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Syntaxonomy of the Numto Nature Park vegetation (north taiga, Western Siberia): 1. Vaccinio-Piceetea Br.-Bl. in Br.-Bl et al. 1939

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ABSTRACT

This paper is the first in a series of publications dedicated to the description of vegetation in the Numto Nature Park, which covers an area of 597189.5 hectares and is located in the northern part of the Khanty-Mansi Autonomous Area (63°7'–64°20'N 69°44'–71°45'E). The territory of the park is representative of the entire subzone of the northern taiga in the central part of Western Siberia. The initial stage of the study focused on determining the syntaxonomic diversity of forest vegetation belonging to the class Vaccinio–Piceetea Br.-Bl. in Br.-Bl et al. 1939. Nine associations (5 new ones, incl. 2 provisional), 2 subassociations, 10 variants, and 3 community types were identified and assigned to 4 alliances within 3 orders. A new alliance, Sphagno fimbriati–Pinion sibiricae all. nov., was proposed within the class Vaccinio–Piceetea, covering vegetation of swampy forest and wooded swamps in the valleys of small rivers and streams in the northern and middle taiga of Western Siberia. The plant communities are described on the basis of 180 geobotanical relevés. The t-SNE method, supplemented with cluster analysis, was employed to assess the degree of similarity between individual syntaxa. The article also discusses the issues related to the syntaxonomic affiliation of swampy forest and wooded swamps vegetation.

Keywords: vegetation, zonal forests, Scots pine forests, swamps, Braun-Blanquet classification, northern taiga, Khanty-Mansiysk Autonomous Area – Yugra, Beloyarsky district, Western Siberia

РЕЗЮМЕ

Лапшина Е.Д., Филиппов И.В., Веревкина Е.Л., Ганасевич Г.Н. Синтаксономия растительности природного парка Нумто (северная тайга, Западная Сибирь): 1. Vaccinio–Piceetea Br.-Bl. in Br.-Bl et al. 1939. Настоящая статья открывает серию публикаций, посвященных описанию растительности природного парка Нумто площадью 597189,5 га, расположенного на севере Ханты-Мансийского автономного округа (63°7'–64°20'N 69°44'–71°45'E), территория которого является репрезентативной для всей подзоны северной тайги в центральной части Западной Сибири. На первом этапе установлено синтаксономическое разнообразие лесной растительности, относящейся к классу Vaccinio–Piceetea Br.-Bl. in Br.-Bl et al. 1939. Выделено 9 ассоциаций (из них 5 – новые, включая 2 провизорных), 2 субассоциации, 10 вариантов и 3 типа сообществ, которые отнесены к 4 союзам из 3 порядков. Предложен новый союз Sphagno fimbriati–Pinion sibiricae all. nov. в пределах класса Vaccinio–Piceetea, охватывающий растительность заболоченных лесов и лесных болот долин малых рек и ручьев северной и средней тайги Западной Сибири. Дана характеристика растительных сообществ, основанная на 180 полных геоботанических описаниях. Проведена ординация выделенных синтаксонов методом t-SNE, дополненная кластерным анализом, для оценки степени сходства между отдельными синтаксонами. Обсуждаются вопросы синтаксономической принадлежности растительности заболоченных лесов и лесных болот.

Ключевые слова: растительность, зональные леса, сосновые леса, лесные болота, классификация Браун-Бланке, северная тайга, Ханты-Мансийский автономный округ – Югра, Белоярский район, Западная Сибирь

The Numto Nature Park was established in 1997 with the aim of preserving the natural and historical complex of the Kazym River basin (a right tributary of the Ob River) in its upper course, as well as Numto Lake. The park is home to unique natural, historical, and ethnographic complexes and aims to protect the habitats and economic activities of the indigenous peoples of the North. It covers an area of 597189.5 hectares (Valeeva et al. 2008, Moskovchenko et al. 2017). The park is located in the Belayarsky District of the Khanty-Mansi Autonomous Area – Yugra, practically in the center of the West Siberian Plain. It is a representative territory for studying the typological diversity and vegetation structure of the northern taiga subzone within the forest zone of Western Siberia as a whole.

During the course of long-term research, the flora of the nature park has been fairly well documented, and annotated lists of higher vascular plants, mosses, and lichens have been compiled (Valeeva et al. 2017, Tolpysheva & Shishkonakova 2022). However, the vegetation of the park has been studied to a lesser extent, with a focus on dominant or ecologically-physiognomic approaches for its description. As a result, the findings of these studies typically provide only generalized information in the form of vegetation sketches (Il'ina et al. 1985, Shalatonov & Moskovchenko 2007, Shalatonov 2004, 2009, Valeeva et al. 2008, 2017). Detailed characteristics of plant communities, including floristic species lists indicating their abundance and frequency of occurrence, are lacking in these works which is a serious hindrance to effective use of the research for organizing monitoring of biota responses to environmental changes and developing specific nature conservation measures.

In this regard, the floristic approach of the Braun-Blanquet school appears to be more promising, as it is successfully utilized for vegetation inventory in all European countries, ensuring a unified approach to describing community composition, classification, and presenting results.

In this paper, we attempt to assess the actual phytocenotic diversity of vegetation communities in the northern taiga of Western Siberia, on the example of the Numto Nature Park, and present it within the framework of a floristic classification system.

