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Snowbed vegetation in the plain East European tundra: new alliances and place in syntaxonomic system

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ABSTRACT

We studied snowbed communities in place of long-lying snow in the typical and southern tundra subzones of the East European sector of the Arctic. Three new associations (Salicetum herbaceae-polaris Lavrinenko et Lavrinenko **ass. nov.**, Salici polaris–Sibbaldietum procumbentis Lavrinenko et Lavrinenko **ass. nov.** and Myosotido asiaticae–Salicetum polaris Lavrinenko et Lavrinenko **ass. nov**.) on siliceous substrates united into a new alliance Veronico alpinae–Salicion polaris Lavrinenko et Lavrinenko **all. nov.** in order Salicetalia herbaceae and class Salicetea herbaceae. One new association (Pinguiculo alpinae–Salicetum reticulatae Lavrinenko, Lavrinenko et Neshataev **ass. nov.**) on stabilized calcareous soils is placed in a preliminary alliance Carici parallelae–Salicion reticulatae Lavrinenko, Lavrinenko et Neshataev prov. in order Arabidetalia caeruleae and class Thlaspietea rotundifolii. Table analysis, cluster analysis of relevés and syntaxa and analysis of association coenofloras from East European tundra, from mountainous areas of Northern Europe and from Arctic Siberia confirm the reliability of defining new alliances.

Keywords: snowbed vegetation, Salicetea herbaceae, Arabidetalia caeruleae, Braun-Blanquet classification, tundra zone, Arctic

РЕЗЮМЕ

Лавриненко О.В., Лавриненко И.А., Нешатаев В.В. Нивальная растительность равнинных восточноевропейских тундр: новые союзы и место в синтаксономической системе. Изучены нивальные сообщества в местах долгого лежания снега в подзонах типичных и южных тундр восточноевропейского сектора Арктики. Три новые ассоциации на силикатных породах (Salicetum herbaceae-polaris Lavrinenko et Lavrinenko **ass. nov.**, Salici polaris–Sibbaldietum procumbentis Lavrinenko et Lavrinenko **ass. nov.**, Myosotido asiaticae–Salicetum polaris Lavrinenko et Lavrinenko **ass. nov.**) объединены в новый союз Veronico alpinae–Salicion polaris Lavrinenko et Lavrinenko **all. nov.** в порядке Salicetalia herbaceae и классе Salicetea herbaceae. Одна новая ассоциация на стабильном карбонатном субстрате (Pinguiculo alpinae–Salicetum reticulatae Lavrinenko, Lavrinenko et Neshataev **ass. nov.**) помещена в предварительный союз Carici parallelae–Salicion reticulatae Lavrinenko, Lavrinenko et Neshataev prov. в порядке Arabidetalia caeruleae и классе Thlaspietea rotundifolii. Анализ таблиц, кластерный анализ описаний и синтаксонов и анализ ценофлор ассоциаций из восточноевропейских тундр, из горных районов Северной Европы и из арктической Сибири подтверждают обоснованность описания новых союзов.

Ключевые слова: нивальная растительность, Salicetea herbaceae, Arabidetalia caeruleae, классификация по Браун-Бланке, тундровая зона, Арктика

In plain tundra, the presence of hilly or ridged relief, or, on the contrary, relief dissected by canyon-like river valleys, i.e. the presence of slopes of different exposures, significantly enriches the vegetation cover. Herbaceous (low-herb) meadows and dwarf shrub-herb-moss grasslands with beautifully flowering arctoalpine and hypoarcto-montane species are formed on the slopes. The lower parts of the slopes of the northern exposure in places of long-term snow cover are occupied by snowbed vegetation with mosses and dwarf willows. Snowbed communities in ecological, floristic and physiognomic respects represent one of the most peculiar types of tundra vegetation. In East European tundras, these communities are usually developed locally and have a very small extent. The floristic composition is primarily determined by the long snow cover. This factor leads to a significant shortening of the vegetation period, increased soil moisture due to the inflow of water from melting snowfalls, and a decrease in soil and aboveground temperatures.

Snowbed vegetation was initially recorded in the mountains of central Europe and subsequently observed in alpine Fennoscandia, in Iceland and in Arctic Greenland. Creating a classification of the floristic-sociological hierarchy using the Braun-Blanquet approach was a complex process, with different perspectives on understanding the ranking of the higher syntaxa (see, for example, Molenaar 1976, Daniëls 1982, Koroleva et al. 2019).

The modern classification of snowbed communities based on a combination of floristic and ecological criteria was introduced by R. Nordhagen (1936, 1943). In Norway, Nordhagen distinguished four alliances, which he merged into the order Salicetalia herbaceae Br.-Bl. in Br.-Bl. et Jenny 1926. Later, E. Dahl (1957) revised Nordhagen's classification system by giving greater importance to ecological criteria. The author narrowed down the concept of the order Salicetalia herbaceae, for the purpose to solely encompass the plant communities that exist on solifluction soils and have a short growing season, i.e. snowbed communities specifically of the alliances Cassiopo–Salicion herbaceae Nordhagen 1943 and Ranunculo–Oxyrion digynae Nordhagen 1943 [in Mucina et al. 2016 reduced to a synonym for Saxifrago stellaris–Oxyrion digynae Gjaerevoll 1950].

J.G. de Molenaar (1976) proposed the use of similarities and differences in ecology and community structure as a practical solution to classify floristically similar snowpack communities with their many mutual transitions, using the approach of Nordhagen (1943) as modified by E. Dahl (1957). He also distinguished two alliances of snowbed vegetation in the strict sense of the term. Oligotrafent cryptogamous and cryptogam-rich dwarf shrub communities, grouped under the alliance Cassiopo–Salicion herbaceae, occur on mobile substrates subject to solifluction, with a superficial, acidic and usually thin but distinct humus layer. These communities occur only where the upper part of the substrate is washed away by excessive inputs of mineral-poor water from nearby snow drifts. The Ranunculo–Oxyrion digynae usually combines three-layered mesotrafent and eutrafent herbaceous communities dominated by hygrophytes. These communities are sometimes rich in cryptogams and occur on stable (or relatively stable) soils enriched with humus up to peat in the surface layers.

Describing the alliance Cassiopo–Salicion herbaceae Nordhagen (1943) noted the fact that acidophityc-oligotrophic species of the genera *Kiaeria*, *Conostomum*, *Anthelia*, *Gymnomitrion*, *Marsupella*, *Nardia*, *Pleuroclada* as well as *Polytrichum sexangulare* provide the greatest coverage in the composition of its communities. These mosses consistently create a dark color on the bottom. Sometimes lichens *Cetraria islandica*, *Cetrariella delisei*, *Solorina crocea*, *Cladonia gracilis elongata* (probably *C. ecmocyna* is behind this name) dominate along with the mosses. The moss flora of the alliance Ranunculo–Oxyrion digynae was much more eutrophic or mesotrophic and was characterised by green or red carpets of *Pohlia* and *Bryum* species, *Bartramia ithyphylla*, *Drepanocladus*, *Brachythecia*.

F.J.A. Daniëls (1982), who conducted a study of the Greenland snowbed vegetation, also reports that chionophyte communities are indeed floristically related (sometimes very strongly), and may show a gradual transitions from one type to another. However, true snow cover vegetation is characterised by the same two alliances.

The character species of the alliance Cassiopo–Salicion herbaceae, comprising arctic and boreo-arctic late snow-free snowbed dwarf scrub on siliceous substrates in Scandinavia, Svalbard, Iceland and Greenland (Mucina et al. 2016), are commonly cited as *Anthelia juratzkana*, *Beckwithia glacialis* (=*Ranunculus glacialis*), *Carex lachenalii*, *Conostomum tetragonum*, *Dichodon cerastoides* (=*Cerastium cerastoides*), *Epilobium alpinum* (=*E. anagallidifolium*), *Gymnomitrion concinnatum*, *Harrimanella hypnoides* (=*Cassiope hypnoides*), *Kiaeria falcata*, *K. starkei*, *Marsupella brevissima* (=*M. varians*), *Omalotheca supina* (=*Gnaphalium supinum*), *Pleurocladula albescens*, *Pohlia commutata*, *Polytrichastrum alpinum* [incl. var. *fragile* and var. *septentrionale* (=*P. norvegicum*)], *P. sexangulare*, *Salix herbaceae*, *Sibbaldia procumbens*, *Solorina crocea* (Nordhagen 1936, 1943, Molenaar 1976, Daniëls 1982, Dahl 1987, Dierßen 1992, 1996). O. Gjaerevoll (1950) examines this alliance in the "Snowbed communities poor in calciphiles, on soils with highly acid reaction" and "Season-hygrophilous sub-series with field-layer". According to Nordhagen (1943) while it was difficult to divide the alliance Cassiopo–Salicion herbaceae into sociations and associations, but a pattern can be detected: *Cardamine bellidifolia*, *Luzula arcuata* aggr. (*Luzula arcuata*, *L. confusa*) and *Ranunculus glacialis* are found in the communities located in high-mountain and mid-alpine belts, while *Omalotheca supina*, *Sibbaldia procumbens* and *Veronica alpina* have high occurrence and abundance in the low-alpine snowbed communities, where *Phleum alpinum* and *Rumex acetosa lapponicus* are also present.

The alliance Saxifrago stellaris–Oxyrion digynae [syn. Ranunculo–Oxyrion digynae] unites the vegetation of herb-rich acidic water-saturated solifluction snowfields in the alpine belt of Scandinavia and the Middle Arctic zone (Mucina et al. 2016). The alliance is defined by the presence of *Oxyria digyna* and often *Saxifraga stellaris*, from which its derives its name; *Salix herbacea* and *Harrimanella hypnoides* are sparingly present, and stead hygrophilous species such as *Arabis alpina*, *Dichodon cerastoides*, *Epilobium alpinum* and *Veronica alpina* are abundant. The alliance is best developed in areas where the irrigation by melt water lasts very long. As a result of melt water erosion, the fine materials are washed away, consequently causing the communities of alliance to predominantly occur on stony soil. The bottom layer is interrupted by scattered rocks. *Anthelia juratzkana*, *Pohlia commutata* and *P. wahlenbergii* are prevailing, whereas the lichens are inconspicuous (Gjaerevoll 1950). *Andreaea rupestris*, *Cardamine bellidifolia*, *Deschampsia alpina*, *Hymenoloma crispulum*, *Luzula arcuata* aggr., *Pohlia drummondii*, and *Saxifraga cernua* are also character species of the alliance (Lünterbusch et al. 1997, Koroleva et al. 2019, Koroleva & Kopeina 2020).

The vicarious Salicion herbaceae Br.-Bl. in Br.-Bl. et Jenny 1926 from the mountains of Central Europe, which occurs in similar habitats, is, according to Braun-Blanquet (1964, cited in Molenaar 1976), a boreo- and arctic-alpine relict type. The Salicion herbaceae differs from the Cassiopo–Salicion herbaceae by the presence of the character (faithful) taxa *Alchemilla pentaphyllea* and orther *Alchemilla* species (see eVeg [website]), *Arenaria biflora*, *Cardamine alpina*, *Potentilla aurea*, *Sedum alpestre*, *Soldanella pusilla*, and the absence the northern *Carex bigelowii* and *Harrimanella hypnoides* (Molenaar 1976, Daniëls 1982).

In the past, not all researchers have supported the separation of snowbed vegetation into these two alliances. Thus, Gjaerevoll (1950) cited both names as synonyms for the alliance Herbaceon. K. Dierßen (1992, 1996) also considered them as synonyms, specifying the ass. Cassiopo–Salicetum herbaceae (Fries 1913) Nordhagen 1936 as a nomenclatural type of the alliance Salicion herbaceae. Daniëls (1982) believed that there is a slight difference between them, and after some additional research both alliances might possibly be combined. E. Hadač (1971), while conducting research on snow-land communities in Iceland, discovered the challenges that arise when attempting to classify them within the phytocoenological system. There is no doubts on their belonging to the Salicetalia herbaceae, but it is challenging to find an alliance fully corresponding with the plant communities found in Iceland. Although the above character species of the Salicion herbaceae are absent in the snowbed communities of Iceland, Hadač placed them into this alliance on the basis of high floristic similarity to Salicion herbaceae from the Tatra (Krajina 1933). The Salicetum herbaceae tatricum Krajina 1933 and the corresponding Icelandic association have the 19 species in common. "We find that the same character species [in Salicion herbaceae] are lacking there, too, but nevertheless – even Braun-Blanquet (1930) has self recognized its communities as belonging to his Salicion herbaceae" (Hadač 1971: 113).

The literature review shows that floristic differentiation of snowfield communities is difficult due to the limited number of species adapting to the conditions of short growing season and melt water inflow from snowfields. In addition, these species can form various combinations under the influence of other (concomitant) environmental factors on slopes – duration of snow cover, moisture level, habitat drainage, substrate mobility (presence of solifluction and cryoturbation), lime content in soil and its acidity, permafrost depth, etc.

According to the latest vegetation survey of Europe (Mucina et al. 2016), the alliance Salicion herbaceae (snowbed communities on siliceous substrates in the alpine and nival belt of mountain ranges in the nemoral zone of Europe) belongs to the Last glacial maximum (LGM) relict group of alliances, whereas Cassiopo–Salicion herbaceae and Saxifrago stellaris–Oxyrion digynae [=Ranunculo–Oxyrion digynae] are assigned to the Arctic group of alliances.

Until recently, all known snowbed communities in Europe were classified within the Salicetea herbaceae. Bedding differentiation is reflected at the order level. The Salicetalia herbaceae and Arabidetalia caeruleae Rübel ex Nordhagen 1937 include communities on siliceous and calcareous rocks, respectively. Within each order, a number of vicariant alliances have been described (Dierßen 1984).

Currently, Mucina et al. (2016) consider calciphile-rich snowbed communities on near-neutral calcareous soils as belonging to a different class – Thlaspietea rotundifolii Br.-Bl. 1948. Order Arabidetalia caeruleae (Vegetation of snowbeds on stabilized calcareous screes of the arctic zone and the alpine and subnival belts of European mountains) combines 2 alliances. The first of these, Ranunculo–Poion alpinae Gjaerevoll ex Daniëls in Mucina et al. 2016 unites grassy vegetation of snowbeds in the boreo-montane belt of Scandinavia and the Arctic Archipelago. Daniëls named the following diagnostic taxa of this validated alliance: *Carex bigelowii* s. str., *Bistorta vivipara*, *Poa alpina*, *Potentilla crantzii*, *Ranunculus acris*, *Saussurea alpina*, *Solidago virgaurea*, *Trollius europeus*, *Viola biflora*, and mosses *Sanionia uncinata* and *Hylocomium splendens* (Mucina et al. 2016:155).

The second alliance, Saxifrago oppositifoliae–Oxyrion digynae Gjaerevoll 1950 [Salicion polaris Gjaerevoll 1950 and Saxifrago–Ranunculion nivalis Nordhagen 1943 are being cited in synonyms] unites the vegetation of herb-rich snowbeds on stabilized calcareous soils in the boreo-montane belt of Scandinavia and the Arctic Archipelago. Character species of the alliance: *Cerastium regelii*, *Oxyria digyna*, *Phippsia algida*, *P. concinna*, *Ranunculus nivalis*, *R. pygmaeus*, *R. sulphureus*, *Sagina saginoides*, *Salix polaris*, *Saxifraga aizoides*, *S. cernua*, *S. oppositifolia*, *S. rivularis*, *S. tenuis* (Nordhagen 1943, Gjaerevoll 1950, Dierßen 1992).

The class Salicetea herbaceae includes only one homonymous order Salicetalia herbaceae, representing snowbed vegetation on non-calcareous bedrock exclusively, with snow during 8 to 10 months or longer; they composed mainly of mosses, liverworts, hemicryptophytes and creeping, low chamaephytes. These communities are typically located in alpine and arctic regions of the northern hemisphere. They thrive in moist, acid, and humic soils that can be stony in certain areas. Additionally, they are impacted by solifluction and cryoturbation but are not affected by strong erosion (Daniëls 1982). As the study of snowbed vegetation progressed, information on character (faithful) taxa of class and order changed, with various species being assigned to them (Table 1), the most commonly named: vascular plants *Beckwithia glacialis*, *Carex lachenalii*, *Dichodon cerastoides*, *Epilobium alpinum*, *Omalotheca supina*, *Ranunculus pygmaeus*, *Salix herbacea*, *S. polaris*, *Saxifraga rivularis*, *Sibbaldia procumbens*, *Taraxacum croceum*, *Veronica alpina*, bryophytes *Anthelia juratzkana*, *Conostomum tetragonum*, *Gymnomitrion concinnatum*, *Kiaeria falcata*, *K. starkei*, *Marsupella brevissima*, *Pleurocladula albescens*, *Pohlia drummondii*, *Polytrichastrum sexangulare*, and lichen *Solorina crocea* (Hadač 1971, 1985, Molenaar 1976, Daniëls 1982, Dahl 1987, Dierßen 1996, Mucina 1997, Ermakov 2012, Mucina et al. 2016).

In the Russian Arctic, syntaxa of the class Salicetea herbaceae have been described in the Kola Peninsula (Koroleva 1999, 2006, Koroleva et al. 2019), Siberia (Matveyeva 1994, Telyatnikov 2011, Telyatnikov et al. 2013, 2014, 2015, 2019, 2021), Wrangel Island (Kholod 2007), and Chukotka (Razzhivin 1994) according to the classification consistent with the Braun-Blanquet approach.

Soviet geobotanists in the tradition of the dominant approach also described snowbed communities. I.D. Bogdanovskaya-Guihéneuf (1938), studying the vegetation of Kolguev Island, did not single out the snowbed communities as an independent type, but considered it as part of the meadow type (tundra meadows). She emphasised that the thickness and duration of snow cover depend mainly on the topography. Snow accumulates in shallow valleys and ravines. Slope exposure and the magnitude of runoff affect the rate of snowmelt. The second most important environmental factor is moisture, which is generated by spring and early summer snowmelt. Subsequently, the middle and lower parts of slopes are constantly moistened by slowly percolating permafrost water, resulting in constant saturation and movement of clay soils. However, the slope in all cases provides effective drainage. In the lower parts of the slopes, where thick snow cover accumulates on clayey soils for a long time, two plant communities were identified and classified into 2 associations: *Salix polaris–Equisetum arvense* and *Salix*

Table 1. Character species of the class Salicetea herbaceae and the order Salicetalia herbaceae according to the data of different authors

Taxon	Hadač 1971	Molenaar 1976	Daniëls 1982	Dahl 1987	Dierßen 1996	Mucina 1997	Ermakov 2012	Mucina et al. 2016
*Alchemilla glomerulans**								+
Alopecurus alpinus						+	+	
Anthelia juratzkana	+			+	+	+	+	+
Astragalus alpinus subsp. *arcticus*				+				
Beckwithia glacialis (=*Ranunculus glacialis*)*				+		+	+	+
Cardamine bellidifolia						+	+	+
Carex lachenalii	+			+				+
Cephalozia ambigua						+	+	
Cerastium regelii						+	+	+
Conostomum tetragonum	+			+		+	+	+
Deschampsia alpina								+
Dichodon cerastoides (=*Cerastium cerastoides*)	+	+	+			+	+	+
Draba alpina						+	+	+
Draba lactea						+	+	+
Epilobium alpinum (=*E. anagallidifolium*)	+			+				+
Gymnomitrion concinnatum	+			+			+	
Gymnomitrion corallioides						+	+	
Harrimanella hypnoides (=*Cassiope hypnoides*)						+	+	+
Kiaeria falcata	+					+	+	+
Kiaeria starkei	+		+	+		+	+	+
Luzula arcuata						+		+
*Luzula confusa**				+		+	+	+
*Luzula nivalis**								+
Marsupella brevissima (=*M. varians*)	+			+	+	+	+	
Minuartia biflora							+	
Moerckia blyttii						+	+	
Omalotheca supina (=*Gnaphalium supinum*) *	+		+	+	+	+	+	+
Oxyria digyna				+				
Pleurocladula albescens				+		+	+	+
Poa arctica						+	+	
Pohlia commutata	+							
Pohlia drummondii			+		+	+	+	+
Polytrichastrum alpinum [incl. var. *fragile*, var. *septentrionale* (=*P. norvegicum*)]	+			+				
Polytrichastrum sexangulare						+	+	+
*Racomitrium lanuginosum**								+
Ranunculus propinquus (=*R. acris* subsp. *borealis*)						+		+
Ranunculus nivalis						+	+	+
Ranunculus pygmaeus			+	+	+	+	+	+
Ranunculus sulphureus							+	+
Sagina saginoides subsp. *saginoides**		+						+
Salix herbacea			+	+	+	+	+	+
Salix polaris				+		+	+	+
*Saxifraga cespitosa**								+
Saxifraga nivalis						+	+	
*Saxifraga rivularis**				+		+	+	+
*Saxifraga tenuis**								+
Sibbaldia procumbens	+		+	+	+	+	+	+
Solorina crocea		+	+	+		+	+	+
*Stellaria crassipes**						+	+	+
Taraxacum croceum				+		+	+	+
Veronica alpina	+	+	+	+			+	+

Note. Species indicated with an asterisk (*) are also indicative for another class in Mucina et al. (2016).

polaris–Equisetum arvense–Marchantia polymorpha. Z.N. Smirnova (1938) also studied the vegetation of Kolguev Island and described one community with *Salix herbacea* in the group of dwarf shrub associations, which can be attributed to snowbed vegetation.

Our study presents the results of a floristic classification of snowbed vegetation consisting of dwarf willows, herbs and mosses distributed in the East European sector of the Arctic. The paper compares the new syntaxa found in this study with similar ones identified in other northern regions and sheds light on their syntaxonomic affiliation with higher syntaxa.

MATERIAL AND METHODS

Study area

Relevés were made at 11 sites (Fig. 1, sites 1–11) within the typical and southern tundra subzones of the East European part of the Arctic (Aleksandrova et al. 1989) in the Nenets Autonomous Area (according to administrative division). All sites are characterized by hilly relief or canyon-like river valleys with numerous gullies, creating suitable slope habitats for snowbed grasslands. For comparison we have also obtained 2 relevés made by O.V. Lavrinenko in the south of the Taymyr Peninsula (Fig. 1, site 12).

On Kolguev Island (area of 5 000 km^2) the relevés were carried out in the drainage basins of the Peschanka and Bugryanka rivers (Fig. 1, sites 1–3). The island comprises of loose clayey and sandy Quaternary sediments. The central part of the island is elevated (100–140 m, up to 173 m a.s.l.) compared to the swampy plain that surrounds it. The center consists of clusters of low (relative height 25–50 m) loamy hills. The entire hilly region is intersected by numerous streams, rivers, ravines with springtime streams. The river valleys have deep cuts, steep slopes and winding channels. In the upper reaches, there are narrow, V-shaped valleys that reach depths of up to 15 m deep and become U-shaped downstream, with depth increasing up to 20 m. Snow blows off the hills and watersheds, accumulating in several valleys and ravines,

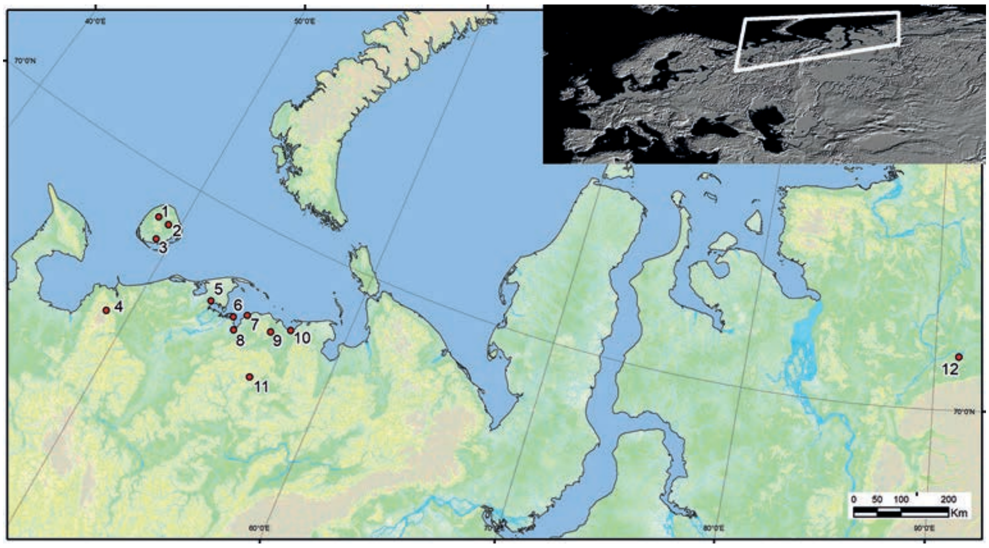

Figure 1 Study area. 1–11 – field sites by authors. 1–3 – Kolguev Isl. (1 – Peschanka River in the upstream, 2 – Peschanka River in the middlestream, 3 – Bugryanka River basin); 4 – the northern part of the Timanskii Kryazh, Belaya River basin; 5 – Malozemelskaya tundra, Nenets Ridge; 6–11 – Bolshezemelskaya tundra (6 – Bolvanskii Nose Cape environs; 7 – Bol'shaya Dvoinichnaya River basin; 8 – Yachei River in the downstream, Bolvanskaya Bay; 9 – Vangureimusyur Upland, Bol'shaya Khekheganyakha River middlestream; 10 – Pakhancheskaya Bay, surroundings of Lutsato Lake; 11 – Vesnimusyur Upland, Shapkina River basin); 12 – Taymyr Peninsula, the confluence of the Kystyktakh and Dudypta rivers.

which results in the relief of the island being mostly leveled in the winter. The hills composed of dark grey clay, are often prone to erosion and feature cirques that are open to the north or northeast.

