: *Salix * divaricata* 21: +; E_1: *Abies sibirica* 19: +; *Astragalus propinquus* 60: +; *Carex canescens* 23: +; *Carex* sp. 41: 1; *Dendranthemum zawadskii* 60: +; *Diphasiastrum complanatum* 32: +; *Dracocephalum nutans* 6: r; *Dryas punctata* 49: 2b; *Empetrum subholarcticum* 21: +; *Geranium albiflorum* 45: +; *Hieracium umbellatum* 27: r; *Luzula * kamtschadalorum* 11: +; *Minuartia biflora* 24: +; *Orthilia secunda* 19: 1; Rosa *acicularis* 21: 1; *Salix glauca* 21: +; *S. krylovii* 20: +; Salix sp. 50: +; *Silene jenisseensis* 50: +; *Thymus asiaticus* 42: +; E_0: *Cladonia cornuta* 29: +; *C. * chlorophaea* 2: +; *C. crispata* 29: +; *C. deformis* 25: +; *C. fimbriata* 41: +; *Cladonia* sp. 5: +; *C. phyllophora* 12: +; *C. stricta* 41: +; *Cornicularia divergens* 37: +; *Dicranum bergerii* 20: +; *D. muehlenbeckii* 12: +; *Dicranum* sp. 10: +; *D. scoparium* 32: +; *Drepanocladus vernicosus* 20: +; *Lecanora* sp. 17: +; *Peltigera neckerii* 20: +; *Ptilium crista-castrensis* 21: +; *Racomitrium sudeticum* 10: +; *Sphagnum angustifolium* 20: 1; *S. capillifolium* 20: +; *S. palustre* 12: 1; *Stereocaulon glareosum* 18: +;

Headings of relevés of Table 1.

Relevé nr.	Area m^2	Aspect	Slope °	Altit. m	Cover E_3 %	Cover E_2 %	Cover E_1 %	Cover E_0 %	Date 1994
Alectorio ochroleucae-Patrinietum sibiricae									
16	25	W	5	1555	0	0	10	30	6.8.
37	25	S	5	1534	0	0	5	15	8.8.
55	25	SE	3	1530	0	0	6	15	7.8.
7	25	E	15	1560	0	0	15	25	3.8.
13	50	N	3	1550	0	0	10	20	5.8.
14	25	N	5	1555	0	0	10	15	5.8.
17	50	–	–	1610	0	0	5	15	6.8.
18	50	N	3	1610	0	0	10	15	6.8.
49	25	E	3	1576	0	0	25	35	9.8.
15	100	NE	5	1530	0	0	5	10	5.8.
42	25	–	–	1574	0	0	10	20	8.8.
53	100	N	2	1525	0	0	3	15	6.8.
54	25	SE	5	1525	0	0	8	30	6.8.
50	15	W	10	1630	0	0	75	60	9.8.
Anemono sibiricae-Festucetum ovinae									
2	25	S	20	1523	0	0	50	75	3.8.
3	25	S	25	1520	0	0	40	80	3.8.
5	25	S	25	1530	0	0	40	65	3.8.
6	25	SSE	25	1540	0	0	50	60	3.8.
23	50	SE	20	1425	0	0	35	85	7.8.