The objective of this paper is to identify the phytocenotic diversity of forests, swampy forest and wooded swamps with well-developed tree layers in the territory of the Numto Nature Park, which belong to the class Vaccinio–Piceetea Br.-Bl. in Br.-Bl et al. 1939, and to develop a floristic classification, providing detailed characteristics of the identified syntaxa (plant community units).

MATERIAL AND METHODS

Study area

The Numto Nature Park is located in the northwest part of the Khanty-Mansi Autonomous Area (63°7'–64°20'N 69°44'–71°45'E) on the northern slope of the Siberian Uvaly, a low ridge of morainic hills that stretches across the entire West Siberian Plain. The park is bordered by the territory of the Yamal-Nenets Autonomous Area (Priuralsky and Nadym Districts) to the north and east (Fig. 1).

The territory is formed by Quaternary deposits, predominantly alluvial and fluvioglacial in origin, including sands, loams, and clays. Among them, sandy deposits significantly prevail in terms of area. In the southern part of the park, with undulating relief, the elevations reach 150 m above sea level. This is where the largest tributaries of the Ob River originate and diverge in different directions: the Kazym, Nadym, Pim, and Trom-Egan rivers. The central and northern parts of the park are predominantly occupied by flat and gently convex boggy plains with elevations ranging from 95 to 110 m above sea level. These plains are characterized by extensive peatlands with numerous lakes, separated by narrow river valleys.

According to the majority of botanical-geographical regionalization schemes, the nature park is located in the northern taiga subzone of the West Siberian Plain (Il'ina et al. 1985).

A characteristic feature of the park's landscape structure is the prevalence of peat bogs, which cover 63 % of the territory. Zonal birch-coniferous (*Betula pubescens*, *Pinus sibirica*, *Picea obovata* with *Larix sibirica*) dwarf shrub-green moss forests on loamy soils, as well as lichens and dwarf shrub-green moss-lichen pine forests on sandy soils, occupy a considerably smaller area (23.3 %). The aquatic areas of large lakes, rivers, and backwaters, excluding numerous small intra-bog ponds, account for 13.7 % of the area (Moskovchenko et al. 2017).

Sampling and data analysis

Fieldwork was conducted in the southern and central parts of the Numto Nature Park in July-August of 2006, 2017, and 2022. In addition, relevés made in 2019 on the adjacent territory of the Nadym District of the Yamal-Nenets Autonomous Area, which has a similar landscape structure and natural conditions to the northern part of the park, were used for vegetation classification purposes.

The routes and selection of study sites for detailed fieldwork were chosen based on the analysis of Sentinel-2 satellite images, taking into account the overall landscape structure of the territory. Relevés were carried out on well-defined vegetation patches on the plots 100 m^2 (10 × 10 m). We re-

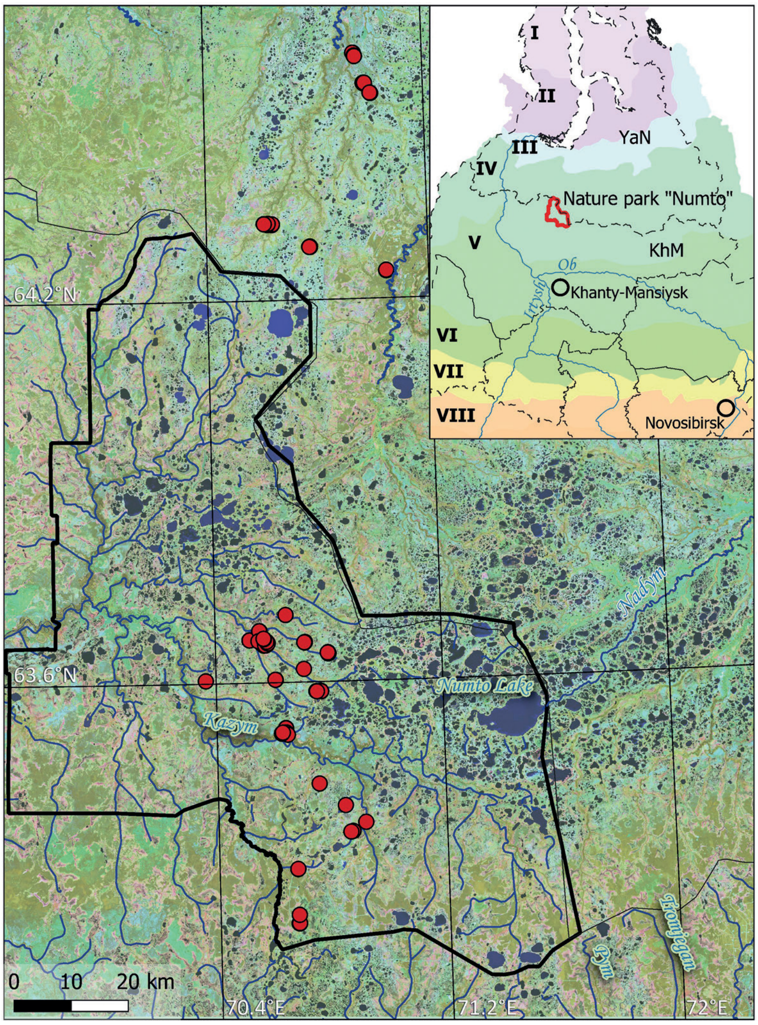

Figure 1 Study area. Sites of relevés (red circles). Zones and subzones: I – typical tundra, II – southern tundra, III – forest-tundra, IV – northern taiga, V – middle taiga, VI – southern taiga, VII – subtaiga (birch-asp small leaved zone), VIII – forest-steppe. Administrative regions: YaN – Yamal-Nenets Autonomous Area, KhM – Khanty-Mansi Autonomous Area

corded the complete species composition (vascular plants, mosses, lichens, liverworts) and estimated visually the percentage cover (%) for the major plant growth forms, as well as cover-abundance scores for each species. Samples were collected of those bryophytes species for which identification in the field was difficult.