In the northern part of the old mountains Timanskii Kryazh the relevés were made within the Belaya River basin (Fig. 1, site 4). The river crosses the Timanskii Kamen Ridge, which composed of Devonian sandstones that are subject to extensive erosion. The hydrographic network of the area is dense, which is connected with intensive erosion of the Belaya River valley slopes, constant formation of ravines and temporary watercourses on their bottoms. Deep valleys, steep walls and narrow canyons contribute to the accumulation of snow up to several meters thick, which in the shadow of slopes of northern exposition may not melt until August. In the Belaya River basin solifluction (displacement of the loose cover material) is more often found not at the foot of slopes, but in high parts of river valleys, because here the process of water saturation of upper soil horizons and their slow sliding is shown in a "pure" form.

In the east of the Malozemelskaya tundra snowbed communities are described on the Nenets Ridge Upland, whose ridges are oriented from northeast to southwest (Fig. 1, site 5). It's the terminal moraine (80–140 m a.s.l.) composed mainly of loam with inclusions of boulders and pebbles. The hydrographic network in this area is highly developed with the presence of small rivers (Seduyaha, Sengryyaha, Neryyaha), as well as streams that run through narrow valleys with grassland communities on slopes or with steep landslides.

In the Bolshezemelskaya tundra, investigations were carried out in regions with hilly or hilly- ridges terrain within the typical and southern tundra subzones (Fig. 1, sites 6–11). On the Bolvanskii Nos Cape, the Vangureimusyur and Vesnimusyur uplands contain groups of hills and ridges (relative height 20–50 m) that are primarily composed of moraine loams. The ridges and hills are devided by vast valleys containing rivers or narrow ravines with streams. Cryogenic processes are prevalent on the slopes of river valleys' terraces and their occurrence varies depending on the slope's steepness, direction, substrate and location. Solifluction occurs on slopes with a gradient from 40 to 3°. On various geomorphological elements in the valleys, there are features of a nival permafrost landscape, which is distinguished by prolonged snow accumulation and the development of nival processes. These landscapes comprise of nival niches, which are minor depressions on a slope or at the bottom of an elevation, and cryoplanation terraces, which are leveled surfaces situates at the base of terraces with inclinations ranging from 1 to 5° (Neshataev & Lavrinenko 2020).

In the southern tundra subzone of the Taymyr Peninsula, relevés were made at the confluence of the Kystyktakh and Dudypta rivers (Fig. 1, site 12). The area is characterized by denudational relief, with numerous river valleys. Two plant communities were observed, one on the bottom and one on the slope of a ravine that descends into the Kystyktakh River, and experiences snowmelt only in early August.

The climate of the East European tundra is maritime arctic, with long severe winters, short summers, indistinct transitional seasons and significant cloudiness, with increasing continentality from west to east. The average annual air temperature on Kolguev Island is -3°C, on the coast of the Barents Sea -5°C, in the central part of the Bolshezemelskaya tundra -6°C. The average air temperature in January varies between -19 and -11°C. The duration of snow cover is 200–230 days. July is the warmest month, when the average air temperature ranges from +8 to +12 °C. The annual precipitation varies between 360 and 450 mm.

The Taymyr Peninsula has a pronounced continental climate. The mean annual air temperature in the Dudypta River basin is -12°C, and in January it drops to -30°C. Snow lies on the territory for about 220–230 days. Despite the short summer, it is relatively warm. The frost-free period lasts from 50 to 70 days. The average temperature of the warmest month is +12°C and the average annual precipitation is 350 mm.

Sampling and data analysis

The syntaxonomic analysis is based on 38 relevés, of which 29 were sampled by O.V. Lavrinenko and I.A. Lavrinenko in 2012–2022 in the East European tundra, 2 by O.V. Lavrinenko and S.S. Kholod in 2008 in Timanskii

Kryazh, 2 by O.V. Lavrinenko, I.A. Lavrinenko and V.V. Neshataev in 2017 in Vangureimyusur Upland, 3 by O.V. Lavrinenko and T.V. D'aychkova in 2021 in Nenets Ridge, and 2 by O.V. Lavrinenko in 2021 in the south of the Taymyr Peninsula. We identified all species (vascular plants, mosses, and lichens) on 16–25 м^2 plots (if the area of the plant community is smaller, within its boundaries) and estimated the percentage cover (%) in total and for the major plant growth forms, as well as cover abundance scores using the Braun-Blanquet scale (Becking 1957, Barkman et al. 1964): r – solitary plants; + – less than 1 %; 1 – 1–5 %; 2a – 6–12 %; 2b – 13–25 %; 3 – 26–50 %; 4 – 51–75 %; 5 – 76–100 %. Estimates of species abundance of syntaxa in the papers of other authors that were used for comparison have been brought to the same scale.

Soil pits on most sites were dug to a depth of 25 cm. Coordinates were determined using a Garmin GPS device (see notes to Tables 2–5).

The vegetation was classified according to the Braun-Blanquet sorted-table method (Westhoff & van der Maarel 1978). The constancy of the species in the tables is given on a percentage scale (%): I – > 0–20, II – 21–40, III – 41–60, IV – 61–80, V – 81–100. Species with constancy V and IV are considered to be highly constant. The median abundance values (if not given, they are "+" or "r") for each species were used to characterize the syntaxa. To calculate these, the Braun-Blanquet scale values were converted to an 8-point numerical scale.

In describing associations and subordinate syntaxa, we used the concept of a "differential species combination" (Beeftink 1965, Molenaar 1976), a group of taxa that are characteristic of a syntaxon when they occur together, although each of them individually may not be characteristic. Differential species combinations were determined by comparing new syntaxa with syntaxa previously described from the North European Mountains, European and Siberian Arctic (broadly defined). The term "characteristic species" (exclusive, selective and preferential) was used to refer to higher syntaxonomic units (Braun-Blanquet 1932, Westhoff & van der Maarel 1978).

Hierarchical clustering of relevés and syntaxa (all species are included in the analysis) was performed by the Complete-linkage clustering (Squared Euclidean distances) in the Statistica 12 package. When analyzing syntaxa, we proposed using an integral constancy-abundance score for species: constancy score (from 1 to 5) plus abundance score in increments of 0.2 (from 0.2 to 1.6). Thus, the minimum score for the species was 1.2, and the maximum was 6.6.

The nomenclature of the species, their geographical and ecological characteristics followed Sekretareva (2004) for vascular plants; Ignatov et al. (2006) for mosses, Potemkin & Sofronova (2009) for liverworts and Santesson et al. (2004) for lichens. The new syntaxonomic units were named according to the International Code of Phytosociological Nomenclature, 4th edition (ICPN) (Theurillat et al. 2021). The nomenclature of the higher vegetation units follows Mucina et al. (2016). Authors of syntaxa are given in the text at first mention and in Prodromus.

RESULTS

After processing the relevé tables (Tables 2–5, 7) and cluster analysis, the snowbed communities of East European tundra were assigned to 5 associations (4 of them new) which are described below.

In places of long-lying snow accumulation on solifluction slopes and in nival niches, herb–dwarf willow (*Salix polaris*, *S. herbacea*)–moss communities united into 3 new associations of the new alliance are formed.

Salicetum herbaceae-polaris Lavrinenko et Lavrinenko **ass. nov.** (Table 2, rel. 1–18, Table 7, syntaxon 10; Fig. 2A–D)

Holotypus: relevé 9 (author's number K37_13), Kolguev Island, upper reaches of the Peschanka River, 69.26882°N 48.84036°E, terraced ravine north-western slope 30°, 04.08.2013, authors O.V. Lavrinenko, I.A. Lavrinenko.

Composition. Differential species combination in the association: dwarf shrub *Salix herbacea* (median abundance score 2a), herbs *Deschampsia glauca*, *Pedicularis sudetica* subsp. *arctoeuropaea*, *Petasites frigidus*, some bryophytes *Anthelia juratzkana* (2a), *Gymnomitrion concinnatum* (1), *Timmia austriaca* (1). Three species (*Salix herbacea*, *Anthelia juratzkana* and *Gymnomitrion concinnatum*) are also character of the class Salicetea herbaceae. The other character species of the class: *Sibbaldia procumbens* (1), *Omalotheca supina* (1) and the mosses *Kiaeria starkei* (2b) and *Polytrichastrum alpinum* (1) occur consistently and often with high abundance. Present are all character species of the new alliance Veronico alpinae–Salicion polaris **all. nov.** (described below).

Based on differences in species composition that reflect soil habitat conditions, two variants were identified typica and inops. The depleted variant (Table 2, rel. 1–4) is characterized by high abundance *Salix herbacea* (3–4) and absence or rare occurrence of taxa of association and alliance differential species combinations, include *S. polaris* (see Table 2).

Total number of taxa registered in association is 128: 72 – vascular plants (5 shrubs, 6 dwarf shrubs, and 61 herbs), 29 – bryophytes, 27 – lichens; 22 – highly constant species (17 %), 63 species with constancy score I (49 %); 30–58 species in communities (mean 39).

Structure. The total cover in the communities is 70–100 %, with the mean cover of dwarf shrubs 55 %, herbs 15 % and mosses 40 %. Shrubs and lichens have a minimal projective cover typically less than 1 % and a maximum of 5 %. Only in one community (rel. 2) the lichen cover was 50 % due to the abundant *Cladonia ecmocyna*. This lichen is found in humid areas in arctic and alpine regions. It grows in the vicinity of late snow banks on humus-rich soils (Thomson 1967). Up to 30 % of the area is covered by patches of open loam and clay as a result of solifluction processes. The bryophytes *Kiaeria starkei*, *Polytrichastrum alpinum*, *Sanionia uncinata* form the basis of the vegetation cover. On top of this base, a well-developed dwarf shrub layer with 1–2 cm in high has been formed by willows *Salix polaris* and *S. herbacea* (only *S. herbacea* in var. *inops*). The first species of willow is more abundant downhill, while and the second species occupies the uphill. In some communities the liverworts *Anthelia juratzkana*, *Gymnomitrion concinnatum* are co-dominant alongside mosses and form mats mainly at the slope's foot. Herbs are typically low-growing (5–10 cm), *Sibbaldia procumbens*, *Omalotheca supina* and *Festuca rubra* subsp. *arctica* predominate. *Cladonia ecmocyna* is the most conspicuous among the lichens (podetia up to 6 cm tall).

Habitats. Snowbed herb–dwarf willow (*Salix polaris*, *S. herbacea*)–moss communities are present in the lower third of the slopes of loamy low hills, ravines, bedrock riverbanks, and their foothills. The slopes are predominantly north-facing and steep (with a slope of 20° to 40° steep), resulting in well-drained habitats. Typically, snow persists in such habitats until mid to late July, and occasionally until early to mid August. Solifluction processes are frequently observed on slopes, resulting in terraced topography: turf breaks and slides down the slope, forming steps that are 5–15 cm high or knolls. Stones measuring 10–30 (up to 50) cm across can

Table 2. Associations of the alliance Veronico alpinae–Salicion polaris in the East European tundra and comparison with similar syntaxa of Soviet geobotanists

Association	Salicetum herbaceae-polaris																		Salici polaris–Sibbaldietum procumbentis						Myosotido asiaticae–Salicetum polaris				Constancy and abundance										
Variant	*inops* (a)				*typica* (b)														–						–														
Projective cover, %: total	90	100	100	99	70	95	100	95	99	80	100	100	70	90	98	70	70	95	100	100	100	100	100	85	80	70	90	95											
shrubs	5	<1	<1	5	<1	<1	<1	<1	0	0	<1	<1	<1	<1	<1	0	<1	<1	1	3	20	<1	0	0	<1	<1	<1	<1											
dwarf-shrubs	40	70	50	60	50	70	50	60	70	60	70	50	40	60	30	40	60	60	1	<1	10	30	1	0	25	20	<1	10											
herbs	20	25	10	10	5	10	5	5	5	15	20	15	30	20	20	20	10	5	20	20	10	50	50	30	30	30	60	60											
bryophytes	90	30	40	40	30	40	80	30	40	50	15	40	60	20	40	15	20	40	90	80	70	40	40	70	60	40	40	90											
lichens	3	50	2	1	1	1	1	1	3	1	3	3	1	1	5	1	1	1	<1	5	10	15	10	<1	<1	<1	<1	<1											
Number of species: total	31	36	30	33	34	35	37	37	33	44	49	36	45	41	47	47	35	58	34	43	44	48	28	36	50	50	47	51											
shrubs	4	3	2	1	1	1	1	2	0	0	2	2	1	1	1	0	1	1	4	4	5	3	0	0	2	2	2	3											
dwarf-shrubs	3	3	2	4	2	2	3	4	2	3	2	2	3	3	3	3	3	3	3	3	4	3	2		2	2	2	1											
herbs	10	13	12	16	20	18	18	17	20	23	28	17	26	25	22	32	21	29	15	22	20	26	11	20	30	29	29	31											
bryophytes	8	4	6	5	4	5	7	6	4	6	7	8	6	5	10	5	2	13	4	4	7	6	5	7	11	13	10	12											
lichens	5	12	8	7	7	9	8	8	7	12	10	8	9	7	11	7	8	12	8	9	8	10	9	8	5	4	4	4											
Date	07.07.2021	29.06.2021	28.08.2013	05.08.2012	08.08.2013	01.08.2013	30.08.2013	03.08.2013	04.08.2013	05.08.2013	17.08.2013	13.08.2013	11.08.2012	11.08.2012	20.08.2012	04.08.2012	02.08.2012	13.08.2012	29.07.2015	29.07.2015	29.07.2015	21.07.2017	15.08.2022	09.08.2017	23.07.2016	23.07.2016	19.07.2016	06.07.2021											
Slope aspect	E	N	N	N	N	N	N	N	NW	N	N	N	N	N	N	N	N	N	N	NW	NW	NE	NW	NW	N	NE	N	N											
inclination	3	20	10	20	20	30	30	25	30	30	25	40	40	30	20	20	30	30	5	15	10	10	5	15	30	30	30	20											
Relevé nr.: by author	НГ52	НГ9	K145_13	K19_12	K63_13	K11_13	K159_13	K29_13	K37_13	K43_13	K100_13	K91_13	K52_12	K51_12	K85_12	K16_12	K8_12	K62_12	ПГ72	ПГ73	ПГ71	Ван62	Я57	Шап8	БД69	БД71	БД48	НГ45											
in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	**a**	**b**	Salicetum herbaceae-polaris	Salici polaris–Sibbaldietum procumbentis	Myosotido asiaticae–Salicetum polaris	Frutices–herbs–*Cladonia gracilis* (Smirnova, 1938; rel. 73)	*Salix polaris–Equisetum arvense* (Bogdanowskaya-Guihéneuf, 1938; rel. 2b)	*Salix polaris–Equisetum arvense* (Bogdanowskaya-Guihéneuf, 1938; rel. 20)	*Salix polaris–Equisetum arvense* (Bogdanowskaya-Guihéneuf, 1938; rel. 22)	unnamed (Bogdanowskaya-Guihéneuf 1938; rel. 183)	*Salix polaris–Equisetum arvense-Marchantia polymorpha* (Bogdanowskaya-Guihéneuf, 1938; rel. 38)
Differential species combination of the Salicetum herbaceae-polaris																																							
Salix herbacea **Sh**	3	4	3	3	3	3	2b	2a	1	+	2a	2a	+	+	2a	+	1	+	.	.	.	.	.	.	.	.	.	.	**V^{3}**	V^{2a}	V^{2a}	.	.	3	2a	.	.	2a	r
Deschampsia glauca	.	.	+	+	+	r	.	r	.	.	.	.	+	+	r	+	+	r	.	.	.	.	.	.	.	.	.	.	III^{+}	IV^{+}	IV^{+}	.	.	.	.	.	.	1	.
Petasites frigidus	.	.	r	.	+	r	+	r	r	1	r	1	r	r	r	r	.	r	.	.	.	.	.	.	+	.	.	.	II^{r}	V^{r}	IV	.	II^{+}	.	2a	.	.	.	.
Pedicularis sudetica subsp. *arctoeuropaea*	+	.	.	.	.	.	r	.	r	.	r	.	r	r	.	+	.	+	.	.	.	.	.	.	.	.	.	.	II^{+}	III^{r}	III^{r}	.	.	+	2a	1	1	.	.
Anthelia juratzkana Sh	.	+	2a	2b	1	2a	.	.	.	.	.	.	2a	2a	.	.	.	.	.	.	.	.	1	.	.	.	.	.	IV^{2a}	II^{2a}	II^{2a}	I^{1}	.	.	.	.	.	.	.
Gymnomitrion concinnatum **Sh**	.	.	2b	2a	.	1	.	.	.	.	.	.	+	+	+	.	.	1	.	.	.	.	.	.	.	.	.	.	**III^{2b}**	II^{+}	II^{1}	.	.	.	.	.	.	.	.
Timmia austriaca	.	.	.	.	.	.	+	.	+	+	.	2a	2b	.	.	.	.	2a	.	.	.	.	.	.	.	.	.	.	.	III^{1}	II^{1}	.	.	.	.	.	.	.	.
Differential species combination of the Salici polaris–Sibbaldietum procumbentis																																							
Trisetum spicatum	.	.	+	.	.	.	.	.	r	.	.	.	r	+	1	+	r	.	1	1	+	.	.	+	.	.	r	.	II^{+}	III^{+}	II^{+}	IV^{1}	II^{r}	1	.	1	.	1	.
Polytrichum strictum	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	2a	2b	+	+	.	.	.	.	.	.	.	I^{1}	I^{1}	IV^{1}	.	.	.	.	.	.	.
Diphasiastrum alpinum	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	+	+	r	+	.	.	.	.	.	.	.	I^{r}	I^{r}	IV^{+}	.	1	.	+	.	.	.
Trientalis europaea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	.	r	.	.	.	.	.	III^{+}	II^{r}	.	.	.	.	.	.
Peltigera scabrosa	.	.	.	.	.	.	.	.	.	.	.	.	+	r	+	.	.	+	r	r	+	+	+	+	.	.	.	.	.	II^{+}	II^{+}	V^{+}	.	1	.	.	.	.	.
Differential species combination of the Myosotido asiaticae–Salicetum polaris																																							
Myosotis asiatica	.	.	.	.	.	.	.	.	.	+	r	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	+	.	I^{+}	I^{+}	.	V^{1}	.	2a	.	1	.	.
Saxifraga cernua	.	.	.	.	r	r	.	.	.	r	.	.	.	.	.	.	.	r	.	.	.	.	.	r	+	+	+	2a	.	II^{r}	II^{r}	I^{r}	V^{+}	.	.	.	.	.	.
Viola biflora	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	r	+	1	+	+	1	r	II^{r}	I^{1}	I^{+}	III^{+}	V^{+}	.	.	.	2a	1	.
Achillea millefolium	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	+	.	.	r	r	r	r	.	I^{r}	I^{r}	I^{+}	V^{r}	+	.	.	.	2b	.
Cardamine pratensis subsp. *angustifolia*	.	.	.	.	.	r	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	r	r	+	+	.	II^{r}	I^{r}	.	V^{+}	.	1	.	.	.	.
Parnassia palustris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	r	.	.	.	.	V^{+}	+	.	.	2a	.	.
Artemisia tilesii	.	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	I^{r}	I^{r}	.	IV^{r}	.	.	.	.	.	+
Agrostis mertensii subsp. *borealis*	.	.	.	.	.	.	.	.	.	.	.	.	r	1	.	.	.	.	.	.	.	.	.	.	+	r	r	.	.	I^{+}	I^{+}	.	IV^{r}	.	.	.	.	.	.
Bistorta elliptica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	r	r	2a	.	.	.	.	II^{r}	IV^{r}	.	.	.	.	.	.
Philonotis tomentella	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	2a	+	.	.	.	.	V^{1}	.	.	.	.	.	.
Oncophorus integerrimus	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	3	2b	2a	.	II^{+}	I^{+}	I^{+}	.	**IV^{2b}**	.	.	.	.	.	.
Mnium blyttii	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	r	.	.	.	.	.	.	.	+	2a	+	.	I^{+}	I^{+}	.	IV^{+}	.	.	.	.	.	.
Character-species of the Veronico alpinae–Salicion polaris																																							
Salix polaris **Sh**	.	.	.	2a	2b	2b	2a	3	4	4	4	3	3	4	2b	3	4	4	1	+	2a	2b	.	.	2b	2b	+	2a	II^{2a}	**V^{3}**	**V^{3}**	IV^{2a}	**V^{2b}**	+	3	3	3	2b	3

Table 2. Continued.