Table 2. Tall-herb and forest communities – result of TWINSPAN classification

Relevé number	33778	367766	1 9088	88897	9	1 708788990	1 66666	111 0009
	45011	193227	8538	05648	5	969774671	34685	0343
Geranio albiflori-Pedicularietum uncinatae								
Pedicularis uncinata	++1++	...+..	....	.....	.	....	.....	....
Thalictrum minus agg.	+13.+	.....	....	.....	.	....	.....	....
Pleurospermum uralense	+.+++	.....	....	.....	.	....	.....	....
Botrychium lunaria	r++..	.....	....	.....	.	....	.....	....
Rubo-Cardaminetum macrophyllae								
E0								
Pseudobryum cinclidioides	+....	ab33b1	....	.....	.	....	.....	....
Brachythecium reflexum	+....	.b..ab	....	....+	.	....	....+	....
Calliergon richardsonii	.....	....aa	....	.....	.	....	.....	....
Trollio asiaticae-Crepidion sibiricae, Mulgedio-Aconitetea								
Geranium albiflorum	11b+3	+r...+	..+.	.+...	.	....	.....	....
Aconitum baicalense	...b.	...+1+	.+..	.....	.	....	.....	....
Lamium album	++.+.	++....	....	.....	.	....	.....	....
Cirsium helenioides	ba.3.	+r.b.+	..++	.....	.	....	.....	....
Trollius asiaticus	11++b	.+.++a	+..a	.....	.	....	.....	....
Anthriscus sylvestris	++.1.	...1.1	.+.1	.....	.	....	.....	....
Myosotis nemorosa	...+.	.1.+.+	++.+	.....	.	....	.....	....
Milium effusum	.+.1.	+...++	..+.	.....	.	....	.....	....
Poa sibirica	..+.+	+.....	....	.....	.	....	.....	....
Cardamino macrophyllae-Abietetum sibiricae								
Cardamine macrophylla	.....	b.313a	4b4b	..++.	+	....	.....	....
Chrysosplenium alternifolium	1....	b1b11+	a1aa	.....	.	....	.....	....
Caltha palustris agg.	+..+.	b33bb1	a+11	.....	.	....	.....	....
Angelica decurrens	b1.+.	a114bb	++ab	.....	.	....	.....	....
Saxifraga punctata	+....	bbb.3a	.1ab	.....	.	....	.....	....
E0								
Calliergon stramineum	.....	.....	b3bb	.....	.	....	.....	....
Plagiochila asplenioides	.....	.....	a+1+	.....	.	....	.....	....
Rhizomnium pseudopunctatum	.....	.....	b1a.	.....	.	....	.....	....
Rhizomnium punctatum	.....	.....	3b1a	..+..	.	....	.....	....
Bryum pseudotriquetrum	.....	.....	.b.+	.....	.	....	.....	....
Marchantia polymorpha	.....	....+1	.+.+	.....	.	....	.....	....
Equiseto hyemalis-Abietetum sibiricae								
E3								
Abies sibirica	.....	.....	3...	3b331	.	..1..a+..	.....	....
Picea obovata	.....	.....	....	.+11.	.	.....+1..	.....	....
E2								
Abies sibirica	.....	.....	...a	1bab+	.	..++.ba+.	.....	....
E1								
Equisetum hyemale	.....	.....	....	+mmrb	.	.......+.	.....	....
Equisetum pratense	.....	.....	++++	33a34	b	....	.....	....
Gymnocarpium dryopteris	.....	.....	+.+.	1a1a1	.	....	..+..	....
Equisetum scirpoides	.....	.....	+...	.+++.	.	....	.....	....
Trientalis europaea	.....	....+.	....	+.+1.	+	......+..	.....	....
Lycopodium annotinum	.....	.....	....	++1+.	.	....	.....	....
Carex iljinii	.....	.....	....	1a1..	.	....	.....	....
Pohlia cruda E0	.....	.....	....	a...b	.	....	.....	....
***Aconitum rubicundum-Duschekia fruticosa* community**								
Carex loliacea	.....	.....	....	.....	a	....	.....	....
Aconito rubicundi-Abietion sibiricae								
Ribes nigrum	.....	.....	a3+r	+a++1	+	....	.....	....
*Veratrum *lobelianum*	++++1	+r.++1	++11	+r.r.	.	....	.....	....
Aconitum rubicundum	1a.a.	...111	+a+a	.....	.	....	.....	....
Urtica dioica	.....	.....	++.+	.r...	+	....	.....	....

Table 2. (continued)