A total of 180 vegetation relevés of forests, swampy forest, and wooded swamps, with well-developed tree layer were conducted during the field research. An Integrated Botanical Information System, IBIS 7.2 (Zverev et al. 2007), was used to process the geobotanical relevés and develop the vegetation classification. In this system, preliminary sorting of relevés and identification of floristically homogeneous groups were performed for subsequent syntaxonomical analysis.

Species abundance in phytocenotic tables is presented in projected cover scores (Mirkin & Naumova 1998): r – solitary, + – less than 1 %, 1 – 1–5 %, 2a – 6–13 %, 2b – 14–25 %, 3 – 26–50 %, 4 – 51–75 %, 5 – 76–100 %. Species constancy in the tables is giving using following percentage scale (%): R – 0–10, I – 11–20, II – 21–40, III – 41–60, IV – 61–80, V – 81–100. The median abundance values were used for each species to characterise syntaxa.

The vegetation classification was conducted according to the principles of the Braun-Blanquet school (Westhoff & Maarel 1978). Descriptions of new syntaxa were carried out following the requirements of the International Code of Phytosociological Nomenclature (Theurillat et al. 2021). The concept of diagnostic species was used for syntaxa delimitation, including selective species (occurring in some syntaxa but with highest constancy in one) and preferential species (equally constant in some syntaxa but more abundant in one). Diagnostic species groups of associations and subassociations represent differential species combinations, where these species are characteristic of the syntaxon if occur together, although individually, each species may not be differentiating (diagnostic) (Matveyeva 2006, Lavrinenko & Lavrinenko 2015, Lavrinenko et al. 2016).

For statistical analysis, the t-SNE method (t-Distributed Stochastic Neighbor Embedding) was used, which allows for the visual representation of high-dimensional feature spaces as compact clusters on a two-dimensional plane (van der Maaten & Hinton 2008). Hierarchical clustering was also employed to determine the degree of similarity between identified phytocoenons and to visualize their structure as a dendrogram.

Nomenclature of the species followed Sekretareva (2004) for vascular plants, Ignatov et al. (2006) for mosses and Konstantinova et al. (2009) for liverworts.

RESULTS

The Numto Nature Park is located entirely in the southern part of the subzone of the northern taiga of Western Siberia. Despite the fact that the West Siberian Plain is a classical area of development for dark coniferous taiga, the park's territory does not have extensive coverage of dark coniferous forests. The dominant tree species in the park is *Pinus sylvestris*, which accounts for approximately 60 % of the forested area. The main forested areas are found in the well-drained southern part of the park, located on the northern slopes of the Siberian Uvaly and in the Kazym River valley. Various types of swampy forest and wooded swamps on peat soils are developed in the valleys of small rivers and streams.

All the diversity of the drained upland forests, swampy forests, and wooded swamps with well-developed tree layers in the Numto Nature Park belong to the class Vaccinio–Piceetea.

Vaccinio–Piceetea Br.-Bl. in Br.-Bl et al. 1939 – coniferous and coniferous-small-leaved deciduous boreal forests of Eurasia

Diagnostic species of the class in Western Siberia include *Picea obovata*, *Pinus sibirica*, *Vaccinium vitis-idaea*, *V. myrtillus*, *Linnaea borealis*, *Goodyera repens*, *Trientalis europaea*, *Orthilia secunda*, *Gymnocarpium dryopteris*, *Hylocomium splendens*, *Pleurozium schreberi*, *Dicranum polysetum*, *Ptilium crista-castrensis*, *Peltigera aphtosa*, and *P. canina*.

Within the territory of the nature park, the vegetation of the class is represented by three orders: Pinetalia sylvestris Oberd. 1957, Ledo palustris–Laricetalia cajanderi Ermakov in Ermakov et Alsynbaev 2004, and Piceo obovatae–Pinetalia sibiricae Ernakov 2013. These orders include the northern taiga forests and wooded swamps consisting of dark coniferous, pine, and mixed forests with the participation of larch and birch.

Moss-lichen pine forests on sandy soils

The order **Pinetalia sylvestris** includes boreal pine forests on sandy and loamy sand soils of oligotrophic moderately dry habitats in Northern Eurasia. Within this order, the northern taiga pine forests of Western Siberia, as well as oligotrophic pine forests of Northern Europe, belong to the alliance Cladonio stellaris–Pinion sylvestris K.-Lund ex Ermakov & Morozova 2011 (Ermakov & Morozova 2011).

The alliance **Cladonio stellaris–Pinion sylvestris** represents pine forests with a dominant presence of ericaceous shrubs and lichens in the forest floor (Makhatkov & Ermakov 2010, Ermakov & Makhatkov 2011).