Relevé nr. in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	**a**	**b**									
Veronica alpina **Sh**	·	r	+	r	1	1	1	+	1	1	1	+	+	1	1	1	1	1	·	+	r	+	·	+	1	1	+	1	IV^{r}	V^{1}	V^{1}	IV^{+}	V^{1}	1	1	1	1	·	r
Carex lachenalii **Sh**	+	+	·	+	r	1	r	+	+	·	r	·	1	+	+	2a	+	+	1	+	·	+	+	1	·	·	+	+	IV^{+}	V^{+}	V^{+}	V^{+}	III^{+}	+	·	·	·	·	·
Pyrola minor	1	·	r	r	r	+	1	1	1	+	1	·	r	+	r	r	·	·	·	r	r	+	1	1	r	·	·	r	IV^{r}	IV^{+}	IV^{+}	V^{+}	III^{r}	+	·	·	·	·	·
Dichodon cerastoides **Sh**	·	·	·	·	r	+	r	+	+	+	+	·	+	1	r	+	+	+	+	+	+	r	·	r	+	r	+	+	·	V^{+}	IV^{+}	V^{+}	V^{+}	+	·	·	·	1	·
Epilobium alpinum **Sh**	+	·	·	·	1	r	+	+	+	1	+	·	+	r	·	+	·	+	·	·	·	·	·	·	1	1	1	+	II^{+}	IV^{+}	IV^{+}	·	V^{1}	·	·	·	·	·	·
Ranunculus glabriusculus	·	r	·	·	r	+	r	·	r	r	+	·	·	+	·	+	·	r	·	r	r	1	·	+	·	1	·	1	II^{r}	IV^{r}	III^{r}	IV^{+}	III^{1}	·	·	·	·	·	·
Cetraria islandica subsp. *islandica*	1	+	+	+	+	+	+	1	1	+	1	1	+	+	+	+	+	+	+	+	r	r	+	+	+	+	r	·	V^{+}	V^{+}	V^{+}	V^{+}	IV^{+}	2a	·	·	·	·	·
Cetrariella delisei	1	+	+	+	·	+	·	+	1	1	+	+	+	r	+	+	+	+	+	+	r	+	·	+	·	r	·	·	V^{+}	V^{+}	V^{+}	V^{+}	II^{r}	1	·	·	·	·	·
Stereocaulon rivulorum	1	2a	+	+	·	·	r	·	r	r	·	+	r	·	r	+	+	+	·	·	+	2a	1	+	+	·	·	r	V^{1}	IV^{r}	IV^{+}	IV^{1}	III^{+}	·	·	·	·	·	·
Cladonia ecmocyna	+	3	1	+	+	1	+	+	1	+	1	1	+	+	2a	1	1	+	+	1	1	2a	1	·	·	·	·	·	V^{1}	V^{1}	V^{1}	V^{1}	·	·	·	·	·	·	·
Character-species of the Salicetalia herbaceae and Salicetea herbaceae																																							
Kiaeria starkei	2b	+	2b	1	2b	3	4	2b	2b	+	+	2b	2b	2b	2b	2b	·	2a	3	3	3	2b	·	·	+	+	·	2a	**V^{2b}**	**V^{2b}**	**V^{2b}**	**IV^{3}**	IV^{+}	·	·	·	·	·	·
Sibbaldia procumbens	+	2a	+	1	+	1	+	+	1	+	+	1	1	1	+	1	1	1	2b	2b	1	3	3	2a	2a	1	r	+	V^{1}	V^{1}	V^{1}	**V^{2b}**	V^{1}	2a	·	2a	2b	3	·
Omalotheca supina	2a	1	1	1	+	+	+	+	1	+	+	1	2a	1	1	+	2a	1	+	1	1	1	2a	1	2a	2a	1	r	V^{1}	V^{1}	V^{1}	V^{1}	V^{2a}	2a	·	2a	·	2b	·
Polytrichastrum alpinum agrr.	·	+	+	+	+	+	·	·	+	+	+	2a	2a	+	2a	1	1	+	2a	2a	1	2a	2b	2b	2b	2a	2b	·	IV^{+}	V^{+}	V^{+}	V^{2a}	**IV^{2b}**	2a	·	·	·	·	·
Solorina crocea	·	+	+	r	·	r	·	·	·	·	·	·	r	·	·	·	+	+	·	·	·	·	r	·	·	·	·	·	IV^{+}	II^{+}	II^{+}	I^{r}	·	1	·	·	·	·	·
Sagina saginoides	·	·	·	·	·	·	·	·	+	+	·	·	r	·	r	r	+	+	·	·	·	·	·	+	·	·	·	r	·	III^{+}	II^{+}	I^{+}	II^{r}	·	·	1	1	·	·
Poa arctica	·	·	·	·	·	·	r	r	·	·	·	r	·	·	·	·	·	·	r	r	r	·	·	·	·	·	·	·	·	II^{r}	I^{r}	III^{r}	·	+	·	·	·	·	·
Luzula arcuata aggr.	·	·	·	r	·	·	·	·	·	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	II^{r}	I^{+}	I^{+}	·	·	+	2a	·	·	·	·
Ranunculus pygmaeus	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·	r	·	I^{r}	I^{r}	·	II^{r}	·	·	·	·	·	·
Oxyria digyna	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	I^{r}	·	·	·	·	·	·	·
Saxifraga rivularis	·	·	·	·	·	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I^{r}	I^{r}	·	·	·	·	·	·	·	·
Conostomum tetragonum	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	II^{+}	·	I^{+}	·	·	·	·	·	·	·	·
Polytrichastrum sexangulare	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	II^{+}	·	I^{+}	·	·	·	·	·	·	·	·
Alchemilla glomerulans	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	I^{+}	I^{+}	·	·	1	·	1	·	1	·
Astragalus alpinus subsp. *arcticus*	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	·	·	·	·	·	·	II^{+}	·	·	·	·	·	·
Constant species of syntaxa																																							
Sanionia uncinata	3	2a	·	+	1	1	2b	1	2b	3	2a	1	+	+	2a	2a	2a	3	2a	2a	3	2b	1	+	2a	2a	2a	4	IV^{2a}	V^{2a}	V^{2a}	V^{2a}	V^{2a}	2a	2a	·	1	·	·
Equisetum arvense subsp. *boreale*	1	2a	+	+	+	+	+	+	+	1	+	·	+	+	+	+	r	+	+	1	+	1	+	1	+	+	+	3	V^{1}	V^{+}	V^{+}	V^{1}	V^{+}	2a	2b	2b	2b	2a	3
Tanacetum bipinnatum	·	r	+	1	r	1	+	+	r	r	+	r	1	+	+	1	+	+	+	+	+	+	r	+	r	r	r	r	IV^{+}	V^{+}	V^{+}	V^{+}	V^{r}	2a	1	1	2a	2b	·
Bistorta vivipara	·	+	+	r	+	r	·	·	·	r	+	r	+	+	+	r	r	+	·	r	+	+	+	1	2a	2a	3	1	IV^{+}	IV^{+}	IV^{+}	V^{+}	V^{2a}	+	2b	2a	2b	1	+
Empetrum hermaphroditum	+	+	r	+	·	·	r	r	·	·	·	·	r	+	+	+	+	r	r	r	+	·	+	·	·	+	·	·	V^{+}	III^{+}	IV^{+}	IV^{+}	II^{+}	·	·	·	·	·	·
Festuca rubra subsp. *arctica*	·	·	r	+	·	1	+	+	+	2a	1	1	+	+	2a	2a	+	+	·	·	·	·	·	+	+	+	+	·	III^{+}	V^{+}	V^{+}	I^{+}	IV^{+}	·	·	1	2a	·	·
Luzula multiflora subsp. *frigida*	·	+	·	r	·	·	r	r	r	·	r	r	+	+	+	+	·	+	·	r	+	·	+	+	r	r	+	·	III^{+}	IV^{+}	IV^{+}	IV^{+}	IV^{r}	·	·	1	1	·	·
Salix hastata	·	r	·	1	·	+	·	r	·	·	·	r	r	r	r	·	r	r	·	r	+	+	·	·	r	+	+	r	III^{+}	III^{r}	III^{r}	III^{+}	V^{+}	·	·	·	1	·	·
Carex aquatilis subsp. *stans*	+	·	+	r	·	·	+	·	·	·	·	·	·	r	+	r	+	r	+	+	r	·	·	·	·	·	r	·	IV^{+}	III^{+}	III^{+}	III^{+}	II^{r}	·	·	1	·	·	+
Nephroma arcticum	·	+	·	·	1	1	+	+	·	+	·	·	+	1	1	r	·	+	+	+	1	1	·	·	·	·	·	·	II^{+}	IV^{+}	IV^{+}	IV^{1}	·	·	1	·	·	·	·
Peltigera aphthosa	·	+	·	·	·	r	·	·	·	·	+	·	+	·	r	+	r	+	·	·	·	+	·	+	r	+	r	r	II^{+}	III^{+}	III^{+}	II^{+}	V^{r}	1	·	·	+	·	·
Salix glauca	1	r	r	·	r	·	r	r	·	·	r	r	·	·	·	·	·	·	+	+	+	r	·	·	·	·	·	r	IV^{r}	II^{r}	III^{r}	IV^{+}	II^{r}	+	·	1	1	·	·
Vaccinium uliginosum subsp. *microphyllum*	2a	1	·	+	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	+	+	+	·	·	·	·	·	IV^{1}	·	I^{1}	V^{+}	·	·	·	·	·	·	·
Veratrum lobelianum	r	r	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	+	+	+	2a	+	+	r	r	+	+	III^{r}	·	I^{r}	V^{+}	V^{+}	·	·	·	·	·	·
Cladonia arbuscula	·	+	r	·	+	·	+	r	r	r	+	+	·	·	r	·	·	·	·	·	·	r	·	·	·	·	·	·	III^{+}	III^{+}	III^{+}	I^{r}	·	+	1	2b	1	·	·
Pachypleurum alpinum	·	·	·	r	·	·	·	r	r	·	1	+	r	r	+	·	+	r	·	·	·	r	·	·	·	·	·	r	II^{r}	IV^{r}	III^{r}	I^{r}	II^{r}	+	1	+	2a	2a	r
Festuca ovina	·	+	·	·	+	·	·	·	·	·	·	r	2a	+	+	·	·	r	·	·	·	+	·	·	·	·	·	·	II^{+}	III^{+}	II^{+}	I^{+}	·	2a	1	·	1	1	·
Equisetum scirpoides	·	·	·	r	·	·	·	+	·	·	1	1	r	·	·	·	+	+	·	·	·	+	·	·	·	·	·	·	II^{r}	III^{+}	II^{+}	I^{+}	·	2a	·	·	·	·	·
Valeriana capitata	·	·	·	·	+	r	·	·	r	+	r	+	·	1	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	III^{+}	II^{+}	·	·	·	1	2a	2b	·	·
Saxifraga hirculus	·	·	·	·	+	·	+	·	·	r	r	·	·	·	+	·	·	+	·	·	·	·	·	·	·	·	·	·	·	III^{+}	II^{+}	·	·	·	·	·	·	·	·
Bartramia ithyphylla	·	·	·	·	·	·	+	+	·	+	+	·	·	·	+	+	·	+	·	·	·	·	·	·	+	·	+	·	·	III^{+}	II^{+}	·	III^{+}	·	·	·	·	·	·
Ranunculus propinquus	·	·	·	·	·	·	·	·	·	·	+	r	·	r	+	r	·	+	·	·	+	1	·	·	·	·	·	·	·	III^{+}	II^{+}	II^{1}	·	·	1	2a	2b	·	+
Nephroma expallidum	·	·	·	r	·	+	·	·	·	r	·	+	+	r	+	·	·	·	·	·	·	1	+	·	·	·	·	·	II^{r}	III^{+}	II^{+}	II^{1}	·	1	·	·	·	·	·
Lobaria linita	·	·	·	r	·	r	·	·	·	r	r	1	·	·	+	·	·	+	·	·	r	·	r	·	·	·	·	·	II^{r}	III^{+}	II^{r}	II^{r}	·	·	·	·	·	·	·
Polemonium acutiflorum	·	·	·	·	r	·	r	·	·	·	·	+	r	·	+	+	·	1	·	·	·	·	·	·	·	·	·	r	·	III^{+}	II^{+}	·	II^{r}	·	1	·	·	·	·
Salix lanata	+	r	r	·	·	·	·	·	·	·	r	·	·	·	·	·	·	·	+	1	2a	·	·	·	·	·	·	r	IV^{r}	I^{r}	II^{r}	III^{1}	II^{r}	·	1	·	·	·	·
Cladonia bellidiflora	·	+	·	·	·	·	·	r	r	·	·	·	·	·	·	·	·	·	+	+	+	·	·	·	·	·	·	·	II^{+}	I^{r}	I^{r}	III^{+}	·	1	·	2a	·	+	·
Cladonia stricta	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	r	r	r	r	·	·	·	+	·	·	·	·	·	I^{r}	I^{r}	III^{r}	·	·	·	·	·	·	·

Table 2. Continued.

Relevé nr. in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	a	b									
Alopecurus pratensis subsp. *alpestris*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	r	r	.	.	.	.	.	.	1	.	I^{+}	I^{+}	III^{r}	II^{1}	+	.	.	2a	.	+
Betula nana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	r	.	.	r	r	r	.	.	.	.	IV^{+}	IV^{r}	+	.	.	.	.	.
Poa alpina	.	r	.	.	.	.	.	.	r	r	r	.	r	.	.	r	.	+	.	.	.	r	.	+	+	+	1	+	II^{r}	III^{r}	II^{r}	II^{+}	V^{+}	.	2a	.	.	1	.
Caltha palustris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	+	.	.	.	.	.	IV^{+}	.	.	.	.	.	.
Allium schoenoprasum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	IV^{r}	.	.	.	.	2a	.
Comarum palustre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	r	.	.	.	.	.	IV^{r}	.	.	.	.	.	.
Brachythecium rutabulum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	IV^{+}	.	.	.	.	.	.
Distichium capillaceum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	IV^{+}	.	.	.	.	.	.
Sagina intermedia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+	+	.	.	I^{+}	I^{+}	.	IV^{+}	.	.	.	.	.	.
Salix reticulata	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	2a	.	+	.	.	I^{+}	I^{+}	I^{+}	III^{1}	.	.	.	2b	.	.
Peltigera neckeri	.	.	+	.	.	.	r	.	1	+	+	r	.	.	.	.	.	.	.	.	.	.	.	.	r	.	r	.	II^{+}	II^{+}	II^{+}	.	III^{r}	.	.	.	.	.	.
Psoroma hypnorum	.	r	.	.	.	r	r	.	.	r	+	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	II^{r}	II^{r}	II^{r}	.	III^{r}	.	1	1	1	.	.
Bryum pseudotriquetrum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	r	.	.	.	.	.	.	.	+	.	1	.	I^{+}	I^{+}	.	III^{1}	.	.	.	.	.	.
Tripleurospermum hookeri	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	I^{r}	I^{r}	.	III^{r}	.	.	.	.	.	.
Marchantia polymorpha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	+	r	.	I^{r}	I^{r}	.	III^{+}	.	.	.	.	.	3
Pogonatum urnigerum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	III^{+}	.	.	.	.	.	.
Dichodontium pellucidum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	III^{+}	.	.	.	.	.	.
Bryum rutilans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	III^{1}	.	.	.	.	.	.
Other species																																							
Salix phylicifolia	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	II^{+}	.	I^{+}	II^{+}	.	.	.	.	.	.	.
Salix nummularia	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{r}	I^{r}	.	.	+	.	.	.	.	.
Anthoxanthum odoratum subsp. *alpinum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	I^{1}	.	+	.	.	.	.	.
Avenella flexuosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	.	.	.	II^{r}	.	+	.	1	.	.	.
Bartsia alpina	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	I^{r}	I^{r}	.	.	.	.	2a	.	.	.
Carex bigelowii subsp. *arctisibirica*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	r	.	.	.	I^{r}	II^{r}	1	.	.	.	.	.
Phleum alpinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	I^{+}	.	.	.	.	.	.	+	.
Pohlia nutans	.	.	.	2a	.	.	.	.	+	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	II^{2a}	II^{+}	II^{+}	.	.	.	.	.	.	.	.
Rumex acetosa subsp. *lapponicus*	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	.	.	r	.	I^{+}	I^{+}	II^{+}	II^{r}	+	2a	2a	1	.	.
Saxifraga hieracifolia	.	.	.	.	r	r	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	r	.	II^{r}	II^{r}	.	II^{r}	.	1	.	.	.	r
Solidago lapponica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	II^{r}	.	.	.	.	1	.
Taraxacum ceratophorum	.	.	.	.	.	.	.	.	.	r	+	.	r	r	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{r}	II^{r}	.	.	.	.	.	.	.	.
Dicranum flexicaule	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	I^{+}	I^{+}	.	II^{+}	.	.	.	.	.	.
Dicranum majus	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	I^{+}	I^{+}	I^{+}	II^{+}	2a	.	.	.	.	.
Dicranum spadiceum	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	I^{+}	I^{+}	I^{+}	.	.	.	.	.	.	.
Pleurozium schreberi	.	.	.	.	.	.	r	.	.	.	.	r	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{r}	I^{r}	.	.	.	.	.	1	1	.
Pohlia cruda	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	II^{+}	.	I^{+}	I^{+}	II^{+}	.	.	.	.	.	.
Polytrichum commune	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	+	.	.	.	.	II^{+}	.	I^{+}	II^{+}	.	.	.	.	.	.	.
Sciuro-hypnum reflexum	.	.	.	.	.	.	.	.	.	+	+	+	.	.	+	.	.	+	.	.	+	+	.	.	.	.	.	.	.	II^{+}	II^{+}	II^{+}	.	.	.	.	.	.	.
Cladonia coccifera	.	r	.	.	r	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{r}	I^{r}	I^{r}	.	.	+	.	.	.	+	.
Cladonia gracilis subsp. *elongata*	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	I^{r}	I^{r}	I^{r}	.	3	1	2b	.	.	.
Peltigera leucophlebia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	+	.	.	.	r	.	I^{+}	I^{+}	II^{+}	II^{r}	.	.	.	.	.	.
Peltigera polydactylon	r	1	.	.	r	.	r	r	.	r	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	r	III^{+}	II^{r}	II^{r}	.	II^{r}	.	.	.	.	.	.
Stereocaulon alpinum	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	r	.	.	.	.	.	.	.	.	II^{+}	.	I^{+}	II^{r}	.	1	.	1	1	1	.
Liverworts	2a	2b	.	.	.	.	.	.	+	1	1	.	.	.	.	.	.	.	.	2a	.	.	2a	3	.	.	.	.	III^{2b}	II^{1}	II^{2a}	III^{2a}	.	.	.	1	.	.	.

Note. Species found in 1–2 relevés with an abundance of r or + (others are indicated in brackets): shrubs – *Salix lapponum* 1; *S. arctica* 21; herbs – *Botrychium lunaria* 28; *Calamagrostis holmii* 16; *Carex rariflora* 1; *Cerastium jenisejense* 16, 18; *Draba sibirica* 22, 28; *Epilobium davuricum* 18; *Euphrasia frigida* 23; *Geranium albiflorum* 28; *Geum rivale* 10, 28; *Huperzia selago* subsp. *appressum* 19, 22; *Juncus arcticus* 22; *J. biglumis* 27; *Luzula wahlenbergii* 16; *Lycopodium dubium* 20, 21; *Primula stricta* 17; *Ranunculus repens* 25; *R. samojedorum* 16; *Saussurea alpina* 15; *Saxifraga cespitosa* 10; *Tanacetum vulgare* 24; *Tussilago farfara* 16 (1); *Viola epipsila* 22; bryophytes – *Brachythecium latifolium* 28; *Bryoerythrophyllum recurvirostre* 26; *Bryum* sp. 24, 25, 28; *Calliergon sarmentosum* 1 (1); *Calliergonella lindbergii* 18; *Dicranella* sp. 24; *D. subulata* 23; *Dicranum acutifolium* 16; *D. bardunowii* (28); *Philonotis fontana* 15; *Pogonatum dentatum* 24; *Pohlia filum* 23; *P. wahlenbergii* 28; *Polytrichastrum longisetum* 1 (2b); *Rhizomnium pseudopunctatum* 1, 18; *Sphenolobus minutus* 8; lichens – *Cladonia acuminata* 27; *C. chlorophaea* 11; *C. crispata* var. *cetrariiformis* 15; *C. phyllophora* 10; *C. pleurota* 14; *C. pocillum* 18; *C. subfurcata* 20; *C. uncialis* 5; *Peltigera didactyla* 23; *P. malacea* 17; *Stereocaulon glareosum* 24.

Species with an abundance from + to 2a found also in relevés by Z.N. Smirnova (1938): *Chamaenerion angustifolium, Geranium sylvaticum, Taraxacum lapponicum, Veronica longifolia, Barbilophozia hatcheri* (2a), *Dicranum elongatum, Niphotrichum canescens* (1), *Polytrichum hyperboreum* (2a), *Cladonia amaurocraea*; by I.D. Bogdanowskaya-Guihéneuf (1938): *Vaccinium vitis-idaea* subsp. *minus, Chrysosplenium alternifolium, Cirsium heterophyllum, Erigeron borealis, Gentiana verna* subsp. *arctica, Pedicularis verticillata, Poa alpigena, Stellaria crassifolia, Tephroseris integrifolia, Aulacomnium turgidum, Brachythecium* sp., *Dicranum* sp., *Hylocomium splendens, Polytrichum* sp., *Ochrolechia frigida, Peltigera canina, Sphaerophorus globosus.*

Table 2. Continued.

GPS coordinates (WGS 84) (N, E): **1** – 68.35253, 53.17342; **2** – 68.36442, 53.15311; **3** – 69.18907, 49.43276; **4** – 68.86647, 49.25490; **5** – 69.21520, 48.87241; **6** – 69.23274, 48.81718; **7** – 69.20041, 49.42126; **8** – 69.22793, 48.89695; **9** – 69.26882, 48.84036; **10** – 69.24470, 48.88551; **11** – 69.23948, 48.84366; **12** – 69.24340, 48.84297; **13** – 68.86743, 49.20974; **14** – 68.86956, 49.21516; **15** – 68.87488, 49.27056; **16** – 68.86134, 49.22145; **17** – 68.88272, 49.22668; **18** – 68.87428, 49.25708; **19** – 68.48761, 57.19583; **20** – 68.48769, 57.19539; **21** – 68.48742, 57.20369; **22** – 68.35450, 56.49181; **23** – 68.07167, 54.81142; **24** – 67.52186, 55.07292; **25** – 68.39644, 55.13789; **26** – 68.39786, 55.12920; **27** – 68.39542, 55.13983; **28** – 68.35336, 53.13094.

Authors. rel. no. 2, 28 – **O.V. Lavrinenko**, **T.V. D'aychkova**; all others relevé numbers – **O.V. Lavrinenko**, **I.A. Lavrinenko**.

Abbreviations.

Locality (in author's relevé nr.): **БД** – Bolshaya Dvoynichnaya River; **Ван** – Vangureimusyur Upland, Bolshaya Khekheganyakha River; **К** – Kolguev Isl.; **НГ** – Nenets Ridge; **ПГ** – Pakhancheskaya Bay environs; **Шап** – Vesnimusyur Upland, Shapkina River basin; **Я** – Yachey River, Bolvanskaya Bay.

Character-species (next to the name of the taxon): **Sh** – class ***Salicetea herbaceae***.

Here and in Tables 3–5, 7 bold type indicates high abundance, blue shading indicates the absence or low constancy of significant species.

* – nomenclatural types (holotypus): rel. no. **9** (author's no. K37_13), Kolguev Island, upper reaches of the Peschanka River, 04.08.2013, authors O.V. Lavrinenko, I.A. Lavrinenko; rel. no. **22** (author's no. – Ван62), Bolshezemelskaya tundra, Vangureimusyur Upland, Bolshaya Khekheganyakha River, 21.07.2017, authors O.V. Lavrinenko, V.V. Neshataev; rel. no. **26** (author's no. – **БД71**), Bolshezemelskaya tundra, Bolshaya Dvoynichnaya River, 23.07.2016, authors O.V. Lavrinenko, I.A. Lavrinenko.

be found on the surface. Organic layer of these soils has a small thickness (1.0–1.5 cm) and low degree of decomposition. All soils of communities of var. typica are loamy, but exhibit regional specificity. The soils at the southern part of Kolguev have a weak structure of mineral horizons. The structure of soils in the central part of Kolguev is more clearly expressed. Soils of communities of var. inops also have a thin organic layer but are characterized by coarser fine earth composition: soils of the Nenets Ridge they are sandy loamy and on Kolguev they are sandy. The latest have morphological evidence of iron-illuvial process.

Distribution. The range of the association lies to the west of the Pechora River encompassing Kolguev Island and the Malozemelskaya tundra. It comprises of sub-zones of typical and southern tundra. Communities have been described in the Bugryanka River basin, and the upper and middle reaches of the Peschanka River on Kolguev Island (Fig. 1, sites 1–3), and on the hillsides of the Nenets Ridge (Fig. 1, site 5).

Note. In the 1930s, Soviet geobotanists, while working on Kolguev Island, to describe communities with character species of the class Salicetea herbaceae within a dominant approach. Thus, Smirnova (1938) described the ass. Frutices–herbs–*Cladonia gracilis* (see Table 2) on a steep slope of the Goltsovka-Yaga River (a tributary of the Peschanka River) and referred it to the group of dwarf shrub tundra. The communities contain *Salix herbacea*, *S. polaris*, *Carex lachenalii*, *Dichodon cerastoides*, *Omalotheca supina*, *Sibbaldia procumbens*, *Veronica alpina*, *Polytrichastrum alpinum*, *Cetrariella delisei*, *Solorina crocea*, and several other species in similarity with the new association (the name *Cladonia gracilis* appears to be followed by *C. ecmocyna*, which was not distinguished). Since the name of the association does not correspond to Art. 10 ICPN, it cannot be validated. Bogdanowskaya-Guihéneuf (1938) has also described several floristically heterogeneous communities found on hillsides and valleys and assigned them to the group of tundra meadow associations. In areas where snow cover accumulates for long periods in the lower parts of slopes or in ravines on clay soil, associations *Salix polaris–Equisetum arvense* and *Salix polaris–Equisetum arvense–Marchantia polymorpha* were described, whose community composition varies greatly (see Table 2). As we have already mentioned, Soviet geobotanists conducted performed descriptions on large areas within the natural boundaries of communities rather than on plots, since the purpose of their work was to assess the reserves of fodder plants in reindeer pastures. We can only say that these tundra meadows described by Bogdanowskaya-Guihéneuf undoubtedly belong to a new alliance.

Salici polaris–Sibbaldietum procumbentis Lavrinenko et Lavrinenko **ass. nov.** (Table 2, rel. 19–24, Table 7, syntaxon 11; Fig. 2E–G)

Holotypus: relevé 22 (author's number Ван62), Bolshezemelskaya tundra, Vangureimusyur Upland, Bolshaya Khekheganyakha River, 68.35450°N, 56.49181°E, terraced ravine northeastern slope 10° steep, 21.07.2017, authors O.V. Lavrinenko, I.A. Lavrinenko.

Composition. Differential species combination in the association: herbs *Diphasiastrum alpinum*, *Trientalis europaea*, *Trisetum spicatum*, moss *Polytrichum strictum* and lichen *Peltigera scabrosa*. The association is distinguished by a high abundance of character species of the class Salicetea herbaceae – *Sibbaldia procumbens* (median abundance score 2b), *Omalotheca supina* (1) and the mosses *Kiaeria starkei* (3) and *Polytrichastrum alpinum* (2a). All character species (selective and preferential) of the new alliance Veronico alpinae–Salicion polaris are present in the communities (see Table 2).

Total number of taxa registered in association is 86: 51 vascular plants (5 shrubs, 5 dwarf shrubs, and 41 herbs), 16 bryophytes, 19 lichens; 21 highly constant species (24 %), 36 species with constancy score I (42 %); 28–48 species in communities (mean 39).

Structure. The total projective cover in the communities is 85–100 %, with the mean cover of shrubs 4 %, dwarf shrubs 7 %, herbs 30 %, mosses 65 %, and lichens 7 %.

The ground cover is predominantly mossy (40–90 %), oligodominant from *Kiaeria starkei*, *Polytrichastrum alpinum*, *Polytrichum strictum* and *Sanionia uncinata*. Among mosses there are predominantly chionophilous lichens, the most common are *Cetraria islandica* subsp. *islandica*, *Cetrariella delisei*, *Cladonia bellidiflora*, *C. ecmocyna*, *C. stricta*, *Nephroma arcticum*, *Peltigera scabrosa*, *Stereocaulon rivulorum*. The dwarf shrub layer is mostly absent or poor except in two communities where its coverage amounts to 10 and 30 %; *Salix polaris* (1–2 cm height) predominates in it. The low herbs layer (5–10 cm height, only *Veratrum lobelianum* up to 30 cm) is slightly to moderately closed (10 to 50 % coverage). It is co-dominated by *Sibbaldia procumbens*, *Omalotheca supina* and *Equisetum arvense* subsp. *boreale*. Low (30–40 cm tall) willow shrubs *Salix lanata* and *S. glauca* (<1 to 20 % cover) can be found in several communities.

Habitats. Herb–moss communities with a non-dense *Salix polaris* layer are found on the lower third of gentle (up to 15°) slopes of bedrock banks of rivers, ravines and hills, including their foothills. The north-western and north-eastern slopes show a somewhat concave surface. These habitats usually retain snow till mid to late July. Soils are sandy or loamy. Organic layer is very thin: less then 1 cm.

Distribution. The association's range is located east of the Pechora River, in the Bolshezemelskaya tundra, covering the subzones of typical and southern tundra. Communities have been described on the slopes of ravines and hills 10–30 m high in the area of Pakhanskaya Bay (vicinity of Lake Lutsato), in ravines in the valleys of the Bolshaya Kheheganyakha (Vangureimusyur Upland), Shapkina (Vesnimusyur Upland) and Yachey River (flowing into Bolvanskaya Bay) (Fig. 1, sites 8–11).