Paris quadrifolia	...+.	.....	+..+	++...	.	.....+...	.....	....
Lonicera pallasii E2	.....	.....	+...	r....	.	.....	.....	....
Duschekia fruticosa juv.	.....	.....	....	..+..	+	.....	.....	....
Equisetum sylvaticum	.....	.....	....	..3..	1	.....	.....	....
Salix taraikensis E2	.....	.....	.1..	.....	+	.....	.....	....
Adoxa moschatellina	..+..	.....+	....	.....	+	.....	.....	....
Calamagrostis obtusatae-Laricetum sibiricae								
E3								
Larix sibirica	.....	.....	....	.+.11	.	.ba.+1aa.	.....	1..1
Pinus sibirica	.....	.....	....	..baa	.	b+.+a+1..	...1.	....
E2								
Pinus sibirica	.....	.....	....	..+..	.	a+a+1..+.	.....	..+.
Sorbus sibirica	.....	.....	....	.+...	.	+.+++.++.	..+..	....
E1								
Atragene sibirica	.....	.....r	....	.....	.	++.+++++.	.....	...+
Pinus sibirica juv.	.....	.....	....	.....	.	.+.+++++.	.....	+...
Viola sacchalinensis	....+	.....	....	.....	.	+..++++..	...+.	...+
Viola uniflora	..+..	.....	....	.....	.	++.+++++.	.....	...+
Pyrola chlorantha	.....	.....+	....	.....	.	+...++.+.	.....	.+..
Spirea media	.....	.....	....	.....	.	...1..++.	...+.	.+..
***Pinus pumila*-*Populus tremula* community**								
E3								
Populus tremula	.....	.....	..3.	3	.	1+.43++.4	33344	...1
E2								
Pinus pumila	....r	.....	....	r.+..	.	++b.1.+r.	bbba1	....
E1								
Pinus pumila juv.	.....	.....	....	.....	.	+.+.....	++++.	....
Pedicularis labradorica	.....	.....	....	.....	.	...++....	++.++	....
Hieracium ganeschinii	.....	.....	....	.....	.	.....	.r++.	....
Silene repens	+....	.....	....	.....	.	.....	++.+.	....
Campanula rotundifolia agg.	....+	.....	....	.....	.	..+.....	+++..	....
Cladonia pleurota E0	.....	.....	....	.....	.	.....+	+.+..	....
Solidago dahurica	..+.+	....+.	....	.....	.	.....r.	++..+	....
Pino sibiricae-Laricion sibiricae								
Diphasiastrum complanatum	.....	.....	....	.....	.	..++.1.+.	..+.+	....
Viola brachyceras	..+..	.....	....	...+.	.	.++...++.	.....	....
Orthilia secunda	....+	.....	....	1	+	...+.+.+.	.....	....
Pyrola asarifolia	.....	.....+	....	...1.	.	.+...1+..	.....	...+
Larix sibirica E2	.....	.....	....	.....	.	+......+.	.....	....
Salix cf. *caprea*	.....	.....	....	....r	.	..r..+...	.....	....
Rubus matsumuranus	.....	.....	....	.....	+	......+..	.....	....
Goodyera repens	.....	.....	....	..+..	.	......+..	.....	....
Luzula pilosa	.....	.....	....	.....	r	......r..	.....	....
Vicia venosa	.....	.....	....	.+...	.	.......+.	.....	....
Vaccinio-Pinetalia sibiricae, Vaccinio-Piceetea								
Duschekia fruticosa E2	.....	.....	1b..	++1+.	4	1b1.+++1.	1..1.	....
Abies sibirica juv.	.....	.....	....	++1..	+	++.+.+.+.	.....	....
Pinus sylvestris juv.	.....	.....	....	....+	.	.+a+..+..	1....	..++
Vaccinium vitis-ideae	..r.+	.....	....	....+	.	babbb3a3.	aaaa1	3b3a
Sorbus sibirica juv.	.....	.....	....	+.+..	.	+...++r+.	....+	....
Lonicera pallasii	.....	.....	....	r+...	.	...+.+.+.	.....	....
Picea obovata E2	.....	.....	....	...1.	.	.....+1..	.....	...+
Linnaea borealis	.....	.....	+...	m11ab	.	+1aa.3ab.	..+.+	....
E0								
Hylocomium splendens	.....	.....	1...	..++.	.	.a1...11.	.....	....
Scorzonero radiatae-Pinetum sylvestris								
E3								
Pinus sylvestris	.....	.....	....	.....	.	33b1aba3.	...11	3443
E2								
Rhododendron dauricum	.....	.....	....	.....	.	.a1...+..	.....	b331
E1								
Scorzonera radiata	.....	.....	....	.....	.	.....	.....	+++r

Table 2. (continued)