Diagnostic species of the order and alliance in Western Siberia include *Cladonia stellaris* (dominant), *C. arbuscula* s. l., *C. deformis*, *C. coccifera*, *C. cornuta*, *C. rangiferina*, *C. uncialis*, *Cetraria islandica*, and *Empetrum hermaphroditum*.

Unlike the lichen pine forests in the southern part of Western Siberia, an important diagnostic feature for communities belonging to the alliance Cladonio stellaris–Pinion sylvestris is the absence of southern boreal and meadow-steppe species of moderately thermophilic flora (Makhatkov & Ermakov 2010).

In the territory of the Numto Nature Park, the alliance is represented by two previously described associations.

Cladonio arbusculae–Pinetum sylvestris Kielland-Lund ex Ermakov & Morozova 2011 (Table 1, 1–21; Table 5, 1–3; Fig. 3, 4, syntaxa 1a, b, c).

The association represents lichen and cranberry-lichen pine forests on dry, poor sandy soils in the northern boreal zone of Eurasia (Fig. 2A).

Diagnostic species: The association is characterized by the same differential species as the alliance.

Structure and composition. The tree layer is formed by *Pinus sylvestris*. Tree density ranges from 0.2 to 0.6. The average height of trees is 10–12 m. The shrub layer is absent or represented by patches of large dwarf shrubs such as *Ledum palustre*, with occasional groups of young pine trees. The lower shrub layer covers 5–60 % and is composed of *Vaccinium vitis-idaea*, often with a small presence of *Empetrum hermaphroditum*. Herbaceous plants are almost absent. The cover of the moss-lichen ground layer reaches 90–100 %, mainly due to the presence of shrubby lichens such as *Cladonia stellaris* and *C. rangiferina*. There is a constant presence of *C. arbuscula*, *C. deformis*, *C. cornuta*, *C. uncialis*, *C. gracilis*, and *Cetraria islandica*. Green mosses, although in small abundance, persistently occur and include *Pleurozium schreberi*, *Dicranum polysetum*, *Polytrichum piliferum*, and *Pohlia nutans*.

Based on the species composition and the degree of lichen development in the forest floor, three variants can be distinguished: typica, Vaccinium myrtillus, and Cladonia cornuta.

The variant **typica** (Table 1, rel. 1–8) includes the old-growth, long-unburned pine forests (over 50 years old). They are characterized by the lowest species diversity (12–20 species per relevé site) and a dense cover of shrubby lichens, with *Cladonia stellaris* dominating and a presence of *C. arbuscula* and *C. rangiferina*. Other lichen species are scarce and inconspicuous.

The variant **Vaccinium myrtillus** (Table 1, rel. 9–16) includes communities that have been affected by low-intensity fires 40–50 years ago. They appear similar (physiognomically) to long-unburned forests, with the main difference being a more pronounced patchy dwarf shrub layer consisting of *Ledum palustre*, *Vaccinium myrtillus*, *V. vitis-idaea*, and a constant presence of tube-forming lichen species such as *Cladonia coccifera*, *C. cornuta*, *C. crispata*, *C. deformis*, *C. gracilis*, and *C. uncialis*, with a dominance of *Cladonia stellaris*.

The variant **Cladonia cornuta** (Table 1, rel. 17–21) corresponds to earlier stages (15–25 years) of post-fire regeneration. The ground cover of such forests is absolutely dominated by tube-forming lichen species, with *Cladonia cornuta*, *C. crispata*, and *C. gracilis* being the most abundant.

Distribution and ecology. The communities of this association are widely distributed within the northern taiga of Western Siberia, where they occur on dry sandy and sandy-loamy poor soils of alluvial and fluvioglacial deposits, on watersheds, and high terraces of river valleys.

Pinetum sibiricae–sylvestris Makhatkov et Ermakov 2010

The association includes the north-taiga pine shrub-lichens and shrub-green-moss-lichens forests of Western Siberia. These forests are found on dry sandy and layered sandy-loamy moderately moist soils, which experience significant summer heat penetration to considerable depths (Makhatkov & Ermakov 2010, Ermakov & Morozova 2011).

Diagnostic species: *Pinus sibirica*, *Empetrum hermaphroditum*, and *Cladonia arbuscula* s. l.

In the Numto Nature Park, this association is represented only by the subassociation ledetosum palustre.

Pinetum sibiricae–sylvestris ledetosum palustre Makhatkov et Ermakov 2010 (Table 1, 22–36; Table 5, 4–5; Figs 3, 4 syntaxa 2a, b).

The subassociation combines dwarf shrub-green-moss-lichen forests (*Ledum palustre*, *Vaccinium vitis-idaea*) and dwarf shrub-lichen-green-moss forests (Fig. 2B).

Structure and composition. The sparse (30–60 %) tree layer, reaching a height of 10–12 m, is dominated by *Pinus sylvestris* with a constant mix of *P. sibirica*, and a minor presence of *Betula pubescens*. In the dwarf shrub layer, *Ledum palustre* predominates (30–60 %) along with *Vaccinium vitis-idaea* and *V. myrtillus*, which form the lower sublayer. Among herbaceous plants, *Carex globularis* is scattered. In the ground cover, *Cladonia stellaris* and *C. rangiferina* dominate, with a mix of *C. arbuscula* s. l. The green moss *Pleurozium schreberi*, with a mix of *Dicranum polysetum*, dominates or is present in significant abundance alongside the shrub lichens (Fig. 2B).