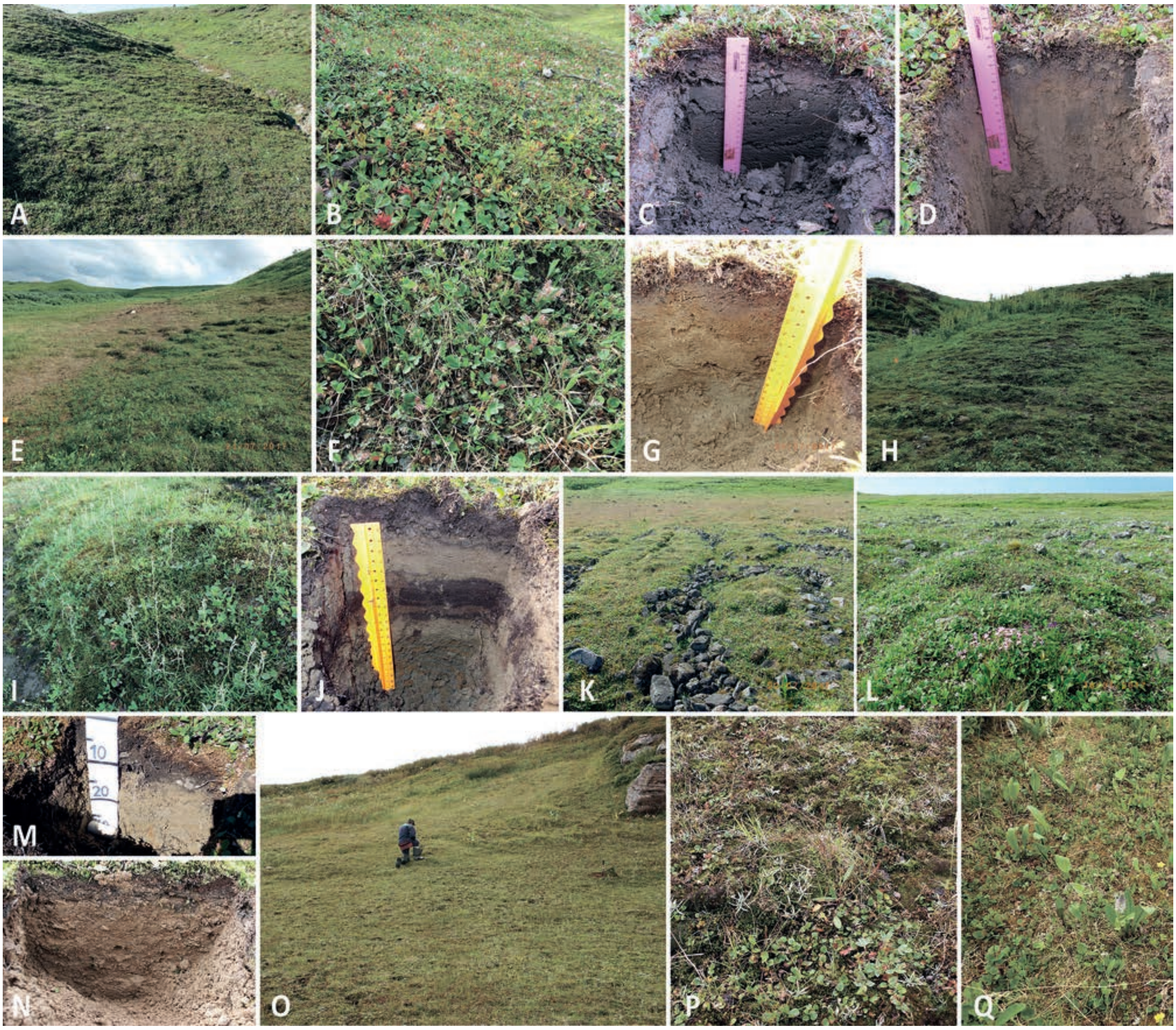

Figure 2 Communities and habitats. A – snowbed stands of the ass. Salicetum herbaceae-polaris var. typica on a steep slope of the northern exposition of a ravine in the upstream of the Peschanka River on Kolguev Island (Table 2, rel. no. 6 (K11_13)); B – close up of previous variant (Table 2, rel. no. 11 (K100_13)); C – loamy soil under the community of previous variant (Table 2, rel. no. 12 (K91_13)); D – sandy soil under the community Salicetum herbaceae-polaris var. inops (Table 2, rel. no. 3 (K145_13)); E – snowbed stands of the ass. Salici polaris–Sibbaldietum procumbentis on the gentle lower part of the ravine slope in the valley of the Bolshaya Khekheganyakha River on the Vangureimusyur Upland (Table 2, rel. no. 22 (Ван62)); F – close up of previous association (same rel.); G – sandy soil under previous community (same rel.); H – snowbed stands of the ass. Myosotido asiaticae–Salicetum polaris on the steep solifluction slope of the northern exposure of the bedrock bank of the Bolshaya Dvoinichnaya River (Table 2, rel. no. 25 (БД69)); I – close up of previous association (Table 2, rel. no. 26 (БД71)); J – loamy soil with buried organic material under the previous community (same rel.); K – snowbed stands of the ass. Pinguiculo alpinae–Salicetum reticulatae on a cryoplanation terrace on the Vangureimusyur Upland (Table 3, rel. no. 1 (Ван65)); L – close up of previous association (Table 3, rel. no. 4 (Ван44)); M – loamy soil with thickness organic layer and contains stones under the community of previous association on Bolvanskii Nose Cape (Table 3, rel. no. 5 (БН3_20)), the soil pit was made by A.G. Shmatova; N – loamy soils with thin organic layer under the community ass. Veratro lobeliani–Salicetum herbaceae (Table 4, rel. no. 1 (Б7)); O – snowbed stands of the ass. Veratro lobeliani–Salicetum herbaceae at the foot of sandstone outcrops in the Timanskii Kryazh (same rel.); P – close up of previous association (same rel.); Q – *Lagotis glauca* subsp. *minor* and *Ranunculus nivalis* in snowbed stands in the southern tundra of the Taymyr Peninsula (Table 5, rel. no. 1 (Та98))

Myosotido asiaticae–Salicetum polaris Lavrinenko et Lavrinenko **ass. nov.** (Table 2, rel. 25–28, Table 7, syntaxon 12; Fig. 2H–J)

Holotypus: relevé 26 (author's number БД71), north-western part of Bolshezemelskaya tundra, Bolshaya Dvoinichnaya River, 68.39786°N 55.12920°E, bedrock bank north-western slope 30° steep, 23.07.2016, authors O.V. Lavrinenko, I.A. Lavrinenko.

Composition. Differential species combination in the association: herbs *Achillea millefolium*, *Agrostis mertensii* subsp. *borealis*, *Artemisia tilesii*, *Bistorta elliptica*, *Cardamine pratensis* subsp. *angustifolia*, *Myosotis asiatica* (median abundance score 1), *Parnassia palustris*, *Saxifraga cernua* and *Viola biflora*, and some mosses: *Mnium blyttii*, *Oncophorus integerrimus* (2b) and *Philonotis tomentella* (1). Character species (except *Cladonia ecmocyna*) of the new alliance Veronico alpinae–Salicion polaris and the class Salicetea herbaceae are frequently and continuously present with high abundance (see Table 2).

Total number of taxa registered in association is 86: 56 vascular plants (4 shrubs, 3 dwarf shrubs, and 49 herbs), 21 bryophytes, 9 lichens; 47–51 species in communities (mean 49).

Structure. The total projective cover in the communities is 70–95 %, with mean cover of dwarf shrubs 20 %, herbs 45 %, mosses 60 %. The projective cover of shrubs and lichens is negligible (<1 %). Communities in this syntaxon are distinguished by a well-developed layer of herbs, with a higher cover compared to the associations described earlier and a greater species richness of herbs present, with an average of 30 species in one community compared to 19 or 20 in others. *Bistorta vivipara* (2a) and *Myosotis asiatica* (1) are quite abundant along with common herbs found in snowbed communities (*Sibbaldia procumbens*, *Omalotheca supina*, *Epilobium alpinum*, *Veronica alpina*). The dwarf shrub layer, on the contrary, is poorly formed, in addition to *Salix polaris* (2b), calciphytic dwarf willow *S. reticulata* (1) sometimes occurs in it. Ground cover is co-dominated by *Sanionia uncinata* (2a) and cryophilous mosses.

Habitats. Herb–moss snowbed communities with a non-dense *Salix polaris* layer are found on the lower half of slopes near bedrock banks of rivers and hills. These slopes are north-facing, steep (with a slope 20–30° steep), solifluctional, terraced, with patches of raw clay due to soil sliding and turf rupture, with stones on the surface. Soils combine layers of sand and loam. Organic layer is thin: 1–2 cm. It contains both weakly and well decomposed organic material. As a result of solifluction (or another geomorphological processes), some of it may be buried. Mineral part of the soil is poorly structured and has some gley features.

Distribution. Communities belonging to the association have been described on both riverbanks of the Pechora River. These are located in the Malozemelskaya tundra on the hillsides of the Nenets Ridge (southern tundra) and in the west of the Bolshezemelskaya tundra on the bedrock banks of the Bolshaya Dvoinichnaya River (typical tundra) (Fig. 1, sites 5, 7).

We propose a new alliance for calciphiles-poor snowbed communities on acid soils within the plain tundra of the East European sector of the Arctic.

All. **Veronico alpinae–Salicion polaris** Lavrinenko et Lavrinenko **all. nov.**

Description. Herb–dwarf willow–moss vegetation with chionophilous species in the snowbed habitats located on solifluction slopes facing northward, as well as of bedrock river banks and ravines on siliceous substrates in the plain East European tundra.

Name-giving taxa: *Veronica alpina* L. s. str., *Salix polaris* Wahlenb.

Holotypus: ass. Salici polaris–Sibbaldietum procumbentis Lavrinenko et Lavrinenko **ass. nov.** (this paper, Table 2, rel. 19–24, Table 7, syntaxon 11).

Character species (including selective and preferential): dwarf shrub *Salix polaris*, herbs *Carex lachenalii*, *Dichodon cerastoides*, *Pyrola minor*, *Ranunculus glabriusculus* and *Veronica alpina*, cryophilous (psychrophilous) lichens *Cetrariella delisei*, *Cetraria islandica* subsp. *islandica*, *Cladonia ecmocyna* and *Stereocaulon rivulorum* plus character species of the class Salicetea herbaceae: *Omalotheca supina*, *Sibbaldia procumbens*, *Kiaeria starkei* and *Polytrichastrum alpinum*.

Habitats. Snowbed communities form in regions with a dissected landscape, characterized by hilly terrain or V-shaped river valleys. The presence of leeward slopes and niches where snow accumulates in winter is a major factor that determines their distribution. These communities are found on the lower sections of the slopes of low hills, ravines, bedrock riverbanks, and their foothills. Slopes mostly face a northerly direction, occasionally north-western or north-eastern, with an incline ranging from 5 to 40°. Sometimes slopes are concave-shaped, cirqus-like, known as "niches of nivation". Usually, snow persists in these habitats until mid – late July, occasionally until early – mid August. Solifluction processes are very often observed on the slopes, resulting in terracing. Habitats on steep slopes are well drained, while those on gentle slopes and foothills tend to be wetter due to inflow of melt water, close permafrost and proximity to streams in ravines. As a rule, the area of communities is small; extending 2–6 m down the slope from top to bottom, along the slope – within ten meter range. The soils are sandy or loamy with thin (<1–2 cm) organic layer. At the end of July, permafrost was detected at a depth of 25–37 cm in the lower parts of the slopes.

Distribution. The alliance's scope covers the typical and southern tundra subzones in the Malozemelskaya and Bolshezemelskaya tundra, and Kolguev Island. The communities are predominantly distributed in areas with hilly or highly dissected landscape, with loamy sediments coming to the surface.

Note. Dwarf willow *Salix herbacea* (key character species of the alliance Cassiopo–Salicion herbaceae) – is a chionophilous and psychrophilous arctoalpine oceanic (Amphiatlantic) species, its range is restricted eastward to the Pechora River. The species is highly uncommon in the Bolshezemelskaya tundra and has recently been newly discovered in its western part (Lavrinenko et al. 2016). In snowbed communities east of the Pechora River it is replaced by *Salix polaris*, a chionophilous arctic Eurasian species. The ranges of these two dwarf willows only intersect in a small territory. Within the scope of this study, this includes Kolguev Island and the eastern section of the Malozemelskaya tundra (Tolmachev 1966).

When determining the diagnostic significance of dwarf willows, it is necessary to consider the change in their activity in the landscape across a latitudinal gradient. Thus, in southern tundra *Salix polaris* is rarely found only in intrazonal habitats – within snowbed communities located on northern slopes. In typical tundra, this species is the prominent in coenoflora of not just snowbed, but also zonal communities on the interfluves (upland surfaces). While in arctic tundra it becomes the main dominant species in numerous communities (Matveyeva 1998, Lavrinenko & Lavrinenko 2018). *Salix herbacea* exhibits a similar behavior pattern: in the southern tundra on northern part of the Timanskii Kryazh it grows only in snowbed habitats, in typical tundra on Kolguev Island it is constant and often abundant in snowbed communities and occasionally can be found in zonal tundra. A number of other species demonstrate analogous characteristics in mountainous areas. At high altitudes, certain snow species (e.g., *Blepharostoma trichophyllum*, *Luzula arctica*, *Salix herbacea*) are also present in communities of other classes, due to which Sieg et al. (2006) believe that their diagnostic value is reduced. However, these species hold significant importance when considered in conjunction with other taxa of differential species combination in the associations and alliances.

The species-rich communities of herb–dwarf willow (*Salix reticulata*)–moss communities are found on cryoplanation terraces with outcrops of stony material showing signs of carbonateness. They are assigned to one new association placed in a provisional alliance.

Pinguiculo alpinae–Salicetum reticulatae Lavrinenko, Lavrinenko et Neshataev **ass. nov.** (Table 3, rel. 1–6; Table 7, syntaxon 13, Fig. 2K–M)

Holotypus: relevé 2 (author's number Ван49), Bolshezemelskaya tundra, Vangureimusyur Upland, Bolshaya Kheheganyakha River, 68.35144°N 56.47003°E, cryoplanation terrace in the river valley, 19.07.2017, authors O.V. Lavrinenko, I.A. Lavrinenko.

Composition. Differential species combination in the association: dwarf shrub *Salix reticulata* (selective and preferential species, median abundance score 3), herbs *Carex capillaris*, *C. parallela* subsp. *redowskiana*, *Lagotis glauca* subsp. *minor*, *Pinguicula alpina* (1), *Potentilla crantzii*, *Selaginella selaginoides*, *Silene acaulis*, *Tofieldia pusilla*, mosses *Brachythecium erythrorrhizon* (1), *Campylium stellatum*, *Dicranum spadiceum* (2a), *Ditrichum flexicaule*, *Hylocomiastrum pyrenaicum*, *Oncophorus integerrimus* (2a), *Pohlia cruda* (1) and lichen *Cladonia pocillum* (1). Most of these species are hemicalciphytes. Three species *Salix reticulata*, *Silene acaulis* and *Thalictrum alpinum* are present in the list of characteristic species of the order Arabidetalia caeruleae and the class Thlaspietea rotundifolii (Mucina et al. 2016). Character species of the order Salicetalia herbaceae and class Salicetea herbaceae were observed in these communities, but they mostly have low constancy and abundance here. Arctoalpine and hypoarcto-montane herbs (*Anthoxanthum odoratum* subsp. *alpinum*, *Bartsia alpina*, *Bistorta vivipara*, *Thalictrum alpinum*, *Trollius europaeus*), which are character species of the alliance Potentillo–Polygonion vivipari Nordhagen 1937, occur in low abundance. The alliance has been recently reestablished for slope grasslands in the Fennoscandian mountain-tundra belt (Koroleva et al. 2019) (see Table 3).

Total number of taxa registered in association is 141: 75 vascular plants (5 shrubs, 7 dwarf shrubs, and 63 herbs), 40 bryophytes, 26 lichens; 41 highly constant species (29 %), 57 species with constancy score I (40 %); 36–78 species in communities (mean 61).

Structure. Total plant cover in the communities is ranging from 70–100 %; with a predominance of dwarf shrubs and mosses (average cover is 55 % and 50 % respectively), average cover of herbs – 15 %, lichens – 3 %, shrubs – <1 %. The horizontal structure mainly consists of fractured-polygonal formations with a large-mesh stone grid. The polygons are 1.0–2.5 m across, with a convex surface, filled with fine soil, occupied by herb–dwarf willow–moss communities. Coarse clastic stony material ranging from 10–50 cm in size is sorted and found in cracks framing the polygons, repeating the structure of polygonal ground-ice wedges. Rarely, the vegetation turf is ruptured by the emergence of disordered groups of stones, covering up to 30 % of the surface area. If the cover is solid (Table 3, rel. 5, 6), stones are still present and are located in the near-surface soil layer. All vegetation layers are close and are located within 10 cm. The ground cover is mossy (0.5–1.5 cm high), multispecies (14–24 species in communities with polygonal structure and 7–9 – with continuous turf).

Mosses (*Dicranum spadiceum*, *Oncophorus integerrimus*, *Hylocomiastrum pyrenaicum*, *Sanionia uncinata*) are overlain by a dense layer of dwarf willows rising 1–2 cm above the mosses; *Salix reticulata* takes precedence, although in certain habitats it is co-dominant with *S. polaris*. Herbs are generally low-growing (5–10 cm), and although they have a large number of species (with a range of 22 to 37 taxa identified in relevés), they are low in abundance. *Astragalus alpinus* subsp. *arcticus*, *Bistorta vivipara*, *Carex parallela* subsp. *redowskiana*, *Equisetum arvense* subsp. *boreale*, *E. variegatum*, *Pinguicula alpina*, *Ranunculus propinquus* reach up about 5 % of the cover, while other species constitute less than 1 %.

Habitats. The communities inhabit areas within the nival frozen landscape characterized by the prolonged presence of snowfields – cryoplanation terraces composed of rough-clastic stony material. These are elevated surfaces with inckines of 1–5° located at the base of north-facing rocky riverbank slopes. The communities extend along the slopes for tens of meters. These soils differ in the relative thickness of the organic horizon: up to 7 cm. It consists of well-decomposed organic material in varying proportions with a mineral component. Mineral part of the soil is poorly structured and contains stones. According to A.G. Shmatova (private data) water pH of soil (rel. 5 in Table 3) is about 7.

The variety of ecological niches present in the habitats explains the growth of species with different ecological characteristics, among which there are many hemicalciphytes – *Salix reticulata*, *Bartsia alpina*, *Carex parallela* subsp. *redowskiana*, *Equisetum variegatum*, *Pedicularis oederi*, *Pinguicula alpina*, *Silene acaulis*, *Thalictrum alpinum*, *Hylocomiastrum pyrenaicum*, *Tomentypnum nitens*, *Cladonia pocillum*. This indicates that base-rich soils are a characteristic feature of these habitats.

Distribution. The association is found within the subzone of typical tundra in two areas with hilly relief located in the west of Bolshezemelskaya Tundra – the Vangureimusyur Upland and Bolvanskii Nose Cape (Fig. 1, sites 6, 9). Apparently, its range is wider and covers areas with hilly moraine landscapes, where the hills are composed of loams with inclusions of stony material.

Note. Herb–dwarf willow–moss stands at the Vangureimusyur Upland were described earlier (Neshataev & Lavrinenko 2020) in the rank of community type *Silene acaulis–Salix reticulata* com. type.

We compared the new association with previously described syntaxa with *Salix reticulata* in other areas of the Far North. The ass. Salici reticulatae–Caricetum parallelae Telyatnikov 2011 has been described in Siberia, in the north-western part of the Putorana Plateau in the lower parts of mountain gentle slopes of the subgoltz belt in snowbed habitats. These habitats are classified by the author as nival meadows dominated by *Carex parallela* subsp. *redowskiana* and *Salix reticulata* in the alliance Salicion polaris Du Rietz 1942 em. Hadač 1989 [synonymized with Saxifrago oppositifoliae–Oxyrion digynae] and the class Salicetea herbaceae, despite the small number of character species of these higher syntaxa in the communities (*Cardamine bellidifolia*, *Cerastium regelii*, *Oxyria digyna*, *Salix polaris*, *Polytrichastrum alpinum*) (Telyatnikov 2011).

Another ass. Salici reticulatae–Trollietum europaei Koroleva et Kopeina in Koroleva et al. 2019 described in the European part, in mountainous areas of the Kola Peninsula (Khibiny, Lovozero Mountains, Monche tundra). These grasslands contain various species of herbs (*Anthoxanthum odoratum* subsp. *alpinum*, *Bistorta vivipara*, *Geranium sylvaticum*, *Saussurea alpina*, *Solidago lapponica*, *Trollius europaeus*, etc.), dwarf shrubs (*Salix reticulata*) and mosses (*Sanionia uncinata*, *Hylocomium splendens*) are widespread in the lower part of the mountain-tundra belt along streams, within cirques and carrs, and on gentle slopes. They are assigned to the alliance Potentillo–Polygonion vivipari, which is mainly comprised of low-grass meadows on southern slopes and base-rich rocks. As of now, this alliance has not been classified into a specific order and class (Koroleva et al. 2019).

The new ass. Pinguiculo alpinae–Salicetum reticulatae shares many species with the ass. Salici reticulatae–Caricetum parallelae (see Table 3); all of them are hemicalciphytes, implying that they have similar habitats of communities of these associations. However, they differ significantly in terms of the various species they contain. In particular, the ass. Pinguiculo alpinae–Salicetum reticulatae has twice the number of species, primarily due to the presence of mosses (40 species vs. 6). With the grassland ass. Salici reticulatae–Trollietum europaei, the new association has less similarity in terms of both composition and in physiognomy.

Snowbed vegetation on calcium-containing substrates in the East European sector of the Arctic we propose to unite into a new alliance Carici parallelae–Salicion reticulatae prov. in the order Arabidetalia caeruleae, which has been left in the status of provisional as only one association has been described.

In the westernmost region of our study, situated in the northern part of the Timanskii Kryazh, in areas of long-standing snow, Lavrinenko and Kholod, described two dwarf willow (*Salix herbacea*)–herb–moss communities with chionophilous vascular plants and almost solid moss and liverwort cover, related to the ass. Veratro lobeliani–Salicetum herbaceae Koroleva 2006.

Ass. **Veratro lobeliani–Salicetum herbaceae** Koroleva 2006 (Table 4, rel. 1–8; Table 7, syntaxon 3; Fig. 2N–P)

In addition to *Phleum alpinum*, *Saxifraga stellaris* and *Veratrum lobelianum* which are diagnostic for the association (Koroleva 2006), *Agrostis mertensii* subsp. *borealis* (median abundance score 1), *Avenella flexuosa* (1) and *Oxyria digyna* (see Table 4) can also be included in the differential species combination.

The association was originally described by Zinserling (1935) and the author (Koroleva 2006) on the Murmansk coast of the Kola Peninsula. Communities inhabit areas of sea-facing slopes and ravines with long-lasting snow cover. In the northern part of the Timanskii Kryazh, snowbed stands are described at the southern limit of the tundra zone in the Belaya River valley with tributaries that cut across Devonian sandstones. At lower levels of the river valley, communities occupy lower parts of leeward slopes and narrow, gorge-shaped valleys where snow masses remain unmelted until the end of July. Soils are loamy and humid. Organic layer is thin. Mineral part of the soil is structured. Gley features is absent.

This leads to the expansion of the range of the association beyond the Kola Peninsula to the Timanskii Kryazh in the east.

Table 3. Association Pinguiculo alpinae–Salicetum reticulatae in East European tundra and comparison with comparable European and Siberian syntaxa.

							Pinguiculo alpinae-Salicetum reticulatae	Salici reticulatae–Caricetum parallelae	Salici reticulatae–Trollietum europaei
Projective cover, %: total	80	80	80	70	100	100			
shrubs	<1	<1	<1	<1	3	0			
dwarf shrubs	50	50	50	40	70	70			
herbs	10	20	20	25	10	5			
bryophytes	40	40	40	40	70	60			
lichens	10	1	1	5	2	1			
Number of species: total	65	78	65	65	56	36			
shrubs	3	2	3	4	3	1			
dwarf shrubs	3	5	3	5	6	2			
herbs	29	37	33	27	26	22			
bryophytes	15	24	14	17	9	7			
lichens	15	10	12	12	12	4			
Date	22.07.2017	19.07.2017	18.07.2017	18.07.2017	27.07.2020	22.07.2017			
Slope aspect	N	N	N	NE	NE	N			
inclination	2	1	1	2	3	5			
Relevé nr.: by author	**Ван65**	**Ван49**	**Ван45**	**Ван44**	**БН3_20**	**Ван66**			
in the table	**1**	**2**	**3**	**4**	**5**	**6**			
Differential species combination of the Pinguiculo alpinae–Salicetum reticulatae									
Pinguicula alpina	+	1	1	2a	+	+	V^{1}	.	I^{+}
Tofieldia pusilla	+	+	+	+	1	+	V^{+}	II^{1}	.
Carex capillaris	.	+	+	+	+	+	V^{+}	.	.
Potentilla crantzii **P-P**	r	+	+	.	.	r	IV^{+}	.	.
Silene acaulis **Ac**	.	r	+	1	r	.	IV^{+}	.	I^{+}
Selaginella selaginoides **P-P**	.	.	+	1	.	r	III^{+}	.	I^{+}
Dicranum spadiceum	2a	1	2a	2a	2a	.	V^{2a}	.	.
Oncophorus integerrimus	.	2a	2a	2a	2b	3	V^{2a}	.	.
Hylocomiastrum pyrenaicum	2a	1	1	1	1	+	V^{1}	.	.
Campylium stellatum	+	+	+	+	+	+	V^{+}	.	.
Ditrichum flexicaule	+	+	+	+	1	.	V^{+}	.	.
Brachythecium erythrorrhizon	1	1	+	1	.	.	IV^{1}	.	.
Pohlia cruda	+	1	+	1	.	.	IV^{1}	.	.
Cladonia pocillum	1	1	+	1	r	.	V^{1}	.	.
Species common to the associations Pinguiculo alpinae–Salicetum reticulatae and Salici reticulatae–Caricetum parallelae									
Carex parallela subsp. *redowskiana*	1	1	.	+	1	+	V^{1}	$\mathbf{V^{4}}$	.
Lagotis glauca subsp. *minor*	+	r	+	+	.	r	V^{+}	IV^{1}	.
Poa alpina	+	+	r	+	.	.	IV^{+}	IV^{+}	I^{+}
Pachypleurum alpinum	r	.	+	r	.	r	IV^{r}	III^{+}	.
Pedicularis oederi	.	r	.	r	r	.	III^{r}	III^{1}	.
Equisetum variegatum	.	+	1	2a	.	.	III^{1}	II^{1}	.
Thalictrum alpinum **Ac, P-P**	.	+	+	1	.	.	III^{+}	II^{1}	.
Cetrariella delisei	+	+	+	1	+	1	V^{+}	III^{2a}	.
Differential species combination of the Salici reticulatae–Caricetum parallelae									
Oxyria digyna **Tr, So-O**	+	+	.	.	.	.	II^{+}	V^{1}	II^{+}
Dryas octopetala	.	.	.	+	.	.	I^{+}	V^{2a}	I^{1}
Salix saxatilis	.	.	.	.	.	.	.	IV^{2a}	.
Carex sabynensis	.	.	.	.	.	.	.	III^{2a}	.
Deschampsia borealis	.	.	.	.	.	.	.	III^{2a}	.
Differential species combination of the Salici reticulatae–Trollietum europaei									
Geranium sylvaticum	.	.	.	.	.	.	.	.	IV^{1}
Juncus trifidus	.	.	.	.	.	.	.	.	III^{1}
Nardus stricta	.	.	.	.	.	.	.	.	III^{+}
Anthoxanthum odoratum subsp. *alpinum* **P-P**	+	.	.	.	+	.	II^{+}	.	$\mathbf{V^{2}}$
Bartsia alpina **P-P**	.	.	.	.	1	.	I^{1}	.	IV^{+}
Character-species of the Salicetea herbaceae									
Salix polaris	2b	2a	r	+	r	+	V^{+}	IV^{1}	.
Astragalus alpinus subsp. *arcticus*	+	1	1	1	.	.	IV^{1}	.	.
Polytrichastrum alpinum	+	r	r	.	.	.	III^{r}	II^{2a}	I^{+}
Veronica alpina	.	+	.	.	.	+	II^{+}	.	III^{+}
Kiaeria starkei	.	.	.	1	.	.	I^{1}	.	.
Sibbaldia procumbens	.	.	.	.	.	+	I^{+}	.	I^{1}
Omalotheca supina	.	.	.	.	.	r	I^{r}	.	.
Ranunculus pygmaeus	r	.	.	.	.	.	I^{r}	.	.
Carex lachenalii	r	.	.	.	.	.	I^{r}	.	.
Cerastium regelii	.	.	.	.	.	.	.	V^{+}	.
Cardamine bellidifolia **So-O**	.	.	.	.	.	.	.	II^{+}	.
Sagina saginoides	.	.	.	.	.	.	.	II^{+}	.
Character-species of the Arabidetalia caeruleae									
Salix reticulata	2b	3	3	3	4	4	$\mathbf{V^{3}}$	$\mathbf{V^{2b}}$	$\mathbf{IV^{2}}$
Saxifraga oppositifolia	.	.	.	.	.	.	.	II^{2a}	.