Sanguisorba officinalis	.....	......	....	.....	.	....	.....	**++++**
Trifolium lupinaster	.....	......	....	.....	.	....	.....	**+.++**
Astragalus fruticosus	.....	......	....	.....	.	.......+.	.....	**.++.**
Rhaponticum uniflorum	.....	......	....	.....	.	....	.....	**+..+**
Festuco altaicae-Laricion, Festuco ovinae-Laricetalia sibiricae, and Rhytidio-Laricetea sibiricae								
Festuca ovina agg.	....+	......	....	.....	.	++.......	**ba+++**	**.++.**
Dendranthemum zawadskii	.....	......	....	.....	.	........+	**+..+.**	**r+r.**
Pulsatilla flavescens	.....	......	....	.....	.	....	**.+.+.**	**.+1.**
Astragalus propinquus	.....	......	....	.....	.	....	**+..1.**	**+..+**
Antennaria dioica	.....	......	....	.....	.	....	**...+.**	**.+r.**
Lathyrus humilis	..+..	......	....	.+...	.	.+...+.+.	**.....**	**+++b**
Hieracium umbellatum	.....	......	....	.....	.	....	**++...**	**....**
Vicia nervata	.....	......	....	.....	.	....	**.....**	**.++.**
Others								
Betula pendula E3	.....	......	ab3.	b31aa	.	a1b+13ba+	133.+	+..b
Betula pendula E2	.....	......	+1.1	+.+.1	+	..1.1++1.	.b1.+	b.1b
Populus tremula E2	....r	......	.1..	+...+	.	11.+..+..	..a++	...b
Betula pendula juv.	.....	......	....	.+...	+	...+.+...	.....	+.r.
Maianthemum bifolium	.r+++	......	+...	1+1a+	+	+1+1++11.	...++	++.1
Calamagrostis obtusata	+aa3.	.+....	.1.1	1+1a1	3	++.+++1..	....+	..++
Calamagrostis purpurea agg.	+++++	+..+1+	.+1+	++.1.	+	....+....	.++.+	...+
Chamerion angustifolium	1baa+	....+.	.+..	+..rr	r	+..r...r.	.++++	+..+
Aegopodium alpestre	+++..	.+...+	+...	...+.	+	.....r+r.	.....	...+
Bergenia crassifolia	....b	....+.	....	b+..+	.	.+.1..+..	.1a.b	....
Rosa acicularis	..r..	......	....	..++.	.	+r+a+a+1+	.....	1++a
Lilium martagon var. *pilosiusculum*	..++r	......	....	.r...	.	.....+...	..+++	...+
Rhododendron dauricum juv.	.....	......	....	.....	.	.+1...+..	.....	.a+.
Carex pediformis	..+.1	......	....	.....	.	++.3+11++	..11+	...a
Populus tremula juv.	..+..	......	....	+++.+	.	++r+++..r	+..++	...+
Pinus sylvestris juv.	.....	......	....	.....	+	....+..+r	...+.	+.++
Aquilegia sibirica	.....	......	.+..	.....	.	...+.+...	.+.r.	....
*Dianthus *alpestris*	..+.+	......	....	.....	.	....	...+.	....
Salix cf. caprea E2	.....	......	....	.....	.	r......r.	.....	...+
Spirea media E2	.....	......	....	.....	.	...+.....	.....	...1
Galium boreale	.....	......	....	...+.	.	....	.....	...+
Calamagrostis lapponica	.....	......	....	.....	.	....	.++..	....
Moehringia lateriflora	....+	......	.+..	.....	1	....	.....	...+
Vaccinium myrtillus	....b	......	....	.....	.	....	.+...	....
Pyrola minor	.....	.....+	....	+....	.	....	.....	....
Polemonium racemosum	.....	....++	....	.....	.	....	.....	....
E0								
Pleurozium schreberi	.....	......	....	a13+1	.	1a4b1+b1.	.+1++	ba1.
Ptilium crista-castrensis	.....	......	....	1.1..	.	+.+++.111	....+	1+..
Cladonia rangiferina	.....	......	....	.....	.	.ra.....3	..+.+	.+1.
Dicranum polysetum	.....	......	....	.....	.	.11+..+..	....+	++a.
Polytrichum commune	.....	......	....	.....	+	.....+++.	1	a...
Drepanocladus uncinatus	.....	......	.1..	.....	.	...+.....	..+.+	....
Peltigera malacea	.....	......	....	.....	.	.r......+	.....	+...
Cladonia stellaris	.....	......	....	.....	.	.r+......	.....	..1.
Peltigera aphthosa	.....	......	....	.....	.	..+......	.....	..+.
Polytrichum juniperinum	.....	......	....	.....	.	....	1.+..	....
Polytrichum piliferum	.....	......	....	.....	.	........+	+....	....

In one relevé only: E_3: *Sorbus sibirica* 80: +; E_2: *Sambucus sibirica* 85: +; E_1: *Allium splendens* 100: r; *Anthoxanthum alpinum* 81: 2a; *Cacalia hastata* 105: +; *Carex globularis* 86: +; *Diplazium sibiricum* 85: +; *Galium uliginosum* 95: +; *Hieracium robustum* 68: +; *Larix sibirica* juv. 103: +; *Listera cordata* 80: +; *Melica nutans* 68: r; *Moneses uniflora* 94: r; *Picea obovata* juv. 86: +; *Poa botryoides* 101: +; *P. stepposa* agg. 68: +; *Polygonum baicalense* 70: +; *Rubus saxatilis* 93: +; *Salix abscondita* juv. 34: +; *Sambucus sibirica* 85: +; *Saxifraga bronchialis* 100: +; *Sorbaria sorbifolia* 105: +; *Woodsia ilvensis* 101: +; E_0: *Brachythecium campestre* 34: +; *B. oedipodium* 31: 2b; *B. starkei* 35: +; *Cetraria* sp. 100: r; *Cladonia * chlorophaea* 77: +; *C. coniocraea* 100: r; *C.*