Based on the ratio of mosses and shrub lichens in the ground cover, two variants are distinguished.

The variant **typica** (Table 1, rel. 22–31) fully corresponds to the association's diagnosis.

The variant **Pleurozium schreberi** (Table 1, rel. 32–36) is characterized by the predominance of green mosses, with cover reaching 60–90 %.

Distribution and ecology. The communities of this subassociation occur on more moist and colder sandy-loamy soils compared to the typical subassociation.

Dark coniferous and mixed (birch-coniferous) dwarf shrub-green-moss forests on clayey soils

The dark coniferous and mixed (birch-coniferous) dwarf shrub-green-moss forests of drained habitats (upland forests) on clayey soils, described in the territory of the Numto Nature Park, are classified into two orders: Ledo palustris–Laricetalia cajanderi Ermakov & Alsynbaev 2004 and Piceo obovatae–Pinetalia sibiricae Ermnakov 2013.

Table 1. Releves and syntaxa of the alliance Cladonio stellaris-Pinion sylesrtris. Pine forest communities on dry sandy soils.

1–21 – ass. Cladonio arbusculae–Pinetum sylvestris (1): 1–8 – var. typica (1a), 9–16 – var. Vaccinium myrtillus(1b), 17–21 – var. Cladonia crispata; 22–36 – ass. Pinetum sibiricae–sylvestris subass. ledetosum palustris (2), 22–31 – var. typica (2a). var. Pleurozium schreberi (2b). Abbreviations: a – tree layer, a3 – undergrowth of trees.

Association	Cladonio arbusculae–Pinetum sylvestris (1)																				
Variant	typica (1a)								Vaccinium myrtillus (1b)								Cladonia cornuta (1c)				
Plant cover, %																					
Trees	20	40	40	55	30	50	30	40	10	35	30	40	15	35	30	45	55	50	30	40	30
Shrubs	10	5	0	0	0	0	0	40	25	0	0	0	5	40	10	0	0	1	0	0	0
Dwarf shrubs	20	15	15	50	16	20	20	30	12	35	10	5	10	15	15	65	45	45	25	20	25
Lichen and mosses	100	100	100	100	100	100	100	100	100	100	95	100	100	95	100	100	100	100	100	90	90
Number of species	12	13	18	16	15	15	19	22	23	25	20	18	27	26	27	25	16	22	25	20	19
Date	17.07.2019	17.07.2019	17.07.2019	17.07.2019	17.07.2019	17.07.2019	17.07.2019	20.10.2022	18.08.2022	17.08.2017	17.08.2017	17.08.2017	18.08.2022	18.08.2022	18.08.2022	17.08.2017	17.07.2019	17.07.2019	17.07.2019	17.07.2019	17.07.2019
Relevé nr. by author	029F19pz	140E19pz	030G19pz	136E19pz	137E19pz	028G19pz	026F19pz	019V22nu	088G22nu	353E17nu	045F17nu	046a17nu	079F22nu	064V22nu	102E22nu	358E17nu	029G19pz	138E19pz	139E19pz	027F19pz	028F19pz
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

Association	Pinetum sibiricae–sylvestris (2)															Constancy and abundance						
Variant	typica (2a)										Pleurozium schreberi (2b)											
Plant cover, %																						
Trees	45	60	30	45	40	60	50	50	40	30	30	60	65	70	25							
Shrubs	3	25	30	50	60	70	30	60	50	50	45	40	10	35	40							
Dwarf shrubs	35	70	60	25	20	35	15	30	30	35	3	40	85	20	25							
Lichen and mosses	100	50	100	100	100	100	100	100	100	95	100	100	90	100	100							
Number of species	16	14	25	20	21	16	20	21	21	23	13	17	17	30	27							
Date	14.08.2022	14.08.2022	13.08.2022	14.08.2022	14.08.2022	20.08.2017	14.08.2022	13.08.2022	13.08.2022	13.08.2022	20.08.2017	14.08.2022	14.08.2022	18.08.2011	18.08.2011							
Relevé nr. by author	032F22nu	020V22nu	019E22nu	041E22nu	031G22nu	409E17nu	031F22nu	017G22nu	017F22nu	005V22nu	087F17nu	032G22nu	042E22nu	006E11oz	007E11oz							
Relevé nr. in the table	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	**1a**	**1b**	**1c**	**1**	**2a**	**2b**	**2**