We present relevés of two communities that we have carried out in snowbed habitats on siliceous substrate in the southern tundra of the Taymyr Peninsula (Table 5, rel. 1–2; Fig. 1, site 12). The two communities exhibit differences in their habitat and dominant species, and they appear to belong to distinct syntaxa. In the first community, found on a slope of northern exposition in a ravine, *Salix polaris* dominates, while *Sanionia uncinata* and *Pohlia nutans* dominate the ground cover. Among herb species, *Lagotis glauca* subsp. *minor*, *Ranunculus nivalis* and *R. pygmaeus* are present with most abundance (Fig. 2Q). The second community is dominated by hygrophilous and psychrophilous mosses and lichens, while *Salix polaris* and chionophilous herbs grow in low abundance. We were unable to identify them using the syntaxa described in the Siberian sector of the Arctic. The most floristically similar ass. Deschampsio–Cerastietum regelii Matveyeva 1994 is also described in Taymyr, but it is located further north, in the northern part of the typical tundra subzone (and two relevés from the arctic tundra subzone).

DISCUSSION

To establish the position of the associations identified within the syntaxonomic space of snowbed vegetation, we compiled a overview of syntaxa that were discovered in mountainous regions of Northern Europe, Arctic islands and Siberian Arctic (Table 6), and recorded associations in a unified synoptic table (Table 7). Subsequently, a cluster analysis of syntaxa and relevés was conducted, and the outcomes offer several points for discussion.

Phytocenological diversity of snowbed vegetation in different habitats in the East European Arctic

Snowbed communities were identified in the westernmost area of our study – on the slopes of north-facing ridges in the Timanskii Kryazh, an ancient mountain formation. They belong to the ass. Veratro lobeliani–Salicetum herbaceae (alliance Cassiopo–Salicion herbaceae), previously known on the East Murman shore of Kola Peninsula (Koroleva 2006). They are brought together by the prevalence of dwarf willow *Salix herbacea*, the presence of *Agrostis mertensii* subsp. *borealis*, *Avenella flexuosa*, *Oxyria digyna*, *Phleum alpinum*, *Saxifraga stellaris* and *Veratrum lobelianum* in the herb layer and the ground cover of snowbed mosses (*Kiaeria falcata*, *K. starkei*, *Polytrichastrum alpinum*) and liverworts.

Herb–dwarf willow–moss communities are found on Kolguev Island as well as in Bolshezemelskaya and Malozemelskaya tundra. These communities are typically established on siliceous substrate (loams and sands) in nival niches and on solifluction slopes with northern exposure where the snow melts later than on flat tundra areas. Characterized by a dense cover mostly of snowbed mosses *Kiaeria starkei*, *Polytrichastrum alpinum* and other mosses (*Sanionia uncinata*) and with participation of psychrophilic lichens (*Cetraria islandica* subsp. *islandica*, *Cetrariella delisei*, *Cladonia ecmocyna*, *Stereocaulon rivulorum*) in the bottom layer, on top of which a cover of dwarf willows leaves and a layer of low herbs is formed, among which the most abundant

Table 3. Continued.

Relevé nr. in the table	1	2	3	4	5	6			
Character-species of the Potentillo–Polygonion vivipari									
Trollius europaeus	r	r	r	.	.	r	IV^{r}	.	V^{1}
Distichium capillaceum	.	+	1	1	.	.	III^{+}	.	.
Saussurea alpina	.	.	+	.	.	.	I^{+}	.	III^{1}
Viola biflora	.	+	.	.	.	.	I^{+}	.	II^{+}
Highly constant species of syntaxa									
Sanionia uncinata	1	1	1	2a	2b	2a	V^{2a}	II^{2a}	V^{1}
Bistorta vivipara **P-P**	1	+	+	1	+	+	V^{+}	V^{1}	V^{+}
Vaccinium uliginosum subsp. *microphyllum*	r	+	+	r	2a	.	V^{+}	II^{1}	II^{1}
Ranunculus propinquus	1	1	1	+	r	+	V^{1}	II^{+}	.
Veratrum lobelianum	r	+	r	+	.	+	V^{+}	.	.
Salix hastata	+	+	+	+	1	+	V^{+}	.	.
Luzula multiflora subsp. *frigida*	+	+	+	+	+	+	V^{+}	.	.
Equisetum arvense subsp. *boreale*	1	+	+	+	+	1	V^{+}	.	.
Hylocomium splendens	+	+	+	+	2a	.	V^{+}	.	II^{3}
Cardamine pratensis subsp. *angustifolia*	r	r	r	.	r	r	V^{r}	.	.
Festuca ovina	1	+	+	+	.	.	IV^{+}	.	I^{+}
Carex bigelowii subsp. arctisibirica	+	+	.	.	r	+	IV^{+}	.	.
Poa alpigena	.	+	+	+	r	.	IV^{+}	.	.
Salix lanata	r	.	r	r	+	.	IV^{r}	III^{+}	I^{1}
Stereocaulon rivulorum	2a	1	+	+	1	1	V^{1}	.	.
Cetraria islandica subsp. *islandica*	+	.	.	+	1	+	IV^{+}	II^{+}	.
Peltigera aphthosa	+	+	r	+	r	1	V^{+}	II^{+}	.
Peltigera rufescens	+	+	+	+	.	.	IV^{+}	.	.
Cladonia coccifera	1	r	r	.	+	.	IV^{+}	.	.
Solidago lapponica	.	.	.	.	.	.	.	.	V^{+}
Vaccinium myrtillus	.	.	.	.	.	.	.	.	IV^{+}
Carex bigelowii s. str.	.	.	.	.	.	.	.	.	IV^{+}
Other species									
Tomentypnum nitens	2a	1	.	+	.	.	III^{1}	.	.
Saxifraga cernua	+	1	+	.	.	.	III^{+}	.	.
Myosotis asiatica	.	+	+	r	.	.	III^{+}	.	.
Eritrichium villosum	.	+	r	+	.	.	III^{+}	.	.
Tephroseris integrifolia	.	r	r	+	.	.	III^{r}	.	.
Geum rivale	r	r	.	.	r	.	III^{r}	.	.
Carex aquatilis subsp. *stans*	r	+	.	.	.	r	III^{r}	.	.
Carex juncella	r	r	+	.	.	.	III^{r}	.	.
Myxobilimbia lobulata	1	.	+	+	.	.	III^{+}	.	.
Cladonia stricta	r	r	.	.	r	.	III^{r}	.	.
Draba sibirica	1	+	.	+	.	.	III^{+}	II^{+}	.
Betula nana	.	.	r	r	+	.	III^{r}	II^{+}	II^{1}
Empetrum hermaphroditum	.	r	.	r	+	.	III^{r}	.	III^{+}
Cladonia arbuscula	r	.	+	+	.	.	III^{+}	.	I^{+}
Andromeda polifolia subsp. *pumila*	.	+	.	.	r	.	II^{+}	.	II^{+}
Salix glauca	r	r	.	.	.	.	II^{r}	.	II^{+}
Dicranum majus	.	1	.	.	.	.	I^{1}	.	II^{2}
Vaccinium vitis-idaea subsp. *minus*	.	.	.	.	+	.	I^{+}	.	II^{+}
Salix myrsinites	.	.	.	r	.	.	I^{r}	.	II^{+}
Cetraria islandica subsp. *crispiformis*	.	r	.	.	.	.	I^{r}	.	II^{1}
Carex vaginata subsp. *quasivaginata*	.	.	r	.	.	.	I^{r}	.	I^{+}
Cladonia uncialis	.	.	.	.	r	.	I^{r}	.	I^{+}
Petasites frigidus	.	.	.	.	r	.	I^{r}	II^{+}	.
Minuartia biflora	.	.	.	r	.	.	I^{r}	II^{1}	.
Carex saxatilis subsp. *laxa*	.	.	.	.	.	.	.	III^{1}	.
Cardamine microphylla	.	.	.	.	.	.	.	III^{1}	.
Cassiope tetragona	.	.	.	.	.	.	.	III^{1}	.
Saxifraga nelsoniana	.	.	.	.	.	.	.	III^{+}	.
Tritomaria quinquedentata	.	.	.	.	.	.	.	.	III^{1}

Note. Species found in 1–2 relevés with an abundance of r or + (others are indicated in brackets): herbs – *Achillea millefolium* 1, 2; *Alopecurus pratensis* subsp. *alpestris* 5,6; *Chrysosplenium alternifolium* 1; *Cortusa matthioli* 3, 5; *Dianthus superbus* 3, 4; *Equisetum palustre* 5 (1); *E. pratense* 5; *E. scirpoides* 3, 6 (1); *Euphrasia frigida* 3, 4; *Festuca rubra* subsp. *arctica* 5; *Huperzia selago* subsp. *appressum* 5; *Pinguicula vulgaris* 5; *Polemonium acutiflorum* 2; *Pyrola grandiflora* 5 (1); *Ranunculus monophyllus* 3; *Saxifraga hieracifolia* 2; *Tanacetum bipinnatum* 1, 5; *Trisetum spicatum* 2; bryophytes – *Bryum moravicum* 1; *B. rutilans* 2, 4; *Bryum* sp. 4; *B. uliginosum* 2; *Calliergonella lindbergii* 1; *Cyrtomnium hymenophyllum* 2, 4; *Dicranoweisia crispula* 1, 2; *Didymodon rigidulus* 2; *Encalypta alpine* 1; *Fissidens osmundioides* 3; *Leptobryum pyriforme* 2; *Limprichtia revolvens* 2, 4; *Meesia uliginosa* 3, 4; *Mnium blyttii* 6; *Orthothecium chryseum* 2; *Philonotis fontana* 6 (1); *Pohlia wahlenbergii* 2; *Ptilidium ciliare* 3 (1); *Rhizomnium andrewsianum* 5; *Schistidium sordidum* 2 ; *S. submuticum* 3; *Sphagnum warnstorfii* 1; *Tayloria lingulata* 2; *Timmia austriaca* 4, 6; *Tortella fragilis* 2; liverworts 5 (1); lichens – *Cladonia bellidiflora* 5; *C. cariosa* 4; *C. chlorophaea* 5; *C. gracilis* subsp. *elongata* 1, 3; *C. macroceras* 1; *Lobaria linita* 1, 5; *Nephroma expallidum* 5; *Ochrolechia frigida* 3, 4 (1); *Protopannaria pezizoides* 1 (1), 2; *Psoroma hypnorum* 2, 3; *Solorina saccata* 3; *Stereocaulon alpinum* 4; *S. glareosum* 4; *S. paschale* 1.

Species with constancy I or II found also in association by M.Yu. Telyatnikov (2011): *Alnus fruticosa, Androsace chamaejasme* subsp. *arctisibirica, Arctagrostis latifolia, Cardaminopsis umbrosa, Chamaenerion latifolium, Eriophorum vaginatum, Festuca rubra* s. str., *Hedysarum hedysaroides* subsp. *arcticum, Juncus biglumis, Minuartia rubella, M. stricta, Pedicularis hirsuta, Petasites sibiricus, Ru-*

are the key chionophilous (snow-loving) species (*Omalotheca supina*, *Sibbaldia procumbens*, *Carex lachenalii* and *Veronica alpina*). Three associations were recorded in the studied area. In the communities of the ass. Salicetum herbaceae-polaris which spread to the west of the Pechora River (Kolguev Island and Malozemelskaya tundra), both species of dwarf willows co-dominate: *Salix herbacea* (East American-European species) and *S. polaris* (Eurasian-West American species). In the communities of the ass. Salici polaris–Sibbaldietum procumbentis, whose range is east of the Pechora River (Bolshezemelskaya tundra), there is only *Salix polaris* in the dwarf shrub layer, high coverage of herbs (dominated by *Sibbaldia procumbens* and *Omalotheca supina*). Communities of another association with *Salix polaris* – ass. Myosotido asiaticae–Salicetum polaris, are notable for their high herb species diversity. Along with chionophilous herbs, *Achillea millefolium*, *Artemisia tilesii*, *Bistorta elliptica*, *Cardamine pratensis* subsp. *angustifolia*, *Myosotis asiatica*, *Parnassia palustris*, *Saxifraga cernua*, *Viola biflora* etc. are also present here.

On cryoplanation terraces situated along the northern slopes, characterized by stony carbonate material and deluvium washed down by meltwater, snow persists for longer periods compared to placors. The ass. Pinguiculo alpinae–Salicetum reticulatae that has been described here, bringing together communities with a large participation of calciphyte species, including the dominant *Salix reticulata*.

The place of associations in the syntaxonomic space and the reasonableness of the necessity to define new alliances

Initially, we assumed that the associations found in plain East European tundra would be referred to the alliance Cassiopo–Salicion herbaceae, the earliest described in the mountainous regions of Northern Europe, for which all major species of the class Salicetea herbaceae are listed as character species. The only source of confusion was that both name-giving taxa (*Harrimanella hypnoides* and *Salix herbacea*) have a limited range. As previously mentioned, the range of *Salix herbacea* is bordered by the Pechora River to the east. *Harrimanella hypnoides* is a rare species included in the Red Data Book of the Nenets Autonomous Area (Matveyeva et al. 2020). The species is exclusive to snowbed habitats located in upland and mountainous landscapes, such as the Timanskii Kryazh. Conversely, it displays a disjointed range on the plains.

The cluster analysis results of relevés of snowbed stands with *Salix herbacea* and *S. polaris* (Fig. 3) indicate that the ass. Veratro lobeliani–Salicetum herbaceae communities, including 2 relevés from the Timanskii Kryazh (Б7, Б34), are grouped in a single cluster together with other European associations of the alliance Cassiopo–Salicion herbaceae. This

Table 3. Continued.

bus arcticus, Rumex acetosa subsp. *lapponicus, R. arcticus, Saxifraga spinulosa, Tofieldia coccinea, Trisetum molle, Dicranum* sp.; by N.E. Koroleva et Kopeina (2019): *Juniperus sibirica, Salix phylicifolia, Calluna vulgaris, Phyllodoce caerulea, Alchemilla alpina, Alchemilla* sp., *Antennaria dioica, Athyrium distentifolium, Avenella flexuosa, Campanula rotundifolia, Chamaenerion angustifolium, Cirsium heterophyllum, Cryptogramma crispa, Diphasiastrum alpinum, Hieracium alpinum, Omalotheca norvegica, Pedicularis lapponica, Phleum alpinum, Potentilla erecta, Pyrola minor, Ranunculus acris, Taraxacum croceum, Aulacomnium turgidum, Barbilophozia lycopodioides, Bucklandiella microcarpa, Diplophyllum taxifolium, Harpanthus flotovianus, Kiaeria glacialis, Leucorchis albida, Lophozia sudetica, L. ventricosa, Moerckia blyttii, Pleurozium schreberi, Rhizomnium pseudopunctatum, Schljakovia kunzeana, Sphagnum compactum, Sphenolobus minutus, Cladonia gracilis.*

GPS coordinates (WGS 84) (N, E): **1** – 68.35075, 56.47919; **2** – 68.35144, 56.47003; **3** – 68.34372, 56.47839; **4** – 68.34731, 56.47825; **5** – 68.29119, 54.49575; **6** – 68.35058, 56.47869.

Authors rel. no. 1, 6 – **O.V. Lavrinenko**, **I.A. Lavrinenko**, **V.V. Neshataev**; rel. no. 2–4 – **O.V. Lavrinenko**, **I.A. Lavrinenko**, rel. no. 5 – **O.V. Lavrinenko**, **T.V. D'aychkova**.

Abbreviations.

Locality (in author's relevé no.): **БН** – Bolvanskii Nose Cape; **Ван** – Vangureimusyur Upland, Bolshaya Khekheganyakha River.

Character-species (next to the name of the taxon) of the higher syntaxa: **P-P** – Potentillo–Polygonion vivipari; **So-O** – Saxifrago oppositifoliae–Oxyrion digynae; **Ac** – Arabidetalia coeruleae; **Tr** – Thlaspietea rotundifolii.

* – nomenclatural types (holotypus): rel. no. **2** (author's no. – Ван49), Bolshezemelskaya tundra, Vangureimusyur Upland, Bolshaya Khekheganyakha River, 19.07.2017, authors O.V. Lavrinenko, I.A. Lavrinenko.

Table 4. Association Veratro lobeliani–Salicetum herbaceae in the Timanskii Kryazh and the East Murman shore

									Veratro lobeliani–Salicetum herbaceae
Cover, %: total	95	85	-	75	50	75	-	-	
herbs and dwarf shrubs	60	35	-	75	50	50	-	-	
bryophytes	80	85	-	35	50	75	-	-	
lichens	5	<1	-	5	<1	<1	-	-	
Slope aspect	NE	NE	-	-	-	-	-	-	
inclination	15	15	-	-	-	-	-	-	
Date	30.08.2008	05.09.2008	-	-	-	-	-	-	
Locality	B	B	M	M	M	M	M	M	
Authors	L, Kh	L, Kh	Z	K	K	K	Z	Z	
Relevé nr.: by author	Б7	Б34	-	116/04	127/04	140/04	-	-	
in the table	1	2	3	4	5	6	7	8	
Differential species combination of the Veratro lobeliani–Salicetum herbaceae									
Veratrum lobelianum	+	1	+	+	+	+	+	.	V+
Saxifraga stellaris	r	r	+	.	.	.	+	+	IV+
Phleum alpinum	1	.	+	1	+	+	.	.	IV+
Agrostis mertensii subsp. *borealis*	2a	2a	.	.	+	+	.	.	III1
Avenella flexuosa	+	1	.	3	1	.	.	.	III1
Oxyria digyna	.	.	+	.	.	+	+	+	III+
Character-species of the Cassiopo–Salicion herbaceae, Salicetalia herbaceae and Salicetea herbaceae									
Salix herbacea	3	2b	+	+	3	3	+	+	V2a
Sibbaldia procumbens	2a	+	+	1	.	.	.	.	III1
Omalotheca supina	2a	+	+	+	.	.	.	.	III+
Polytrichastrum alpinum	.	2a	+	.	.	.	.	.	II1
Carex lachenalii	2a	+	.	.	.	.	.	.	II1
Anthelia juratzkana	2a	3	.	.	.	.	.	.	**II2b**
Solorina crocea	+	r	.	.	.	.	.	.	II+
Kiaeria falcata	4	3	.	.	.	.	.	.	**II4**
Kiaeria starkei	.	.	.	1	.	.	.	.	I1
Ranunculus pygmaeus	.	.	+	.	.	.	+	+	II+
Veronica alpina	.	.	.	.	.	.	+	+	II+
Pleurocladula albescens	.	.	.	.	+	.	.	.	I+
Other species									
Loiseleuria procumbens	r	+	.	+	.	.	.	.	II+
Vaccinium uliginosum subsp. *microphyllum*	r	r	.	.	.	.	.	.	IIr
Carex aquatilis subsp. *stans*	1	+	.	.	.	.	.	.	III1
Deschampsia glauca	1	1	.	.	.	.	.	.	III1
Epilobium davuricum	r	r	.	.	.	.	.	.	IIr
Equisetum arvense subsp. *boreale*	+	+	.	.	.	.	.	.	II+
Juncus filiformis	+	+	.	.	.	.	.	.	II+
Vahlodea atropurpurea	+	+	.	.	.	.	.	.	II+
Cetrariella delisei	1	+	.	.	.	.	.	.	III1
Bistorta vivipara	+	.	.	.	.	+	.	.	II+
Ranunculus propinquus	+	.	+	.	.	.	.	+	II+
Trisetum spicatum	r	.	+	.	.	.	.	+	II+
Empetrum hermaphroditum	.	+	.	+	.	.	.	.	II+
Diphasiastrum alpinum	.	r	.	+	.	.	.	.	II+
Chamaepericlymenum suecicum	.	.	.	+	.	.	.	+	II+
Cerastium sp.	.	.	+	.	.	.	.	+	II+
Rumex acetosa subsp. *lapponicus*	.	.	.	+	.	+	.	.	II+
Saxifraga rivularis	.	.	+	.	.	+	.	.	II+
Solidago lapponica	.	.	.	1	+	.	.	.	III1
Dicranum flexicaule	.	.	.	3	.	+	.	.	II2a
Diplophyllum taxifolium	.	.	.	.	+	+	.	.	II+
Lophozia longiflora	.	.	.	+	.	+	.	.	II+
Sanionia uncinata	.	.	+	.	.	1	.	.	III1
Cladonia coccifera	.	r	.	.	+	.	.	.	II+
Liverworts	1	1	.	.	.	.	.	.	III1

Note. Species found in 1–2 relevés with an abundance of r or + (others are indicated in brackets): dwarf-shrubs – *Phyllodoce caerulea* 2, *Vaccinium myrtillus* 4; herbs – *Anthoxanthum odoratum* subsp. *alpinum* 1, *Athyrium distentifolium* 8, *Bistorta elliptica* 1, *Equisetum sylvaticum* 1 (1), *Festuca ovina* 2, *Juncus trifidus* 4, *Luzula* sp. 5, *Poa alpigena* 1, *P. alpina* 1, *Pyrola minor* 1, *Saxifraga cespitosa* 6, *S. nivalis* 6, *Trientalis europaea* 2, *Viola biflora* 1, *Viola epipsila* 2; bryophytes – *Cephalozia bicuspidata* 6, *Dicranum majus* 4, *D. spadiceum* 6 (1), *Kiaeria blyttii* 4, *K. glacialis* 5, *Limprichtia cossonii* 5 (3), *Lophozia sudetica* 4, *Orthocaulis kunzeanus* 4, *Ptilidium ciliare* 3, *Racomitrium microcarpum* 5 (1), *Sphagnum girgensohnii 6*; lichens – *Baeomyces carneus 2, Cetraria islandica* subsp. *islandica* 4, *Cladonia bellidiflora* 2, *C. ecmocyna* 2, *C. maxima* 4, *Peltigera scabrosa* 1, *Stereocaulon paschale* 1 (1), *S. rivulorum* 2.

GPS coordinates (WGS 84) (N, E): **1** – 67.28553, 48.95833; **2** – 67.3125, 49.02081.

Abbreviations. Authors: L, Kh – **O.V. Lavrinenko**, **S.S. Kholod**; K – **N.E. Koroleva** and Z – **Yu.D. Zinserling** (Koroleva, 2006).

Locality: **Б** – the northern part of the Timanskii Kryazh, Belaya River; **M** – East Murman shore.

enables the alliance to extend the range to the mountainous areas of the western part of the East European tundra (Kanin Kamen, Timanskii Kryazh).

The relevés of associations Salicetum herbaceae-polaris, Salici polaris–Sibbaldietum procumbentis and Myosotido asiaticae–Salicetum polaris on siliceous substrates form their own cluster. Meanwhile, the relevés of Siberian snowbed communities residing on the Gydan Peninsula – the closest geographically – are differentiated from European ones at the highest level.

The relevés related to the ass. Sibbaldietum procumbentis from southwest Greenland (Molenaar 1976) do not form a single cluster with relevés assigned to the same association from southwest Iceland (Hadač 1971). In contrast, some of the relevés from different associations – Sibbaldietum procumbentis and Gnaphalietum supini (Molenaar 1976) form a common cluster. This is explained by small (sometimes at the level of species abundance) floristic differences between North European syntaxa (see Table 7, syntaxa 6–9).

Synoptic table 7, which includes the East European syntaxa, contains some North (mountainous) European and Siberian ones. It shows that the syntaxa of the East European tundra have common groups of species with

Table 5. Two relevés of snowbed stands in the southern tundra of the Taymyr Peninsula (Kystyktakh River basin).