Table 2. (continued)

fimbriata 100: r; *C. * mitis* 77: +; *Cladonia* sp. 66: +; *C. stricta* 101: +; *Dicranum bergerii* 66: +; *D. spadiceum* 101: +; *Grimmia affinis* 101: +; *Hedwigia ciliata* 101: +; *Ortotrichum* sp. 65: +; *Parmelia somloensis* 101: 4; *Parmeliopsis hyperopta* 100: r; *Peltigera polydactylon* 106: r; *Plagiothecium denticulatum* 67: 1; *Plagiomnium rostratum* 62: 2b; *Pohlia nutans* 63: +; *Polytrichum strictum* 70: +; *Rhitidiadelphus triquetrus* 86: +; *Riccardia multifida* 78: +; *Tetraphis pellucida* 78: +; *Tomenthypnum* sp. 67: +; *Umbilicaria muehlenbergii* 101: 2b; *Usnea* cf. *hirta* 86: +;

Headings of relevés of Table 2.

Relevé nr.	Area m^2	Aspect	Slope °	Altit. m	Cover E_3 %	Cover E_2 %	Cover E_1 %	Cover E_0 %	Date 1994
Geranio albiflori-Pedicularietum uncinatae									
34	50	SSW	15	1235	0	0	100	20	7.8.
35	25	S	5	1235	0	0	100	35	7.8.
70	35	SE	5	1170	0	0	100	5	11.8.
71	25	SE	5	1158	0	0	100	30	11.8.
81	50	SSW	10	1183	0	1	95	0	11.8.
Rubo-Cardaminetum macrophyllae									
31	100	S	20	1260	0	0	100	40	7.8.
69	10	SSE	5	1182	0	0	95	50	11.8.
73	9	E	10	1156	0	0	100	60	11.8.
72	20	SE	5	1158	0	0	90	50	11.8.
62	25	SE	10	1130	0	0	100	6	10.8.
67	25	SE	5	1028	0	0	85	4	10.8.
Cardamino macrophyllae-Abietetum sibiricae									
98	20	SE	5	718	40	10	95	70	13.8.
105	10	S	5	628	20	40	80	70	14.8.
83	25	S	5	929	70	0	95	40	11.8.
88	25	NE	10	720	0	10	95	50	12.8.
Equiseto hyemalis-Abietetum sibiricae									
80	400	E	5	923	70	10	85	20	11.8.
85	300	–	–	819	70	15	70	1	12.8
86	400	S	5	839	65	15	80	60	12.8.
94	400	–	–	718	65	30	60	5	13.8.
78	100	E	5	929	70	10	85	30	11.8.
***Aconitum rubicundum-Duschekia fruticosa* community**									
95	50	–	–	720	0	85	90	3	13.8.
Calamagrostis obtusatae-Laricetum sibiricae									
79	400	WSW	10	938	75	10	30	5	11.8.
106	400	NE	25	629	70	40	20	20	14.8.
89	400	?	40	725	60	60	40	80	12.8.
77	400	SE	5	935	75	10	60	10	11.8.
87	400	E	5	931	60	10	30	2	12.8.
84	400	SE	10	835	75	25	35	1	12.8.
96	400	N	20	734	60	15	35	30	13.8.
97	400	SSW	5	815	70	10	40	70	13.8.
101	400	SW	30	650	60	–	5	80	14.8.
***Pinus pumila-Populus tremula* community**									
63	100	W	27	1130	50	35	30	2	10.8.
64	100	SE	30	1130	60	35	30	6	10.8.
66	100	SE	35	1033	75	35	30	2	10.8.
68	100	SW	25	1032	75	10	25	1	10.8.
65	100	S	5	1025	75	6	35	2	10.8.
Scorzonero radiatae-Pinetum sylvestris									
100	400	SW	30	638	60	20	35	15	14.8.
103	400	–	–	528	65	50	20	10	14.8.
104	400	–	–	527	60	50	30	15	14.8.
93	100	S	25	730	65	50	50	0	13.8.