Table 1. 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	29	30	31	32	33	34	35	36	1a	1b	1c	1	2a	2b	2
Species of tree layer																																											
Pinus sylvestris	2b	3	3	4	3	3	2b	2b	2a	3	3	2b	2b	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	1	V^{3}	V^{3}	V^{3}	V^{3}	V^{3}	V^{3}	V^{3}
Pinus sibirica **P. s.-s.**								1		r					+	1						2b	2b	1		1	2b	1	2b	2a	+	+	2b	1		2b	I	II		I	V^{2a}	V^{1}	V^{1}
Betula pubescens				r		1	1	1						+						+		1		+	1	1		1	+	1		1			1	+	III	I	II	II	IV^{+}	IV^{+}	IV^{+}
Larix sibirica	+				+		+													+	r																II		III	II			
Picea obovata				r			r																						+								II			I	I		I
Undergrowth																																											
Pinus sylvestris			1					+	2a	r		2b	+	+	+	1	1	1	+			+	+	+	1	2a	1	+		+	+		1				II	V^{+}	IV^{+}	III^{+}	V^{+}	II	IV^{+}
Pinus sibirica **P. s.-s.**								+		r	r	r		+	+	r						+	+		+	1		r					1	+	+		I	IV^{r}		II	III	IV^{+}	III^{r}
Betula pubescens	+				+	1	+						+							+	+			+	+	1	r		1	+	+		1	+			III^{r}	I	III	II	IV^{+}	III	IV^{+}
Diagnostic species of the Cladonio arbusculae–Pinetum sylvestris																																											
Cladonia sulphurina			+			+	+		1				+	+	+		1	1	2a		r			+							+				+		II	III^{r}	V^{1}	III^{r}	II	II	II
Flavocetraria nivalis		+		+	+		+	+	1	1	r		+	+		r			+																		IV^{+}	IV^{+}	II	III^{r}			
Diagnostic species of the variant Cladonia cornuta																																											
Cladonia cornuta			+	+				+	+	r	r	r	+	+	1	r	1	3	3	2b	2b			r	+	1			1	+	+					r	II	V^{+}	V^{2b}	IV^{+}	IV^{+}	II	III
Cladonia crispata									1	r	r			+	1	r	3	3	2b	2a	2b			r					+		1				r			IV^{r}	V^{2b}	III^{r}	II	II	II
Cladonia gracilis						+				+	r	r	+	+	1	r	3	2b	2b	1																	I	V^{+}	V^{2b}	III^{r}			
Cladonia deformis				+		+				r	r	r	+			r		+	+	1	+			r					+	+	r				r		II	IV^{r}	V^{+}	III^{r}	III	II	II
Cladonia uncialis				+	+	+				1	+	r	r	+	r	r		+	+																		II	V^{r}	III	III^{r}			
Cladonia coccifera									1	+	r		+		+		+	+		+																		IV^{+}	IV^{+}	II			
Polytrichum juniperinum								+		r						r	r		+	+	r									+							I	II	V^{r}	II	I		I
Cladonia cariosa																		+	+	+	r																		V^{+}	I			
Dagnostic species of the Cladonio stellaris-Pinion sylesrtris																																											
Cladonia stellaris	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**4**	**4**	**5**	**5**	**5**	**4**	**4**	**5**	1	1	+	2b	2b	**3**	**3**	**4**	**4**	**3**	**4**	**4**	**3**	**2b**	**2b**	2b	2a	1	1	+	V^{5}	V^{5}	V^{1}	V^{5}	V^{3}	V^{1}	V^{3}
Cladonia rangiferina	2a	1	2b	2a	1	2a	1	2b	2a	2b	r	r	1	2a	2b	1		1	1	1		2a	1	2a	2b	2b	2b	2b	2b	2b	3		2a	2a	+	1	V^{2a}	V^{2a}	IV^{1}	V^{1}	V^{2b}	V^{1}	V^{2a}
Cladonia arbuscula s. l.			+	+	1	2a	+	1		2b	1	+	+	+	+	+	+	1	1	+	r	+	+	2b	2a	2a			1	1	+		1			+	IV^{+}	V^{+}	V^{+}	V^{+}	V^{+}	III	IV^{+}
Empetrum hermaphroditum	+			1	+		+	1	1	+		+	+		+	r	+	+		+	r	+		+	1	1		1	1	+	1	r	1	+	+		IV^{+}	IV^{r}	V^{+}	IV^{+}	V^{+}	V^{r}	V^{+}
Cetraria islandica		+	+	+	+		+		1	+		r	1		+	1					r	+	+	+					1	+	1	r		+			IV^{+}	IV^{+}	II	III^{r}	IV^{+}	III	III^{r}
Dagnostic species of the Vaccinio-Piceetea																																											
Vaccinium vitis-idaea	2b	2b	2b	3	2b	2b	2b	2b	+	3	2a	1	1	2a	2b	4	3	3	2b	2b	2b	3	4	3	2b	2a	3	1	2a	2b	3	2b	3	5	2b	2b	V^{2b}	V^{2a}	V^{2b}	V^{2b}	V^{3}	V^{2b}	V^{2b}
Pleurozium schreberi	1	+	+	2a	+	+	1	1	+	r	r		+	+	+	1	+	1	+	3	3	3	2b	2b	2b	2b	2b	3	3	3	2b	**4**	**4**	**5**	**5**	**5**	V^{+}	V^{+}	V^{1}	V^{+}	V^{2b}	V^{5}	V^{3}
Ledum palustre **P. s.-s.**	2a	1						1	2b				1	3	2a	1		+				1	2b	3	3	3	4	3	1	3	3	2b	3	2a	3	3	II	IV^{1}	II	III	V^{3}	V^{3}	V^{3}
Vaccinium myrtillus			+			1		1	1	r	r	+	1	1	1	r								2b	1	1	2a	1	2b	1	2a	+	+	1	1	2a	II	V^{+}		III^{r}	V^{1}	V^{1}	V^{1}
Dicranum polysetum		+	+		+			+		r		r		+	1	r	+	+	+	+	+	+	+	+	1	1	+	+	1	+	+	r	1	+	1	1	III^{r}	IV^{r}	V^{+}	IV^{r}	V^{+}	V^{1}	V^{+}
Dicranum fuscescens			r								r		+		+					+	+	+	+				+				+			+			I	II	III	II	III	II	II
Other species:																																											
Pohlia nutans	+	+	+		+					+	+	+		+	+	r	+	+	+	+			+		+	+	r			r				+			III	IV^{r}	V^{r}	IV^{r}	III	II	III
Ptilidium pulcherrimum			r		r		r	+																	+	+				+	+		+	+	+	r	III			I	III	V^{r}	III^{r}
Cladonia stygia													+	+	+	+					1			+	+			+				1			+	2a		III	II	II	II	IV^{+}	III
Vaccinium uliginosum								1	1				+		+									+		2b		+	2a		1						I	II		I	III^{r}		II
Dicranum undulatum	+		+													+					+				+			+		+		+	+				II	I	II	I	II	III	II
Carex globularis									+				+											r		1			1						r	r		II		I	II	III	II
Ptilidium ciliare													+	+	+													+					+			+		II		I	I	III	II
Dicranum flexicaule		+	+					+						+					r								+										II	I	II	II	I		I
Polytrichum strictum								+	+					+										+			+										I	II		I	II		I
Dicranum elongatum							+		+					+													+		1								I	II		I	II		I
Cladonia cenotea									1				+		+			+	+																			II	III	II			
Cladonia amaurocraea		+								+				+					+					r													I	II	II	I	I		I
Polytrichum piliferum										+	+	+				+																						III		I			
Flavocetraria cucullata		+		+		+								+																							II	I		I			
Cetraria laevigata	+						+			+																											II	I		I			
Betula nana									1				+		+																							II		I			
Sphagnum capillifolium																												+			1					+					II	II	II
Peltigera sp.																												+							+	+					I	III	II