Cover, %: total	100	100
shrubs	<1	<1
dwarf shrubs	80	<1
herbs	15	7
bryophytes	80	40
lichens	5	60
Slope aspect	N	NE
inclination	20	1
Date	08.08.2021	05.08.2021
Relevé nr.: by author	**Ta98**	**Ta77**
in the table	**1**	**2**
Character-species of the Salicetea herbaceae		
Polytrichastrum alpinum	1	1
Ranunculus pygmaeus	1	+
Carex lachenalii	+	
Anthelia juratzkana	.	2b
Character-species of the class Salicetea herbaceae and constant species in syntaxa of East European and Siberian sectors of Arctic		
Salix polaris	**5**	+
Stereocaulon rivulorum	1	2b
Cetrariella delisei	r	2b
Petasites frigidus	+	+
Saxifraga cernua	+	r
Carex bigelowii subsp. *arctisibirica*	r	1
Poa arctica	r	.
Character-species of the class Salicetea herbaceae and constant species in syntaxa of Siberian sectors of Arctic		
Ranunculus nivalis	1	1
Oxyria digyna	+	+
Lagotis glauca subsp. *minor*	1	r
Saxifraga nelsoniana	+	r
Luzula arcuata aggr.	.	+
Luzula nivalis	.	+
Pohlia drummondii	.	+
Differential species combination of the Deschampsio–Cerastietum regelii Matveyeva 1994		
Cerastium regelii	r	r
Saxifraga hieracifolia	r	r
Deschampsia borealis	.	r
Rumex arcticus	r	.
Constant species of snowbed syntaxa		
Sanionia uncinata	**4**	+
Stereocaulon alpinum	1	2a
Equisetum arvense subsp. *boreale*	+	1
Bistorta vivipara	+	+
Cladonia stricta	1	+
Cetraria islandica subsp. *islandica*	r	.
Distichium capillaceum	+	.
Betula nana	r	r
Salix glauca	.	r
Vaccinium uliginosum subsp. *microphyllum*	.	r
Sagina intermedia	.	r
Other species		
Antennaria lanata	r	+
Saxifraga tenuis	r	+
Festuca vivipara	+	.
Pachypleurum alpinum	r	.
Saxifraga hyperborea	r	.
Pedicularis sudetica subsp. *interioroides*	r	.
Pohlia nutans	2b	.
Dicranum spadiceum	+	.
Straminergon stramineum	+	.
Protopannaria pezizoides	r	.
Pohlia sp.	+	.
Cephaloziella sp.	+	.
Niphotrichum elongatum	.	2a
Stellaria peduncularis	.	+

Table 5. Continued.

in the table	1	2
Cladonia pocillum	.	+
Pogonatum urnigerum	.	+
Tofieldia coccinea	.	+
Pyrola incarnata	.	+
Juncus biglumis	.	r
Cassiope tetragona	.	r
Polytrichum hyperboreum	.	+
Psoroma hypnorum	.	r
Liverworts	+	.

Note. GPS coordinates (WGS 84) (N, E) **and habitat**: **1** – 70.94311, 91.24147 (gentle bottom of a ravine, where snow lies for a long time and melt water runs off, loam with stones); **2** – 70.94475, 91.24606 (solifluction slope of northern exposure in a ravine with a snowbed). Author rel. no. 1, 2 – **O.V. Lavrinenko**.

both sectors. Many of these species are character of the class Salicetea herbaceae. The syntaxa of the East European tundra differ from the others mentioned above by their own group of character species, these are selective character species of the new alliance Veronico alpinae–Salicion polaris – *Veronica alpina*, *Dichodon cerastoides*, *Epilobium alpinum*, as well as *Pyrola minor*, *Ranunculus glabriusculus*, *Cladonia ecmocyna*.

It is evident that in *Salix herbacea* dominates in North (mountainous) European syntaxa of the alliance Cassiopo–Salicion herbaceae, while *Salix polaris* replaces it in syntaxa located in East European (east of the Pechora River) and Siberian

Table 6. The codes of the syntaxa discussed in the paper from mountainous regions of Northern Europe, East European and Siberian sectors of the Arctic.

Code	Syntaxon	Region
THL	Thlaspietea rotundifolii	**Northern Europe (mountainous areas)**
THL	Arabidetalia caeruleae	
A	Ranunculo–Poion alpinae	
A1	*Trollius europaeus*-soc. (Gjarevoll 1950)	
B	Saxifrago oppositifoliae–Oxyrion digynae	
B1	Salicetum polaris Gjarevoll 1950	
HER	Salicetea herbaceae	
HER	Salicetalia herbaceae	
C	Cassiopo–Salicion herbaceae	
C1	Veratro lobeliani–Salicetum herbaceae Koroleva 2006 (includes Belaya River relevés)	
C2	Salicetum herbaceae Nordhagen 1943	
C3	Salici herbaceae–Caricetum bigelowii Koroleva et Kopeina in Koroleva et al. 2019	
C4	Gnaphalietum supini Molenaar 1976	
C5	Sibbaldietum procumbentis Hadač 1971	
C6	Sibbaldio–Salicetum herbaceae Hadač 1971	
C7	Sibbaldietum procumbentis Molenaar 1976 + Gnaphalietum supini	
HER	Salicetea herbaceae	**East European sector of the Arctic**
HER	Salicetalia herbaceae	
D	Veronico alpinae–Salicion polaris	
D1	Salici herbaceae-polaris **ass. nov.**	
D1a	Salici herbaceae-polaris var. inops	
D1b	Salici herbaceae-polaris var. typica	
D2	Salici polaris–Sibbaldietum procumbentis **ass. nov.**	
D3	Myosotido asiaticae–Salicetum polaris ass. nov.	
THL	Thlaspietea rotundifolii	
THL	Arabidetalia caeruleae	
E	Carici parallelae–Salicion reticulatae prov.	
E1	Pinguiculo alpinae–Salicetum reticulatae ass. nov.	
N	? (Siberian snowbed vegetation on stabilized calcareous soils)	**Siberian sector of the Arctic**
N1	Salici reticulatae–Caricetum parallelae Telyatnikov 2011	
N	? (Siberian snowbed vegetation on siliceous substrates)	
N2	Tanaceto bipinnati–Salicetum polaris Khitun in Telyatnikov et al. 2021	
N3	Chrysosplenio sibirici–Polemonietum acutiflorum Telyatnikov, Troeva, Ermokhina et Pristyazhnyuk 2019	
N4	? Deschampsio–Cerastietum regelii var. Peltigera canina (Telyatnikov et al. 2015)	
N5	– (2 relevés by Lavrinenko O.)	
N6	Deschampsio–Cerastietum regelii Matveyeva 1994 var. typica	
N6a	Deschampsio–Cerastietum regelii var. typica	
N6b	Deschampsio–Cerastietum regelii var. Deschampsia borealis	
N7	Gymnomitrio–Phippsietum concinnae Matveyeva 1994	
N8	Saxifrago tenuis–Salicetum polaris Telyatnikov, Troeva, Gogoleva, Cherosov, Pestryakova et Pristyazhnyuk 2013	
N9	Eutremo edwardsii–Sanionietum uncinatae Telyatnikov, Troeva, Gogoleva, Cherosov, Pestryakova et Pristyazhnyuk 2013	
CHY	Carici arctisibiricae–Hylocomietea alaskani	
CHY	Caricetalia arctisibiricae-lugentis Matveyeva et Lavrinenko 2023	
F	Carici arctisibiricae–Hylocomion alaskani Matveyeva et Lavrinenko 2023 (zonal vegetation)	
F1	Astragalo frigidi–Salicetum reptantis Telyatnikov, Troeva, Pristyazhnyuk, Gogoleva, Cherosov et Pestryakova 2015	

Table 7. Synoptic table of syntaxa of snowbed vegetation from Northern (mountainous) Europe, East European and Siberian sectors of the Arctic. For the codes of the syntaxa see Table 6. Sites: SL – Swedish Lapland; MT – Murman+Timan; N – Norway; Kh – Khibiny; G – Greenland; IG – Iceland+Greenland; I – Iceland; K – Kolguev; BT – Bolshezemelskaya tundra; BM – Bolshezemelskaya and Malozemelskaya tundras; P – Putorana; Gy – Gydan; In – Indigirka; T – Taymyr; A – Anabar. Characteristic species (next to the name of the taxon): **Sh** – Salicetea herbaceae and Salicetalia herbaceae; **C-S** – Cassiopo–Salicion herbaceae; **Ss-O** – Saxifrago stellaris–Oxyrion digynae; **Ac** – Arabidetalia caeruleae; **So-O** – Saxifrago oppositifoliae–Oxyrion digynae; **R-P** – Ranunculo–Poion alpinae.

Class	THL		HER										THL		HER								CHY
Order	THL		HER										THL		–	–	–	–	–	–	–	–	CHY
Alliance	A	B	C							D			E	–	–	–	–	–	–	–	–	–	F
Association (syntaxon)	A1	B1	C1	C2	C3	C4	C5	C6	C7	D1	D2	D3	E1	N1	N2	N3	N4	N5	N6	N7	N8	N9	F1
Site	SL	SL	MT	N	Kh	G	IG	I	G	K	BT	BM	BT	P	Gy	Gy	In	T	T	T	A	A	In
Number of relevés	10	4	8	?	10	6	16	20	16	18	6	4	6	4	7	15	8	2	22	14	6	6	4
Number of syntaxon	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Character-species of the Salicetalia herbaceae and Salicetea herbaceae																							
Polytrichastrum alpinum [incl. var. *fragile*, var. *septentrionale* (=*P. norvegicum*)] **Sh, C-S**	I^{1}	**III**^{3}	II^{1}	II^{1}	II^{+}	V^{2a}	**V**^{2b}	**V**^{2b}	I^{1}	V^{+}	V^{2a}	**IV**^{2b}	III^{r}	II^{2a}	.	II^{1}	.	2^{1}	.	.	I^{2a}	.	.
Carex lachenalii **Sh, C-S**	III^{1}	V^{1}	II^{1}	II^{1}	.	II^{+}	II^{+}	II^{+}	.	V^{+}	V^{+}	III^{+}	I^{r}	.	III^{1}	III^{1}	I^{2a}	1^{+}	.	.	.	.	.
Sibbaldia procumbens **Sh, C-S**	I^{1}	II^{1}	III^{1}	III^{1}	III^{+}	V^{1}	**V**^{4}	V^{r}	**V**^{3}	V^{1}	**V**^{2b}	V^{1}	I^{+}	.	III^{+}	.	.	.	.	.	.	.	.
Omalotheca supina **Sh, C**-S	.	III^{1}	III^{+}	**V**$^{1-5}$	II^{+}	**V**^{4}	V^{2a}	V^{+}	IV^{1}	V^{1}	V^{1}	V^{2a}	I^{r}	.	I^{+}	.	.	.	.	.	.	.	.
Kiaeria starkei **Sh, C-S**	.	.	I^{1}	**V**$^{2-5}$	**V**^{2b}	IV^{2a}	IV^{+}	III^{+}	.	**V**^{2b}	**IV**^{3}	IV^{+}	I^{1}	.	.	.	.	.	.	.	.	.	.
Solorina crocea **Sh, C-S**	.	.	II^{+}	II^{1}	.	.	.	I^{r}	.	II^{+}	I^{r}	.	.	.	III^{1}	.	.	.	.	.	.	.	.
Sagina saginoides **Sh, So-O**	.	I^{1}	.	.	.	.	.	.	.	II^{+}	I^{+}	II^{r}	.	II^{+}	.	.	.	.	.	.	.	.	.
Character-species of the alliances and class Salicetea herbaceae and constant species in syntaxa of mountains in Northern Europe																							
Salix herbacea **Sh, C-S**	I^{1}	**III**^{1}	V^{2a}	**V**$^{4-5}$	**V**^{2b}	**IV**^{3}	**V**^{2b}	**V**^{5}	**V**^{3}	V^{2a}	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthelia juratzkana **Sh, C-S**	.	**III**^{3}	**II**^{2b}	III$^{1-3}$	I^{+}	**V**^{2b}	III^{1}	III^{r}	.	II^{2a}	I^{1}	.	.	.	.	.	.	**1**^{2b}	II^{+}	I^{r}	.	.	.
Lophozia sudetica (=*L. alpestris*)	.	**IV**^{2b}	I^{+}	I^{1}	III^{+}	IV^{+}	III^{+}	II^{r}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pohlia commutata **Sh, C-S**	II^{1}	V^{1}	.	I^{2}	.	V^{+}	II^{+}	.	I^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Conostomum tetragonum **Sh, C-S**	.	.	.	II$^{1-2}$	II^{+}	III^{+}	II^{+}	III^{r}	.	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.
Pleurocladula albescens **Sh, C-S**	.	I^{1}	I^{+}	III^{2}	II^{+}	II^{1}	I^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Harrimanella hypnoides **Sh, C-S**	.	II^{1}	.	I$^{1-2}$	II^{+}	I^{+}	II^{r}	I^{r}	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Taraxacum croceum (+*T. officinalis*) **Sh**	II^{1}	III^{1}	.	II^{1}	.	III^{+}	V^{+}	III^{r}	V^{2a}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex bigelowii s. str. **R-P**	**V**^{2b}	I^{1}	.	.	**V**^{2b}	V^{+}	V^{+}	V^{2a}	V^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deschampsia alpina **Sh, Ss-O**	.	I^{1}	.	.	.	.	IV^{r}	IV^{r}	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kiaeria falcata **Sh, C-S**	.	.	**II**^{4}	.	.	.	II^{1}	IV^{2a}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gymnomitrion concinnatum **Sh, C-S**	.	.	.	.	I^{1}	.	I^{r}	II^{r}	.	II^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga rivularis **Sh, So-O**	.	.	II^{+}	.	.	.	.	.	.	I^{r}	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Ranunculo acris–Poetum alpinae (*Trollius europaeus*-soc.)																							
Trollius europaeus **R-P**	**V**^{2b}	.	.	.	.	.	.	.	.	.	.	.	IV^{r}	.	.	.	.	.	.	.	.	.	.
Saussurea alpina **R-P**	**V**^{2b}	I^{1}	.	.	.	.	.	.	.	I^{+}	.	.	I^{+}	.	.	.	.	.	.	.	.	.	.
Anthoxanthum odoratum subsp. *alpinum*	V^{1}	.	I^{+}	III$^{1-2}$	II^{+}	.	I^{r}	.	.	.	I^{1}	.	II^{+}	.	.	.	.	.	.	.	.	.	.
Festuca rubra s. str.	**IV**^{2b}	.	.	.	.	.	.	.	.	.	.	.	.	**II**^{2b}	.	I^{1}	.	.	.	.	.	.	.
Tritomaria quinquedentata	IV^{1}	.	.	.	I^{2a}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Plagiochila asplenioides	III^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Salicetum polaris																							
Stereocaulon paschale	.	IV^{1}	I^{1}	.	.	.	.	.	.	.	.	.	I^{+}	.	I^{+}	I^{+}	.	.	.	.	.	.	.
Salix herbacea x polaris	.	V^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Erigeron uniflorus	.	IV^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pohlia wahlenbergii	.	**II**^{2b}	.	.	.	.	.	.	.	.	.	II^{+}	I^{+}	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Veratro lobeliani–Salicetum herbaceae																							
Veratrum lobelianum	.	.	V^{+}	.	.	.	.	.	.	I^{r}	V^{+}	V^{+}	V^{+}	.	III^{+}	I^{+}	.	.	.	.	.	.	.
Phleum alpinum	.	I^{1}	IV^{+}	I^{1}	.	I^{1}	III^{r}	I^{r}	I^{+}	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.
Saxifraga stellaris **Ss-O**	.	I^{1}	IV^{+}	I^{1}	I^{+}	.	I^{r}	II^{r}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Avenella flexuosa	I^{1}	.	III^{1}	III^{+-1}	II^{1}	.	II^{r}	.	.	.	II^{r}	.	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Salicetum herbaceae																							
Marsupella brevissima **C-S**	.	.	.	**V**$^{1-4}$	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichastrum sexangulare **C-S**	.	.	.	**V**$^{2-3}$	.	.	.	.	.	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.
Moerckia blyttii **C-S**	.	.	.	III$^{1-3}$	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Beckwithia glacialis **Sh, Ar**	.	.	.	I^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Salici herbaceae–Caricetum bigelowii																							
Barbilophozia lycopodioides	.	.	.	.	IV^{2a}	.	.	I^{r}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diplophyllum taxifolium	.	.	II^{+}	.	IV^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lophozia wenzelii	.	I^{1}	.	.	III^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium myrtillus	.	.	I^{+}	.	III^{1}	.	I^{r}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Gnaphalietum supini																							
Polytrichum piliferum	.	.	.	I^{1}	.	III^{2a}	I^{2a}	.	I^{+}	.	.	.	.	.	I^{2a}	.	.	.	.	.	.	.	.
Bartsia alpina	I^{1}	II^{1}	.	.	I^{+}	III^{+}	I^{+}	.	II^{1}	I^{r}	.	.	I^{1}	.	.	.	.	.	.	.	.	.	.
Differential species combination of the syntaxa from Iceland																							
Niphotrichum canescens	.	.	.	.	I^{+}	I^{+}	**IV**^{4}	**V**^{4}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Viola palustris	.	.	.	.	.	I^{+}	IV^{1}	II^{r}	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Alchemilla alpina	.	.	.	.	II^{2a}	.	IV^{r}	III^{r}	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Festuca vivipara	V^{1}	III^{1}	.	.	.	.	III^{r}	IV^{+}	.	.	.	.	.	.	.	.	.	1^{+}	.	.	.	.	.
Luzula spicata	I^{1}	.	.	.	.	.	II^{r}	III^{r}	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Sibbaldietum procumbentis + Gnaphalietum supini in Grenland																							
Hieracium alpinum aggr.	I^{1}	.	.	I^{1}	.	.	.	.	III^{2a}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tortula hoppeana (=*Desmatodon latifolius*)	.	.	.	.	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Character-species of the alliances and class Salicetea herbaceae and constant species in syntaxa of East European and Siberian sectors of Arctic																							
Salix polaris **Sh, So-O**	I^{1}	**V**^{4}	.	.	.	.	.	.	.	**V**^{3}	IV^{2a}	**V**^{2b}	V^{+}	IV^{1}	**V**^{2b}	**IV**^{2b}	**IV**^{2b}	**2**^{2b}	IV^{1}	III^{r}	**V**^{3}	**V**^{2b}	.

Table 7. Continued.

Number of syntaxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Cetrariella delisei	.	I^{1}	II^{1}	I^{1}	.	.	.	.	.	V^{+}	V^{+}	II^{r}	V^{+}	III^{2a}	IV^{1}	II^{+}	.	2^{1}	IV^{1}	.	II^{1}	I^{1}	.
Stereocaulon rivulorum	.	.	I^{+}	.	.	.	.	.	.	IV^{+}	IV^{1}	III^{+}	V^{1}	.	.	.	.	2^{2a}	.	.	I^{+}	II^{2a}	V^{1}
Tanacetum bipinnatum	.	.	.	.	.	.	.	.	.	V^{+}	V^{+}	V^{r}	II^{+}	.	V^{1}	I^{1}	.	.	.	.	.	.	.
Petasites frigidus	.	.	.	.	.	.	.	.	.	IV^{r}	.	II^{+}	I^{r}	II^{+}	I^{+}	IV^{1}	V^{1}	2^{+}	III^{+}	.	.	.	III^{1}
Saxifraga cernua **Ss-O**	I^{1}	II^{1}	.	.	.	.	.	.	.	II^{r}	I^{r}	V^{+}	III^{+}	.	.	IV^{1}	II^{1}	2^{+}	V^{1}	V^{+}	V^{1}	V^{1}	III^{1}
Myosotis asiatica	.	.	.	.	.	.	.	.	.	I^{+}	.	V^{1}	III^{+}	.	.	IV^{1}	.	.	IV^{r}	III^{r}	V^{1}	IV^{1}	.
Artemisia tilesii	.	.	.	.	.	.	.	.	.	I^{r}	.	IV^{r}	.	.	I^{+}	I^{1}	IV^{1}	.	I^{+}	I^{r}	IV^{+}	I^{1}	.
Cardamine pratensis	.	.	.	.	.	.	.	.	.	I^{r}	.	V^{+}	V^{r}	.	.	I^{+}	.	.	IV^{+}	II^{r}	I^{+}	I^{+}	.
Ranunculus propinquus **Sh, R-P**	**V^{2b}**	I^{1}	II^{+}	.	.	.	III^{r}	I^{r}	.	II^{+}	II^{1}	.	V^{1}	II^{+}	I^{+}	V^{1}	II^{1}	.	IV^{+}	I^{r}	.	.	.
Poa arctica **Sh**	.	.	.	.	.	.	.	.	III^{+}	I^{r}	III^{r}	.	.	.	II^{+}	V^{1}	IV^{1}	1^{r}	V^{1}	V^{+}	.	II^{1}	V^{1}
Carex bigelowii subsp. *arctisibirica*	.	.	.	III^{1}	.	.	.	.	.	.	I^{r}	II^{r}	IV^{+}	.	III^{1}	I^{1}	I^{1}	2^{+}	II^{+}	.	.	.	.
Astragalus alpinus subsp. *arcticus* **Sh**	.	II^{1}	.	.	.	.	.	.	.	.	.	II^{+}	IV^{1}	.	.	.	.	.	.	.	III^{+}	.	V^{2a}
Character-species of the Veronico alpinae–Salicion polaris																							
Veronica alpina **Sh**	I^{1}	IV^{1}	II^{+}	I^{1}	.	II^{+}	I^{+}	III^{r}	III^{+}	V^{1}	IV^{+}	V^{1}	II^{+}	.	.	.	.	.	.	.	.	.	.
Dichodon cerastoides **Sh, C-S**	II^{1}	II^{1}	.	.	.	II^{+}	I^{+}	II^{r}	I^{+}	IV^{+}	V^{+}	V^{+}	.	.	.	.	.	.	.	.	.	.	.
Epilobium alpinum **Sh, C-S**	.	I^{1}	.	.	.	.	III^{r}	II^{r}	.	IV^{+}	.	V^{1}	.	.	.	.	.	.	.	.	.	.	.
Pyrola minor	.	.	I^{r}	.	.	.	II^{r}	I^{r}	I^{+}	IV^{+}	V^{+}	III^{r}	.	.	I^{+}	.	.	.	.	.	.	.	.
Ranunculus glabriusculus	.	.	.	.	.	.	.	.	.	III^{r}	IV^{+}	III^{1}	.	.	.	.	.	.	.	.	.	.	.
Cladonia ecmocyna	.	.	I^{+}	.	I^{+}	.	.	.	I^{+}	V^{1}	V^{1}	.	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Salici herbaceae-polaris																							
Deschampsia glauca	.	.	II^{1}	.	.	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.	.	.	.	.	.
Pedicularis sudetica subsp. *arctoeuropaea*	.	.	.	.	.	.	.	.	.	III^{r}	.	.	.	.	.	.	.	.	.	.	.	.	.
Timmia austriaca	.	.	.	.	.	.	.	.	.	II^{1}	.	.	II^{+}	.	.	.	.	.	I^{+}	.	.	.	.
Differential species combination of the Salici polaris–Sibbaldietum procumbentis																							
Trisetum spicatum	III^{1}	III^{1}	II^{+}	I^{1}	.	I^{+}	I^{+}	.	II^{+}	II^{+}	IV^{1}	II^{r}	I^{+}	.	I^{+}	.	.	.	.	.	.	.	.
Diphasiastrum alpinum	.	.	II^{+}	.	III^{+}	.	I^{2a}	.	.	I^{r}	IV^{+}	.	.	.	I^{+}	.	.	.	.	.	.	.	.
Polytrichum strictum	.	.	.	.	.	.	.	.	.	I^{1}	IV^{1}	.	.	.	.	I^{2a}	I^{2a}	.	.	.	.	.	.
Peltigera scabrosa	.	.	I^{r}	.	I^{+}	.	.	.	.	II^{+}	V^{+}	.	.	.	III^{+}	I^{+}	I^{+}	.	.	.	.	.	.
Trientalis europaea	.	.	I^{r}	.	.	.	.	.	.	.	III^{+}	II^{r}	.	.	.	.	.	.	.	.	.	.	.
Differential species combination of the Myosotido asiaticae–Salicetum polaris																							
Oncophorus integerrimus	.	.	.	.	.	.	.	.	.	I^{+}	.	**IV^{2b}**	V^{2a}	.	.	.	.	.	.	.	.	.	.
Viola biflora **R-P**	V^{1}	II^{1}	I^{r}	.	II^{+}	.	.	.	.	I^{+}	III^{+}	V^{+}	I^{+}	.	.	.	.	.	.	.	.	.	.
Achillea millefolium	.	.	.	.	.	.	.	.	.	I^{r}	I^{+}	V^{r}	II^{r}	.	.	.	.	.	.	.	.	.	.
Parnassia palustris	III^{1}	I^{1}	.	.	.	.	.	.	.	.	.	V^{+}	.	.	.	.	.	.	.	.	.	.	.
Agrostis mertensii subsp. *borealis*	.	I^{1}	III^{1}	I^{1}	.	II^{+}	I^{+}	.	II^{1}	I^{+}	.	IV^{r}	.	.	.	.	.	.	.	.	.	.	.
Bistorta elliptica	.	.	I^{r}	.	.	.	.	.	.	.	II^{r}	IV^{r}	.	.	.	II^{1}	.	.	.	.	II^{1}	II^{2a}	.
Philonotis tomentella	.	II^{1}	.	.	.	.	.	.	.	.	.	V^{1}	.	.	.	.	.	.	.	.	.	.	.
Mnium blyttii	.	.	.	.	.	.	.	.	.	I^{+}	.	IV^{+}	I^{+}	.	.	I^{1}	.	.	.	.	.	.	.
Differential species combination of the Pinguiculo alpinae–Salicetum reticulatae and Salici reticulatae–Caricetum parallelae (from Arabidetalia caeruleae)																							
Salix reticulata **Ac**	.	III^{1}	.	.	.	.	.	.	.	I^{+}	I^{+}	III^{1}	**V^{3}**	**V^{2b}**	.	II^{1}	.	.	.	.	.	.	.
Carex parallela subsp. *redowskiana*	.	.	.	.	.	.	.	.	.	.	.	.	V^{1}	**V^{4}**	.	.	.	.	.	.	.	.	.
Pachypleurum alpinum	.	.	.	.	.	.	.	.	.	III^{r}	I^{r}	II^{r}	IV^{r}	III^{+}	I^{+}	II^{+}	.	1^{r}	.	.	.	.	.
Equisetum variegatum	.	I^{1}	.	.	.	.	.	.	.	.	.	.	III^{1}	II^{1}	.	.	.	.	.	.	.	.	.
Thalictrum alpinum **Ac**	III^{1}	II^{1}	.	.	.	.	II^{r}	I^{r}	I^{2a}	.	.	.	III^{+}	II^{1}	.	.	.	.	.	.	.	.	.
Pedicularis oederi	.	.	.	.	.	.	.	.	.	.	.	.	III^{r}	III^{1}	.	III^{+}	.	.	III^{r}	.	V^{1}	V^{1}	.
Differential species combination of the Pinguiculo alpinae–Salicetum reticulatae																							
Pinguicula alpina	.	.	.	.	I^{+}	.	.	.	.	.	.	.	V^{1}	.	.	.	.	.	.	.	.	.	.
Tofieldia pusilla	.	II^{1}	.	.	.	II^{+}	I^{+}	.	.	.	.	.	V^{+}	II^{1}	.	.	.	.	.	.	.	.	.
Carex capillaris	.	.	.	.	.	.	.	.	.	.	.	.	V^{+}	.	.	.	.	.	.	.	.	.	.
Potentilla crantzii **R-P**	V^{1}	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.	.	.
Silene acaulis **Ac**	.	II^{1}	.	.	.	.	II^{r}	II^{r}	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.	.	.
Selaginella selaginoides	IV^{1}	.	.	.	.	.	I^{r}	I^{r}	.	.	.	.	III^{+}	.	.	.	.	.	.	.	.	.	.
Dicranum spadiceum	.	.	I^{1}	.	.	.	.	.	.	I^{+}	I^{+}	.	V^{2a}	.	I^{3}	I^{2a}	.	1^{+}	II^{+}	.	.	.	.
Hylocomiastrum pyrenaicum	.	.	.	.	.	.	.	.	.	.	.	.	V^{1}	.	.	.	.	.	.	.	.	.	.
Campylium stellatum	.	I^{1}	.	.	.	.	.	.	.	.	.	.	V^{+}	.	.	.	.	.	.	.	I^{2a}	.	.
Ditrichum flexicaule	.	.	.	.	.	.	.	.	.	.	.	.	V^{+}	.	I^{+}	I^{+}	.	.	.	.	.	.	.
Brachythecium erythrorrhizon	.	.	.	.	.	.	.	.	.	.	.	.	IV^{1}	.	.	.	.	.	.	.	.	.	.
Pohlia cruda	.	.	.	.	.	.	.	I^{r}	.	I^{+}	I^{+}	II^{+}	IV^{1}	.	I^{+}	I^{1}	.	.	.	.	.	.	.
Cladonia pocillum	.	.	.	.	.	.	.	.	.	I^{r}	.	.	V^{1}	.	.	.	.	1^{+}	.	.	.	.	.
Differential species combination of the Salici reticulatae–Caricetum parallelae																							
Dryas octopetala	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	V^{2a}	I^{+}	I^{2a}	.	.	.	.	.	.	.
Salix saxatilis	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{2a}	.	.	.	.	.	.	.	.	.
Carex sabynensis	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{2a}	.	.	.	.	.	.	.	.	.
Character species of the alliances and class Salicetea herbaceae and constant species in syntaxa of Siberian sectors of Arctic																							
Lagotis glauca subsp. *minor*	.	.	.	.	.	.	.	.	.	.	.	.	V^{+}	IV^{1}	.	V^{1}	IV^{1}	2^{+}	V^{+}	I^{r}	V^{2a}	V^{1}	V^{1}
Oxyria digyna **Ss-O, So-O**	I^{1}	III^{1}	III^{+}	I$^{1-2}$	.	.	I^{r}	I^{r}	I^{1}	.	I^{r}	.	II^{+}	V^{1}	II^{+}	II^{1}	II^{1}	2^{+}	IV^{+}	III^{r}	V^{1}	I^{1}	.
Luzula arcuata aggr. **Sh, Ss-O**	.	II^{1}	.	I^{1}	.	.	.	I^{r}	.	I^{+}	.	.	.	.	III^{+}	I^{1}	I^{+}	1^{+}	IV^{+}	.	III^{1}	III^{1}	IV^{1}
Saxifraga nelsoniana	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	III^{+}	III^{1}	V^{1}	2^{+}	IV^{+}	III^{r}	V^{1}	V^{1}	V^{1}
Ranunculus nivalis **Sh, So-O**	.	I^{1}	.	.	.	.	.	.	.	.	.	.	.	.	II^{+}	II^{1}	IV^{1}	2^{1}	III^{+}	III^{r}	IV^{1}	I^{+}	.
Alopecurus alpinus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	IV^{1}	.	III^{1}	III^{+}	V^{+}	IV^{1}	II^{1}
Valeriana capitata	.	.	.	.	.	.	.	.	.	II^{+}	.	.	.	.	.	II^{1}	V^{1}	.	.	.	IV^{+}	V^{1}	V^{1}
Saxifraga hirculus	.	.	.	.	.	.	.	.	.	II^{+}	.	.	.	.	.	I^{1}	III^{1}	.	IV^{+}	II^{r}	III^{+}	V^{1}	V^{1}
Cerastium regelii **Sh, So-O**	.	.	.	.	.	.	.	.	.	.	.	.	.	V^{+}	.	I^{+}	.	2^{r}	**V^{2b}**	V^{+}	II^{1}	I^{1}	.
Deschampsia borealis	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{2a}	.	I^{1}	.	1^{r}	V^{1}	V^{+}	I^{+}	.	.
Saxifraga hieracifolia	.	.	.	.	.	.	.	.	.	II^{r}	.	II^{r}	I^{r}	.	.	I^{+}	II^{1}	2^{r}	V^{+}	III^{r}	II^{1}	II^{1}	II^{1}
Ranunculus pygmaeus **Sh, So-O**	.	II^{1}	II^{+}	I^{1}	.	.	.	.	.	I^{r}	.	II^{r}	I^{r}	.	I^{+}	I^{+}	.	2^{+}	V^{+}	II^{r}	.	.	.
Saxifraga nivalis **Sh**	.	.	I^{+}	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	II^{1}	.	IV^{+}	II^{r}	III^{+}	.	V^{1}
Cardamine bellidifolia **Sh, Ss-O**	.	.	.	I^{1}	II^{+}	.	.	.	.	.	.	.	.	II^{+}	.	.	I^{1}	.	.	.	II^{1}	I^{1}	IV^{1}
Luzula nivalis **Sh**	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	1^{+}	.	.	III^{+}	II^{1}	IV^{1}
Pohlia drummondii **Sh, Ss-O**	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{1}	.	1^{+}	.	.	.	.	.

Table 7. Continued.

Number of syntaxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Minuartia biflora **Sh**	I^{1}	II^{1}	.	.	.	.	.	.	.	.	.	.	I^{r}	II^{1}	.	.	.	.	I^{+}	.	.	.	.
Draba alpina **Sh**	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{1}	.	.	.	.	.	.	.
Differential species combination of the Tanaceto bipinnati–Salicetum polaris																							
Ochrolechia frigida	.	.	.	II^{1}	.	II^{2a}	I^{2a}	.	.	.	.	.	II^{1}	.	IV^{1}	.	.	.	.	.	.	.	.
Huperzia arctica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.
Differential species combination of the Chrysosplenio sibirici–Polemonietum acutiflorum																							
Polemonium acutiflorum	.	.	.	.	.	.	.	.	.	II^{+}	.	II^{r}	I^{r}	.	II^{+}	V^{1}	V^{2a}	.	.	.	.	.	V^{1}
Chrysosplenium alternifolium	.	.	.	.	.	.	.	.	.	.	.	.	I^{r}	.	.	V^{1}	II^{+}	.	II^{+}	.	.	II^{1}	.
Nephroma expallidum	.	.	.	.	.	.	.	.	.	II^{+}	II^{1}	.	I^{r}	.	I^{+}	III^{+}	II^{+}	.	I^{+}	.	.	.	.
Differential species combination of the ? Deschampsio–Cerastietum regelii var. Peltigera canina																							
Pedicularis sudetica subsp. *albolabiata*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	III^{1}	.	.	.	III^{+}	.	.
Carex aquatilis subsp. *stans*	.	.	II^{1}	.	.	.	.	.	.	III^{+}	III^{+}	II^{r}	III^{r}	.	II^{2a}	I^{+}	IV^{2a}	.	I^{+}	.	I^{+}	**IV^{3}**	.
Bistorta plumosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{1}	.	.	.	.	.	V^{2a}
Salix pulchra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	.	IV^{1}	.	.	.	.	.	.
Peltigera canina	II^{1}	.	.	II^{1}	.	.	.	.	.	.	.	.	.	.	.	II^{1}	V^{+}	.	.	.	.	I^{1}	III^{+}
Differential species combination of the Gymnomitrio-Phippsietum concinnae and Deschampsio–Cerastietum regelii																							
Campylium polygamum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{3}	.	.	**IV^{2b}**	V^{1}	.	.	.
Draba glacialis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	.	IV^{+}	V^{+}	II^{1}	I^{+}	.
Distichum capillaceum	II^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	V^{+}	.	.	.
Encalypta alpina	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	.	.	.	.	III^{+}	IV^{+}	.	.	.
Stellaria edwardsii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{+}	III^{r}	.	.	.
Differential species combination of the Deschampsio–Cerastietum regelii																							
Nostoc commune	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V^{1}	.	.	.	.
Cladonia symphicarpa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	II^{r}	.	.	.
Rumex arcticus	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	.	II^{1}	IV^{1}	1^{r}	IV^{+}	I^{r}	.	.	.
Niphotrichum ericoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	I^{r}	.	.	.
Ranunculus sulphureus **So-O**	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.	.	.
Differential species combination of the Gymnomitrio–Phippsietum concinnae																							
Phippsia concinna **So-O**	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	**V^{2b}**	III^{1}	.	.
Gymnomitrion corallioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{r}	**V^{4}**	.	.	.
Brachythecium mildeanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{1}	.	.	I^{+}	IV^{r}	.	.	.
Preissia quadrata	.	IV^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{+}	V^{+}	.	.	.
Differential species combination of the Saxifrago tenuis–Salicetum polaris																							
Saxifraga tenuis **Sh, So-O**	.	II^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{1}	.	2^{+}	I^{+}	.	V^{+}	.	.
Minuartia arctica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V^{1}	.	.
Eritrichium villosum	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.	I^{1}	.	.	.	.	IV^{1}	I^{1}	.
Marchantia polymorpha	.	.	.	.	.	.	.	.	.	I^{r}	.	III^{+}	.	.	.	.	I^{1}	.	.	.	IV^{1}	.	.
Juncus biglumis	.	**II^{2b}**	.	.	.	.	.	.	.	.	.	II^{r}	.	II^{+}	.	I^{+}	.	1^{r}	III^{+}	I^{r}	IV^{1}	.	.
Papaver lapponicum subsp. *orientale*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	I^{+}	II^{1}
Taraxacum macilentum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	.	.
Petasites glacialis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	.	.
Stellaria peduncularis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	II^{1}	.	1^{+}	.	.	IV^{+}	.	III^{1}
Differential species combination of the Eutremo edwardsii–Sanionietum uncinatae																							
Eutrema edwardsii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	II^{1}	.	III^{r}	I^{r}	I^{+}	V^{1}	IV^{1}
Tomentypnum nitens	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	.	.	**I^{2b}**	**II^{2b}**	.	.	.	.	**V^{2b}**	**V^{4}**
Hylocomium splendens **R-P**	V^{1}	.	.	.	I^{+}	.	.	I^{r}	.	.	.	.	V^{+}	.	.	**II^{2b}**	**II^{3}**	.	.	.	.	V^{2a}	**V^{2b}**
Dryas punctata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	I^{1}	IV^{2a}	V^{2a}
Eriophorum angustifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{+}	I^{1}	.	I^{+}	.	.	V^{2a}	.
Ptilidium ciliare	.	.	I^{+}	.	.	.	.	I^{r}	.	.	.	.	I^{1}	.	II^{1}	.	**I^{2b}**	.	I^{+}	.	.	V^{2a}	.
Ranunculus affinis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{1}	.	.	.	I^{+}	III^{1}	.
Tephroseris atropurpurea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{1}	.	.	.	I^{+}	III^{1}	.
Differential species combination of the Astragalo frigidi–Salicetum reptantis																							
Astragalus frigidus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V^{1}
Draba lactea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{1}
Cetrariella fastigiata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	.	.	.	.	.	IV^{+}
Constant species of syntaxa																							
Bistorta vivipara **R-P**	V^{1}	V^{1}	II^{+}	I^{1}	I^{+}	III^{+}	V^{+}	V^{+}	V^{2a}	IV^{+}	V^{+}	V^{2a}	V^{+}	V^{1}	V^{1}	V^{2a}	III^{1}	2^{+}	IV^{+}	.	II^{1}	V^{2a}	V^{1}
Equisetum arvense subsp. *boreale*	III^{1}	III^{1}	II^{+}	.	.	.	I^{r}	I^{r}	I^{+}	V^{+}	V^{1}	V^{+}	V^{+}	.	IV^{2a}	V^{2a}	V^{1}	2^{1}	III^{1}	.	I^{+}	III^{2a}	.
Sanionia uncinata **R-P**	**V^{4}**	.	II^{1}	I$^{1-2}$	II^{1}	II^{+}	IV^{+}	IV^{r}	I^{+}	V^{2a}	V^{2a}	V^{2a}	V^{2a}	II^{2a}	IV^{2a}	V^{2a}	**V^{4}**	**2^{2b}**	**V^{2b}**	V^{1}	**V^{3}**	**V^{3}**	.
Poa alpina **R-P**	**V^{2b}**	III^{2a}	I^{r}	II^{1}	.	I^{+}	II^{r}	III^{r}	II^{+}	II^{r}	II^{+}	V^{+}	IV^{+}	IV^{+}	.	.	I^{1}	.	I^{1}	.	.	II^{1}	.
Cetraria islandica subsp. *islandica*	.	I^{1}	I^{+}	III^{1}	II^{1}	.	.	.	.	V^{+}	V^{+}	IV^{+}	IV^{+}	II^{+}	V^{1}	IV^{1}	II^{+}	1^{r}	.	.	I^{2a}	I^{1}	.
Empetrum hermaphroditum	.	.	II^{+}	.	I^{1}	I^{1}	III^{r}	II^{r}	III^{1}	IV^{+}	IV^{+}	II^{+}	III^{r}	.	.	.	.	.	.	.	.	.	.
Cladonia arbuscula	.	I^{1}	.	II^{1}	I^{+}	I^{+}	II^{r}	II^{r}	I^{+}	III^{+}	I^{r}	.	III^{+}	.	IV^{+}	I^{1}	.	.	.	.	.	.	.
Stereocaulon alpinum	.	.	.	II^{1}	II^{+}	.	I^{+}	I^{r}	.	I^{+}	II^{r}	.	I^{+}	.	III^{+}	IV^{1}	III^{1}	2^{2a}	II^{+}	II^{r}	IV^{2a}	.	III^{+}
Solidago lapponica **R-P**	III^{1}	.	II^{1}	I^{1}	III^{+}	.	.	.	.	.	.	II^{r}	.	.	.	.	.	.	.	.	.	.	.
Euphrasia frigida	.	II^{1}	.	.	I^{+}	.	III^{r}	I^{r}	I^{+}	.	I^{+}	.	II^{r}	.	.	.	.	.	.	.	.	.	.
Poa alpigena	V^{1}	I^{1}	I^{+}	I^{1}	.	.	.	.	.	.	.	.	IV^{+}	.	V^{1}	IV^{1}	II^{1}	.	.	.	I^{+}	.	.
Salix glauca	.	.	.	.	.	.	.	.	.	III^{r}	IV^{+}	II^{r}	II^{r}	.	V^{+}	I^{2a}	II^{1}	1^{r}	.	.	.	II^{1}	V^{2a}
Salix lanata	.	.	.	.	I^{1}	.	.	.	.	II^{r}	III^{1}	II^{r}	IV^{r}	III^{+}	III^{1}	V^{2a}	I^{2a}	.	.	.	.	.	.
Festuca rubra subsp. *arctica*	.	.	.	.	.	.	.	.	.	V^{+}	I^{+}	IV^{+}	I^{+}	.	III^{+}	I^{1}	I^{+}	.	II^{+}	.	.	.	II^{1}
Salix hastata	.	.	.	.	.	.	.	.	.	III^{r}	III^{+}	V^{+}	V^{+}	.	.	.	.	.	.	.	.	.	.
Luzula multiflora subsp. *frigida*	III^{1}	I^{1}	.	.	.	.	.	.	.	IV^{+}	IV^{+}	IV^{r}	V^{+}	.	II^{+}	.	.	.	.	.	.	.	.
Nephroma arcticum	.	.	.	.	.	.	.	.	.	IV^{+}	IV^{1}	.	.	.	I^{1}	I^{+}	.	.	.	.	.	.	.
Betula nana	.	.	.	.	I^{+}	.	.	.	.	.	IV^{+}	IV^{r}	III^{r}	II^{+}	V^{2a}	I^{2a}	.	2^{r}	.	.	.	.	.
Vaccinium uliginosum subsp. *microphyllum*	.	.	II^{r}	.	.	II^{+}	II^{+}	I^{+}	.	I^{1}	V^{+}	.	V^{+}	II^{1}	III^{+}	I^{1}	I^{1}	1^{r}	.	.	.	.	II^{1}
Cladonia stricta	.	.	.	.	.	.	.	.	.	I^{r}	III^{r}	.	III^{r}	.	.	I^{1}	.	2^{1}	.	.	.	.	.
Alopecurus pratensis subsp. *alpestris*	.	.	.	.	.	.	.	.	.	I^{+}	III^{r}	II^{1}	II^{r}	.	.	.	.	.	.	.	.	.	.
Cladonia bellidiflora	.	I^{1}	I^{r}	III^{1}	.	.	.	.	I^{+}	I^{r}	III^{+}	.	I^{r}	.	.	.	.	.	.	.	.	.	.
Peltigera aphthosa	II^{1}	I^{1}	.	I^{1}	I^{+}	.	.	.	I^{1}	III^{+}	II^{+}	V^{r}	V^{+}	II^{+}	.	II^{1}	V^{1}	.	I^{+}	.	.	.	V^{1}
Caltha palustris	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.	.	.	.

Table 7. Continued.

Number of syntaxon	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Allium schoenoprasum	.	.	.	.	.	.	.	.	.	.	.	IV^{r}	.	.	.	.	.	.	.	.	.	.	.
Comarum palustre	.	.	.	.	.	.	.	.	.	.	.	IV^{r}	.	.	.	.	.	.	.	.	.	.	.
Brachythecium rutabulum	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.	.	.	.
Distichium capillaceum	.	**III^{3}**	.	.	.	.	.	I^{r}	.	.	.	IV^{+}	III^{+}	.	.	I^{2a}	.	1^{+}	.	.	II^{2a}	.	.
Sagina intermedia	.	II^{1}	.	.	.	.	.	.	.	I^{+}	.	IV^{+}	.	.	.	.	.	1^{r}	III^{+}	.	III^{+}	.	.
Bryum pseudotriquetrum	.	.	.	II$^{2-3}$	.	.	.	.	.	I^{+}	.	III^{1}	.	.	.	II^{2a}	.	.	.	.	.	.	.
Bryum rutilans	.	.	.	.	.	.	.	.	.	.	.	III^{1}	II^{+}	.	.	.	.	.	.	.	.	.	.
Peltigera neckeri	.	.	.	.	.	.	.	.	.	II^{+}	.	III^{r}	.	.	.	I^{+}	I^{+}	.	.	.	.	.	.
Bartramia ithyphylla	I^{1}	III^{1}	.	II^{1}	.	.	.	.	I^{+}	II^{+}	.	III^{+}	.	.	.	.	.	.	.	.	.	.	.
Tripleurospermum hookeri	.	.	.	.	.	.	.	.	.	I^{r}	.	III^{r}	.	.	.	.	.	.	.	.	.	.	.
Pogonatum urnigerum	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.	.	I^{1}	.	1^{+}	I^{+}	.	.	.	.
Dichodontium pellucidum	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.	.	.	.	.	.	.	.	.	.
Psoroma hypnorum	.	I^{1}	.	.	.	I^{2a}	I^{2a}	.	II^{+}	II^{r}	.	III^{r}	II^{+}	.	III^{+}	.	I^{+}	1^{r}	.	.	.	.	III^{+}
Festuca ovina	I^{1}	.	I^{r}	.	I^{+}	.	.	.	.	II^{+}	I^{+}	.	IV^{+}	.	II^{1}	.	.	.	.	.	.	.	.
Cladonia coccifera	.	I^{1}	II^{+}	II^{1}	II^{+}	I^{+}	I^{+}	.	I^{+}	I^{r}	.	.	IV^{+}	.	III^{+}	.	I^{+}	.	I^{+}	.	I^{+}	.	III^{+}
Peltigera rufescens	.	**II^{2b}**	.	.	.	.	III^{r}	II^{r}	.	.	.	.	IV^{+}	.	.	I^{1}	I^{+}	.	I^{+}	.	I^{+}	.	III^{1}
Draba sibirica	.	.	.	.	.	.	.	.	.	.	I^{r}	II^{+}	III^{+}	II^{+}	.	I^{1}	.	.	.	.	.	.	.
Geum rivale	.	.	.	.	.	.	.	.	.	I^{r}	.	II^{r}	III^{r}	.	.	.	.	.	.	.	.	.	.
Carex juncella	.	.	.	.	.	.	.	.	.	.	.	.	III^{r}	.	.	.	.	.	.	.	.	.	.
Tephroseris integrifolia	.	.	.	.	.	.	.	.	.	.	.	.	III^{r}	.	.	.	.	.	.	.	.	.	.
Myxobilimbia lobulata	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.	.	.	.	.	I^{+}	.	.	.
Saxifraga oppositifolia **Ac, So-O**	.	II^{1}	.	.	.	.	.	.	.	.	.	.	.	II^{2a}	.	.	.	.	.	.	III^{+}	.	.
Cassiope tetragona	.	II^{1}	.	.	.	.	.	.	.	.	.	.	.	III^{1}	.	.	I^{1}	1^{r}	.	.	III^{+}	.	.
Carex saxatilis subsp. *laxa*	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	.	.	.	.	I^{+}	.	.	.	.
Polytrichum juniperinum	II^{1}	II^{1}	.	II^{1}	II^{1}	.	I^{+}	.	IV^{+}	.	.	.	.	.	V^{2a}	.	.	.	II^{+}	.	.	.	.
Polytrichum hyperboreum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**IV^{2b}**	II^{1}	.	1^{+}	.	.	.	.	.
Dicranum elongatum	.	.	.	.	.	I^{2a}	I^{2a}	.	I^{1}	.	.	.	.	.	**IV^{2b}**	I^{1}	.	.	.	.	.	.	**III^{2b}**
Aulacomnium turgidum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V^{1}	.	.	.	.	.	.	I^{2a}	**V^{2b}**
Dactylina arctica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	I^{1}	II^{1}	.	I^{+}	.	.	.	V^{1}
Cladonia chlorophaea	.	.	.	.	.	.	.	.	.	I^{+}	.	.	I^{r}	.	IV^{+}	.	III^{+}	.	.	.	.	.	V^{+}
Cladonia uncialis	.	I^{1}	.	.	I^{1}	.	.	.	I^{+}	I^{r}	.	.	I^{r}	.	IV^{+}	.	.	.	.	.	.	.	.
Sphenolobus minutus	.	.	.	.	II^{+}	.	.	.	.	I^{+}	.	.	.	.	IV^{+}	.	.	.	.	.	.	.	.
Cladonia gracilis subsp. *elongata*	.	II^{1}	.	III^{1}	.	.	.	I^{1}	.	I^{r}	I^{r}	.	II^{+}	.	IV^{1}	I^{1}	.	.	.	.	.	.	.
Vaccinium vitis-idaea subsp. *minus*	.	.	.	.	II^{+}	.	.	.	.	.	.	.	I^{+}	.	V^{+}	.	.	.	.	.	.	.	.
Carex vaginata subsp. *quasivaginata*	.	.	.	.	.	.	.	.	.	.	.	.	I^{r}	.	III^{+}	I^{+}	.	.	.	.	.	.	.
Pohlia nutans	.	.	.	II$^{1-3}$	I^{+}	.	.	.	II^{+}	II^{+}	.	.	.	.	III^{+}	I^{1}	.	**1^{2b}**	.	.	.	.	.
Pleurozium schreberi	.	.	.	.	I^{+}	.	.	.	.	I^{r}	.	.	.	.	III^{+}	I^{2a}	.	.	.	.	.	.	.
Cladonia amaurocraea	.	.	.	.	I^{+}	.	.	.	.	.	.	.	.	.	III^{1}	I^{+}	.	.	.	.	.	.	II^{+}
Cladonia stygia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	.	.	.	.	.	.	.	.
Arctocetraria andrejevii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	I^{1}	.	.	.	.	.	.	.
Cladonia pleurota	.	.	.	.	I^{+}	.	.	.	.	I^{r}	.	.	.	.	III^{+}	.	.	.	.	.	.	.	.
Cladonia subfurcata	.	.	.	.	I^{+}	.	.	.	.	.	I^{r}	.	.	.	III^{+}	.	.	.	.	.	.	.	.
Ledum palustre subsp. *decumbens*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.	.	.	.	.	.	.
Flavocetraria nivalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	I^{1}	.	.	.	.	.	.	.
Hierochloë alpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	I^{1}	.	.	.	.	.	.	.
Sphaerophorus globosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.	.	.	.	.	.	.
Empetrum subholarcticum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	.	.	.	.	.	.	.	.
Antennaria lanata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	I^{1}	.	2^{+}	.	.	.	.	.
Flavocetraria cucullata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}	III^{+}	I^{+}	.	.	.	I^{1}	.	V^{2a}
Arctagrostis latifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	.	III^{1}	II^{1}	.	II^{+}	.	.	V^{1}	IV^{2a}
Brachythecium turgidum	III^{1}	II^{1}	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{1}	.	.	II^{+}	.	.	.	.
Arctagrostis arundinacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{2a}	III^{1}	.	.	.	.	.	V^{1}
Salix reptans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	I^{1}	IV^{1}	.	IV^{+}	II^{r}	.	.	V^{2a}
Draba oblongata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{r}	III^{r}	.	.	.
Parrya nudicaulis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	I^{+}	II^{1}	.	I^{+}	.	IV^{+}	II^{1}	IV^{1}
Lloydia serotina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	I^{1}	.	.	I^{+}	IV^{1}	III^{+}	.
Pedicularis capitata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}	.	.
Cochlearia arctica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	III^{1}	.	.
Draba pauciflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	.	.	.	III^{1}	.	II^{1}
Pedicularis hirsuta	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{+}	.	.	.	.	.	.	III^{+}	I^{1}	II^{1}
Luzula tundricola	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{1}	I^{1}	.	.	.	.	.	V^{1}
Bryocaulon divergens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	.	.	.	.	.	.	V^{+}
Cetraria islandica subsp. *crispiformis*	.	.	.	.	.	.	.	.	.	.	.	.	I^{r}	.	.	.	.	.	.	.	.	.	V^{1}
Saussurea tilesii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	.	.	.	IV^{+}	.	V^{1}
Saxifraga spinulosa	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	.	.	.	.	.	.	.	.	IV^{1}
Bryoria nitidula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV^{+}
Ochrolechia androgyna	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V^{+}
Delphinium chamissonis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{+}	.	.	.	.	I^{+}	III^{1}
Lecanora epibryon	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III^{+}
Solorina saccata	.	.	.	.	.	.	.	.	.	.	.	.	I^{r}	.	.	.	.	.	I^{+}	I^{r}	.	.	III^{+}
Peltigera polydactylon	.	I^{1}	.	.	.	.	.	.	.	II^{r}	.	II^{r}	.	.	.	.	I^{+}	.	.	.	.	.	III^{+}
Thamnolia vermicularis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I^{+}	.	.	.	.	.	.	.	IV^{+}
Cetraria laevigata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II^{1}	I^{+}	.	.	.	.	.	IV^{1}
Liverworts	.	.	II^{1}	.	.	.	.	.	I^{+}	I^{2b}	III^{2a}	.	I^{1}	.	.	I^{2a}	.	1^{+}	.	.	.	.	.