Figure 2 Photos of described forest and wooded swamp communities in the Numto Nature Park. A – pine-lichen forest ass. Cladonio arbusculae–Pinetum sylvestris subass. typicum on sandy soils; B – pine-dwarf shrub (*Ledum palustre*, *Vaccinium vitis-idaea*)-green moss-lichen forest ass. Pinetum sibiricae–sylvestris subass. ledetosum palustre; C – birch-larch-fir (*Betula pubescens*, *Larix sibirica*, *Picea oboata*)-dwarf shrub-green moss forest ass. Vaccinio uliginosi–Piceetum obovatae; D – birch-dark coniferous-reed grass (*Calamagrostis purpurea*)-herb swamp (sogra) ass. Pseudobryo cinclidioidis–Pinetum sibiricae var. inops; E – birch-dark coniferous-reed grass (*Calamagrostis purpurea*)-herb swamp (sogra) ass. Pseudobryo cinclidioidis–Pinetum sibiricae var. Sphagnum girgensohnii; F – birch-*Pinus sibirica*-*Menyanthes trifoliata*-*Sphagnum* swamp (sogra) ass. Oxycocco palustris–Pinetum sibiricae; G – birch-reed grass (*Calamagrostis purpurea*)-*Sphagnum* low woodlands ass. Sphagno fimbriati–Betuletum pubescentis; H – sedge-birch community type *Carex aquatilis*-*Betula pubescens*

The **Ledo palustris–Laricetalia cajanderi** comprises deciduous light coniferous and coniferous mixed forests that develop in the cold and continental climate of the boreal zone of Northern Eurasia (Ermakov & Makhatkov 2011).

The alliance **Pino sibiricae–Laricion sibiricae**, described by Ermakov et Alsynbayev in 2004, represents an order found in the northern forest zone of Western Siberia. This alliance includes low-diversity mixed and coniferous dwarf shrub-lichen forests, with co-dominance of *Larix sibirica*, *Picea obovata*, *Pinus sylvestris*, *P. sibirica*, and *Betula pubescens*. Ground cover lichens are present with high constancy but in smaller abundance compared to bryophytes.

Diagnostic species for the order and alliance include *Larix sibirica*, *Empetrum hermaphroditum*, *Ledum palustre*, *Vaccinium uliginosum*, *Carex globularis*, and *Sphagnum girgensohnii*.

Despite the significant presence of shade-tolerant tree species in the canopy layer, these forests differ from typical southern and middle taiga dark coniferous forests of the alliance Piceo obovatae–Pinetalia sibiricae. Common species found further south, such as *Abies sibirica*, *Calamagrostis obtusata*, *Gymnocarpium dryopteris*, *Maianthemum bifolium*, *Orthilia secunda*, *Rosa acicularis*, *Sorbus sibirica*, *Stellaria bungeana*, and *Trientalis europaea*, are absent in these forests. Within the alliance, two associations have been identified.

Vaccinio uliginosi–Piceetum obovatae ass. nov. (Table 2, rel. 1–14, Table 5, 6; Fig. 2C, Fig. 3, 4, syntaxon 3).

Holotypus: relevé 2 (author's number – 250E19pz), Yamal-Nenets Autonomous Area, Nadym District, upper reach of Kheygiyakha River in 30 km from Priozernyi settlement, 23.07.2019, author E.D. Lapshina.