Note. Other species with constancy only I and II are not included in the table. The diagnostic species of associations cited from the authors are taken in the frame.

regions. The only exception witnessed is the ass. Salicetum polaris Gjaerevoll 1950, placed in the eponymous alliance Polarion (orig. form), which Gjaerevoll (1950) described in Swedish Lapland, therefore this syntaxon was included in the analysis. In the proposed snowbed calciphytic communities of the alliance with circum-neutral, calcareous soils feature *Salix reticulata* and are dominated by *S. polaris*. “Like *Salix herbacea* it may form dense carpets. It is accompanied by other calciphiles: *Saxifraga oppositifolia*, *Silene acaulis* and *Thalictrum alpinum* and in the bottom layer *Distichium* capillaceum*, *Preissia quadrata* and *Blepharostoma trichophyllum*" (Gjaerevoll 1950: 416). The alliance Polarion is now synonymized with the Saxifrago oppositifoliae–Oxyrion digynae (Vegetation of herb-rich snowbeds on stabilized calcareous soils in the boreo-montane belt of Scandinavia and the Arctic Archipelago) within the order Arabidetalia caeruleae and class Thlaspietea rotundifolii. We also included in analysis the relevés of the community Trollius europaeus-soc. (ass. Ranunculo acris–Poetum alpinae Daniëls in Mucina et al. 2016) from the alliance Ranunculo–Poion alpinae, combining grassy snowbeds on stabilized calcareous soils, in the same order and class. "They are shining in yellow colours from *Ranunculus propinquus*, *Trollius europaeus*, *Potentilla crantzii* and *Taraxacum croceum*" (Gjaerevoll 1950: 416); important species are also *Carex bigelowii* s. str., *Poa alpina*, *Parnassia palustris*, *Saussurea alpina*.

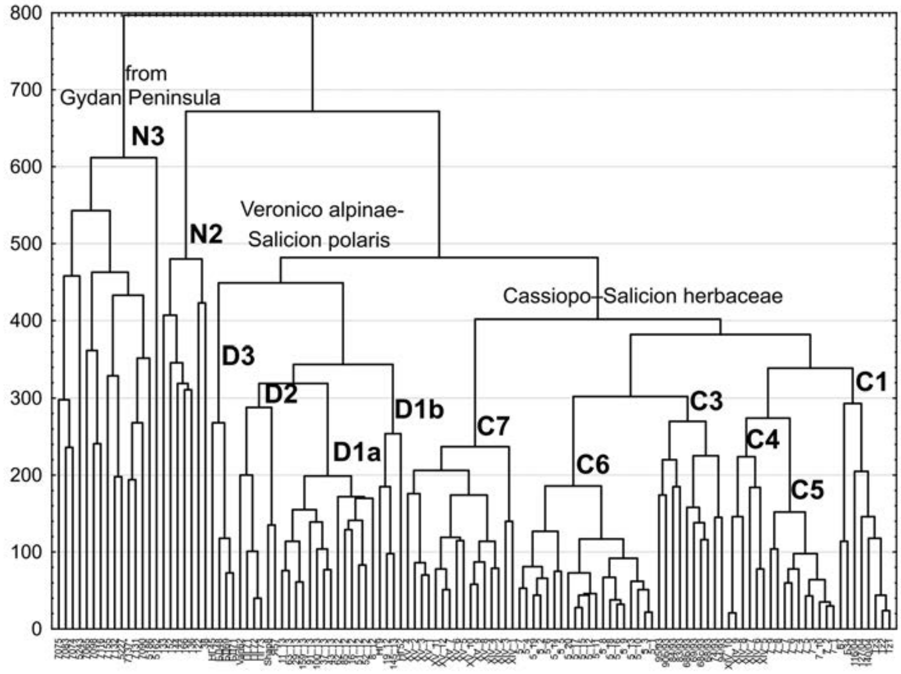

Figure 3 The similarity of relevés of snowbed stands from different sectors of the Arctic, established by the Complete-linkage clustering (Squared Euclidean distances). For the codes of the syntaxa see Table 6

The dendrogram of syntaxa allowed us to identify blocks of floristically similar associations (Fig. 4). East European associations (syntaxa D1–E1) are divided from both North European associations (from Swedish Lapland, Norway, Kola Peninsula, Greenland, Iceland) (syntaxa A1–C7) and Siberian associations (from Gydan Peninsula, Taymyr Peninsula, Anabar Plateau, lower reaches of the Indigirka River) (syntaxa N1–N9) at the highest level.

The cluster of East European snowbed vegetation is not homogeneous. Three syntaxa on siliceous substrates form a single cluster (syntaxa D1–D3), which we merged into a new alliance Veronico alpinae–Salicion polaris in the Salicetea herbaceae. At a higher level, the association (syntaxon E1) of snowbed vegetation on stabilized calcareous soils was separated from them. A provisional alliance Carici parallelae–Salicion reticulatae prov. in the order Arabidetalia caeruleae and the class Thlaspietea rotundifolii has been proposed for it.

Similarly, among North European syntaxa: both syntaxa of alliances Ranunculo–Poion alpinae (syntaxon A1) and Saxifrago oppositifoliae–Oxyrion digynae (B1) from the order Arabidetalia caeruleae are separating at a higher level from associations from the alliance Cassiopo–Salicion herbaceae (syntaxa C1–C7) of the class Salicetea herbaceae. In the Siberian syntaxa, the cluster (N1–N9) ass. Salici reticulatae–Caricetum parallelae (syntaxon N1) on carbonate substrates separated from the other syntaxa at the highest level.

That is, the cluster analysis (Fig. 4) demonstrates well that regional differences in the species composition of syntaxa "outweigh" differences in habitat ecology. This justifies the necessity of combining syntaxa into vicarious alliances taking into account ecological conditions at the level of large meridional-latitudinal regions.

In the order Salicetalia herbaceae and class Salicetea herbaceae for the North European Cassiopo–Salicion herbaceae the vicarious alliance is the East European Veronico alpinae–Salicion polaris, and in order Arabidetalia caeruleae and class Thlaspietea rotundifolii for Saxifrago oppositifoliae–Oxyrion digynae the vicarious alliance is Carici parallelae–Salicion reticulatae prov.

Snowbed vegetation in the Siberian sector of the Arctic

In the Taymyr Peninsula, in the High Arctic (arctic tundra and in the northern part of the typical tundra subzones), Matveyeva (1994) described 2 associations that were united into one cluster (syntaxa 19 and 20 in Table 7, syntaxa N6 and N7 in Figs 4, 5). She identified *Phippsia concinna*, *Cerastium regelii*, *Salix polaris*, *Sanionia uncinata* and *Cetrariella delisei* as the main species of snowbed vegetation for the northern part of the tundra zone. We have carried out only two relevés of snowbed vegetation in the southern tundra of the Taymyr Peninsula, which vary in species composition and habitats. Nevertheless, they were closer to the "Taymyr" syntaxa than to the "Gydan" syntaxa (Fig. 5, N5). The listed core species can be added to the ones commonly found in snowbed stands in the southern and northern Taymyr: *Deschampsia borealis*, *Lagotis glauca* subsp. *minor*, *Luzula arcuata* aggr., *Oxyria digyna*, *Poa arctica*, *Ranunculus nivalis*, *R. pygmaeus*, *Saxifraga cernua*, *S. nelsoniana*, *S. hieracifolia*.

Cluster analysis at the syntaxa level (Fig. 4) showed that they group well into low-level clusters according to the regional latitude-longitude principle: two associations on

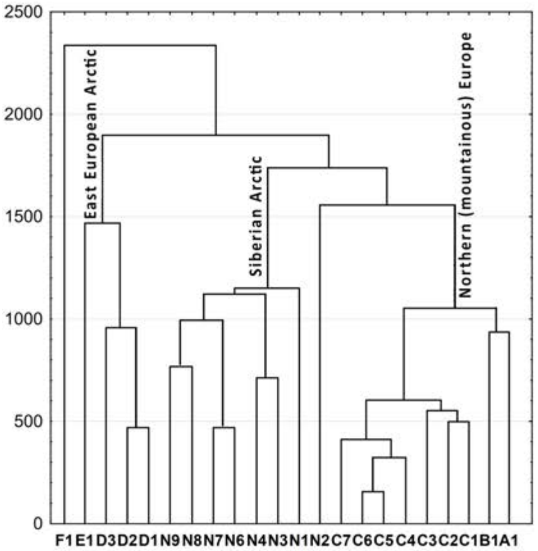

Figure 4 The similarity of syntaxa of snowbed communities from different sectors of the Arctic, established by the Complete-linkage clustering (Squared Euclidean distances). For the codes of the syntaxa see Table 6

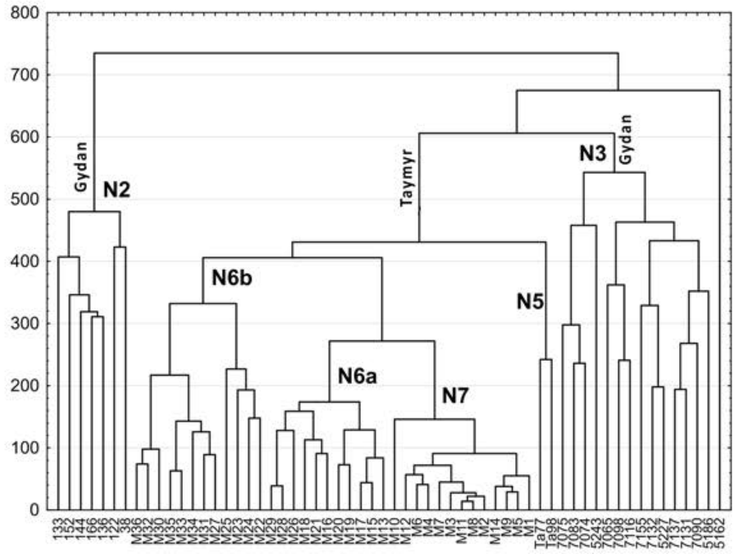

Figure 5 The similarity of relevés of snowbed stands from Siberian sector of the Arctic (Taymyr and Gydan), established by the Complete-linkage clustering (Squared Euclidean distances). For the codes of the syntaxa see Table 6

the Taymyr Deschampsio–Cerastietum regelii and Gymnomitrio–Phippsietum concinnae Matveyeva 1994 (syntaxa N6 and N7), two associations on the Anabar Plateau Saxifrago tenuis–Salicetum polaris Telyatnikov et al. 2013 and Eutremo edwardsii–Sanionietum uncinatae Telyatnikov et al. 2013 (syntaxa N8 and N9). However, there are some exceptions. Thus, the syntaxon described in the lower Indigirka River (Telyatnikov et al. 2015) as Deschampsio–Cerastietum regelii var. Peltigera canina has little in common with the "Taymyr" ass. Deschampsio–Cerastietum regelii, floristically it is closer to Chrysosplenio sibirici–Polemonietum acutiflorum Telyatnikov et al. 2019 and united in one cluster with it (syntaxa N3 and N4).

The ass. Tanaceto bipinnati–Salicetum polaris Khitun in Telyatnikov et al. 2021 recently studied on the Gydan Peninsula departs from the general pattern. It is interesting to note that it exhibits syntaxa characteristics that are more similar to those found in North Europe than to other associations of Gydan and in Siberia as a whole (Fig. 4, syntaxon N2). The author grouped 7 communities into the association, the composition of which is highly variable among them (Telyatnikov et al. 2021: Table 2, rel. 1–7 in Appendix 1 on the journal website) and two of them lack character species of the class Salicetea herbaceae. The author's relevés covered an extensive area, ranging from 50 to 100 m^2, which is too large for snowbed communities. The quality of the relevés and the correctness of the syntaxonomic solution are questionable in this case.

In the synoptic table and in the analysis, we also included the ass. Astragalo frigidi–Salicetum reptantis Telyatnikov et al. 2015, which the authors labeled as graminoid–dwarf shrub–green mossy nival tundra. It is detached from all others at the highest level (Table 7, syntaxon 23 and Fig. 4, syntaxon F1). During the compilation of the Russian Arctic vegetation checklist, this association with ground cover consisting of *Aulacomnium turgidum*, *Hylocomium splendens* and *Tomentypnum nitens* was reclassified as the zonal tundra vegetation class Carici arctisibiricae–Hylocomietea alaskani Matveyeva et Lavrinenko 2023 (Matveyeva & Lavrinenko 2021, 2023). This decision has proven to be accurate.

Matveyeva (1994: 823) wrote: "There are many plant communities on snowbeds in different parts of the tundra zone of Taymyr and they probably belong to more than one class. Their species composition varies greatly within a single site as well as in different subzones". New alliances for snowbed vegetation in the Siberian sector of the Arctic have yet to be described as data is collected. Nevertheless, alliances with a circumpolar range are potentially achievable for this type of vegetation in the high Arctic. This is due to the progressive reduction of vascular plant flora along the latitudinal gradient from southern to Arctic tundra and the overall scarcity of community diversity as we move northwards. Matveyeva predicted that in the high Arctic "syntaxonomic impoverishment occurs not only at the level of associations, but also of higher rank units" (Matveyeva 1998: 88).

Analysis of the coenoflora of vascular plants within syntaxa of snowbed vegetation along a longitudinal gradient

In the coenofloras of North (mountainous) European syntaxa (Fig. 6A, syntaxa A1–C7) the proportion of European and amphiooceanic species is comparable with circumpolar species, and about 10–20 % are Eurasian species. In the coenofloras of syntaxa of the East European Arctic (syntaxa D1–E1) these proportions are very different: the percentage of Eurasian species is comparable with circumpolar species, while the part of European species remains at around 10–15 %. In the Siberian Arctic coenofloras (syntaxa N1–N9, F1) are rich in species of the circumpolar fraction, the proportion of Eurasian species is comparable with Asian and Asian-American species, while

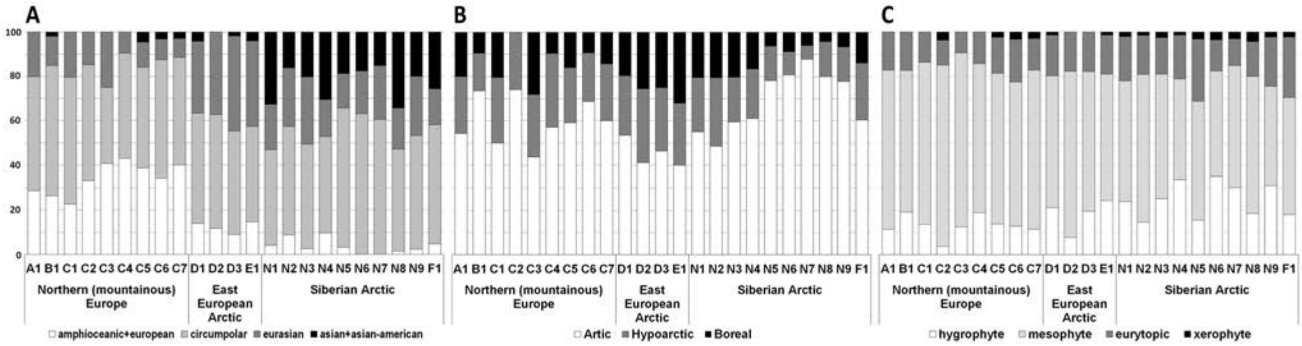

Figure 6 The percentage of species of different longitude (A), latitude (B) and ecological (C) groups in syntaxa coenofloras. For the codes of the syntaxa see Table 6

European species are almost absent.

The analysis of latitudinal geographic groups (Fig. 6B) revealed that the coenofloras of all syntaxa are dominated by species of the arctic fraction (including arctoalpine species). Within each region, the proportion of boreal species well reflects the affiliation to the botanico-geographical zone/subzone. In the East European Arctic, the share of boreal species in syntaxa increases along the typical – southern tundra gradient.

Thus, the analysis clearly illustrated the geographical features and differences of the snowbed vegetation of East European syntaxa from North (mountainous) European and Siberian ones.

Ecological-biological analysis (spectra of life forms and ecobiomorphs) well reflects the habitat conditions. Mesophytes, including hygromesophytes, are the prevailing in all syntaxa of snowbed vegetation. Even though the high humidity of habitats is due to meltwater inflow, the percentage of hygrophilous and eurytope species is comparable to each other and overall lower than that of mesophytes (Fig. 6C).

Syntaxa of different regions differ in the proportion of chionophilous species in coenofloras (Fig. 7A). Their share in North (mountainous) European syntaxa reaches 45 %, in East European Arctic – 35 %, and in Siberian syntaxa it is mainly 15–25 %.

The content of acidophytes and hemicalciphytes in snowbed syntaxa (Fig. 7B) clearly indicates the belonging of the associations to different orders. In North (mountainous) European syntaxa A1 and B1, related to Ranunculo–Poion alpinae and Saxifrago oppositifoliae–Oxyrion digynae in the order Arabidetalia caeruleae, the proportion of hemicalciphytes is similar or higher compared to acidophytes. The percentage of hemicalciphytes is two times higher also in syntaxa E1 and N1 – these are associations with *Salix reticulata* on carbonate stable substrates in the East European and Siberian Arctic. Hence, the analysis verifies the validity of the separation of the alliance Carici parallelae–Salicion reticulatae prov. in the order Arabidetalia caeruleae in the East European tundra. A higher proportion of hemicalciphytes is also present in two associations studied by Matveyeva (1994) in the northern Taymyr (syntaxa N6 and N7), a finding that should be emphasized when assessing whether these syntaxa belong to higher ranks. Each association contains 6–8 character species of the alliance Saxifrago oppositifoliae–Oxyrion digynae (see Table 7).

The spectra of life forms and ecobiomorphs are comparable across various syntaxa (Fig. 8A and B), implying uniform ecological conditions in their respective habitats, despite minor distinctions. The foundation of plant communities consists of herbs and bryophytes (mosses and liverworts). The insignificant presence of bryophytes in certain Siberian

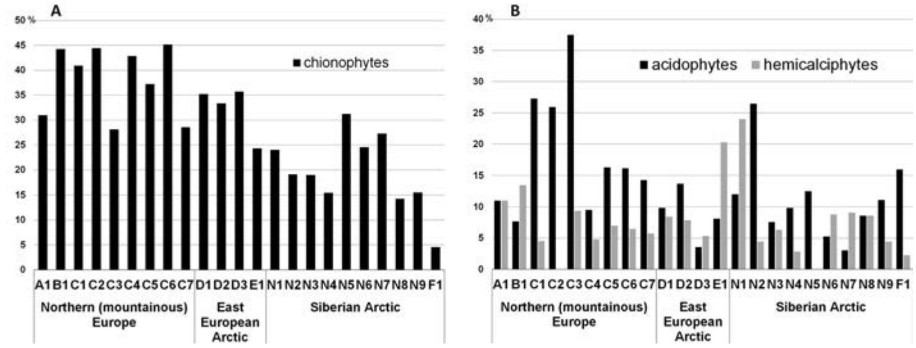

Figure 7 The percentage of chionophylous species (A) and species of different ecological groups in relation to soil acidity (B) in syntaxa coenofloras. For the codes of the syntaxa see Table 6

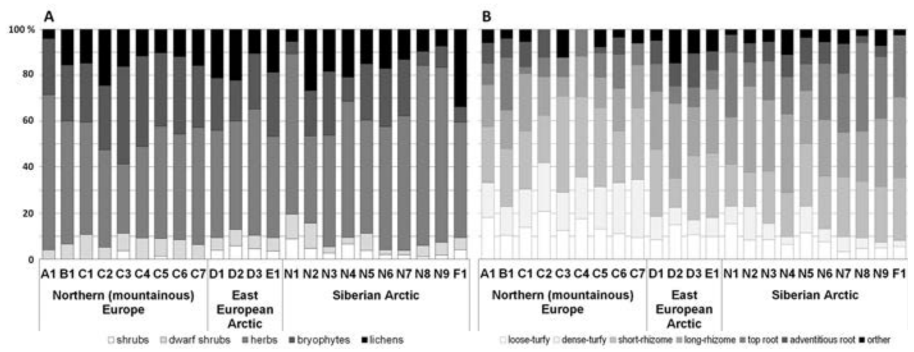

Figure 8 The percentage of species of different life forms in total coenoflora (A) and the same for herbaceous plant fracture (B) in syntaxa coenofloras. For the codes of the syntaxa see Table 6

syntaxa (such as N1) is likely due to challenges in identification. Long- and short-rhizome species (38–56 %) predominate among herbaceous plants in snowbed communities. In North (mountainous) European syntaxa (A1–C7), a high proportion of dense- and loose-turfy plants (about 30 % in total), and in Siberian syntaxa (N1–N9) – species with top and adventitious roots (30–40 % in total). East European syntaxa (D1–E1) are in the middle – about 20 % of dense- and loose- turfy species and the same percentage of species with top and adventitious roots. North European syntaxa are described in mountainous areas, apparently, this explains the large proportion of dense- and loose-turfy herbs in its spectrum.

Prodromus of snowbed vegetation of East European tundra

Class
Order
Alliance
Association
Variant

Salicetea herbaceae Br.-Bl. 1948
Salicetalia herbaceae Br.-Bl. in Br.-Bl. et Jenny 1926
Cassiopo–Salicion herbaceae Nordhagen 1943
Veratro lobeliani–Salicetum herbaceae Koroleva 2006
Veronico alpinae–Salicion polaris Lavrinenko et Lavrinenko **all. nov.**
Salicetum herbaceae-polaris Lavrinenko et Lavrinenko **ass. nov.**
typica
inops
Salici polaris–Sibbaldietum procumbentis Lavrinenko et Lavrinenko **ass. nov.**
Myosotido asiaticae–Salicetum polaris Lavrinenko et Lavrinenko **ass. nov.**
Thlaspietea rotundifolii Br.-Bl. 1948
Arabidetalia caeruleae Rübel ex Nordhagen 1937
Carici parallelae– Salicion reticulatae Lavrinenko, Lavrinenko et Neshataev prov.
Pinguiculo alpinae–Salicetum reticulatae Lavrinenko, Lavrinenko et Neshataev **ass. nov.**

CONCLUSIONS

The bryophyte cover is well developed in the snowbed communities of East European tundra, which is almost always covered with small rounded leaves of strongly squat dwarf willows (*Salix herbacea* and *S. polaris*). Low-growing herbs often have sparse cover and are accompanied with the abundant chionophilous species. In Northern Europe, snowbed communities are common in mountainous areas with long slopes and diverse nival habitats. In plain East European tundra, the slopes of hills and gullies are less long (within ten meters), and communities occupy small patches located at the bottom of north-facing slopes and at their foothills. In contrast, in the East European tundra, the number of species occurring in independent communities and syntaxa is almost twice as large, and includes many species of bryophytes and grasses, many of which belong to the class Salicetea herbaceae. The new alliance Veronico alpinae–Salicion polaris, with three associations, brings together snowbed communities on siliceous substrates. In addition to its own group of characteristic species, the alliance shares species of the North European and Siberian syntaxa and occupies an intermediate position between them in terms of botanical-geographical and ecological-biological characteristics of the coenoflora.

A new association is defined for snowbed communities on stable carbonate substrates. This association consolidates herb-dwarf willow (*Salix reticulata*)–moss communities with a considerable number of hemicalciphytes and placed in the provisional alliance Carici parallelae–Salicion reticulatae in the order Arabidetalia caeruleae, which now belongs to the class Thlaspietea rotundifolii.

Cluster analysis of syntaxa from the Northern (mountainous) Europe, East European, and Siberian sectors of the Arctic revealed that regional variations in species composition "outweigh" differences in habitat ecology. This validates the necessity of combining associations into vicarious alliances considering the ecological conditions at the level of large meridional-latitudinal regions.

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