Diagnostic species: *Larix sibirica*, *Picea obovata*, *Betula nana*, *Pedicularis labradorica* и виды союза *Carex globularis*, *Empetrum hermaphroditum*, *Ledum palustre*, *Vaccinium uliginosum*.

The association comprises birch-fir-larch and larch-fir dwarf shrub-lichen forests on well-drained and moderately drained clayey soils in the northern taiga subzone of Western Siberia (Fig. 2C).

Structure and composition. The tree layer consists of three tree species: *Larix sibirica*, *Picea obovata*, and *Betula pubescens*, with a crown cover of 30–60 %. The sparse upper layer (5–20 %) is composed of larch and fir trees in varying proportions, 18–20 m high. The denser lower layer (30–45 %) is composed of fir and birch trees, reaching a height of 10–12 m, with some larch mixed in. The understory is sparse, ranging from 0.5 to 3 m in height, consisting of birch and fir with a minor presence of *Pinus sibirica*. In the dense dwarf shrub layer, *Vaccinium vitis-idaea* dominates (25–80 %) along with *Ledum palustre* (1–30 %), and a small presence of *Empetrum hermaphroditum* and *Vaccinium myrtillus*. Herbaceous plants are rare and low in abundance. The ground cover is predominantly occupied by *Pleurozium schreberi* with some *Hylocomium splendens*. Among the mosses, *Cladonia stellaris*, *C. rangiferina*, and *Peltigera* spp. lichens are present with high constancy but in small abundance.

Ecology and distribution. These forests develop on moderately drained sandy-loamy clay soils in watershed areas and river terraces within the northern taiga subzone and forest-tundra of Western Siberia. They are relatively widespread in the northern part of the nature park and are described near its northeastern boundaries.

Ledo palustris–Pinetum sibiricae Ermakov et Makhatkov 2011 (Table 2, rel. 14–34; Table 5, 7–8; Fig. 3, 4, syntaxa 4a, b).

The association comprises typical zonal mixed birch-fir-*Pinus sibirica* (with larch and Scots pine in the tree layer) dwarf shrub-green moss forests in the northern taiga and forest-tundra of Western Siberia.

Diagnostic species: Due to the extremely poor species composition, the communities of this association do not have their own differential species and are characterized by diagnostic species of the class and order.

Structure and composition. In the tree layer, ranging from 16 to 20 meters in height, *Pinus sibirica*, *P. sylvestris*, *Picea obovata*, *Larix sibirica*, and *Betula pubescens* co-dominate in varying proportions. The shrub layer is weakly developed or absent. The herbaceous-dwarf shrub layer is dense, covering 25–80 %, and is dominated by *Vaccinium vitis-idaea* and *V. myrtillus*. The upper sublayer often includes *Ledum palustre* (up to 25 %). In smaller quantities but with high consistency, *Empetrum hermaphroditum*, *Linnaea borealis*, and occasionally *Diphasiastrum complanatum* and *Melampyrum pratense* are present. The continuous moss cover is predominantly composed of *Hylocomium splendens* and *Pleurozium schreberi*, with a minor presence of *Dicranum polysetum*, *Ptilium crista-castrensis*, *Polytrichum commune*, and the lichen *Peltigera aphthosa*. *Dicranum fuscescens*, *Ptilidium pulcherrimum*, and *Pohlia nutans* are common on the tree bases and stumps.

Within this association, at the current stage of study, two variants, corresponding to different post-fire recovery stages, can be distinguished.

The variant **typica** corresponds to typical zonal old-growth forests. They are characterized by the dominance of dark coniferous species, *Pinus sibirica* and *Picea obovata*, in the tree layer, as well as a weak development or complete absence of lichens.

The variant **Pinus sylvestris** represents prolonged successional stages of post-fire recovery in zonal northern taiga forests. They are characterized by a noticeable decrease in the role of dark coniferous species and an increase of *Pinus sylvestris*, which is more resistant to ground fires. In sparser and better warmed forests on sandy soils, the ratio of lichens slightly increases. Otherwise, the species composition and structure of the lower layers are similar to undisturbed variants.

Distribution and ecology. The communities of this association are most common in the subzone of the northern taiga in Western Siberia. They occupy moderately drained habitats on watersheds and in river terraces, where they develop on moderately moist clayey and layered sandy-clayey soils.

Notes. The communities described by us in the Numto Nature Park show some resemblance to the communities of the ass. Melampyro pratense–Laricetum sibiricae Ermakov & Makhatkov 2011. They occupy similar types of habitats in terms of ecological conditions. Sporadically and in low abundance, the diagnostic species of this association, such as *Calamagrostis lapponica*, *Diphaziastrum complanatum*, and *Melampyrum pratense*, are present in their composition.

The order **Piceo obovatae–Pinetalia sibiricae** comprises the dark coniferous forests of the majority of the taiga zone in Western Siberia, the Urals, and partially the northeast of the European part of Russia (Ermakov & Makhatkov 2011, Ermakov & Martynenko 2022).

Diagnostic species of the order include *Abies sibirica*, *Picea obovata*, *Pinus sibirica*, *Sorbus sibirica*, *Atragene sibirica*, *Calamagrostis obtusata*, and *Stellaria bungeana*.

Within the order, four alliances are distinguished, one of which is represented in the Numto Natural Park – the alliance Pino sibiricae–Abietion sibiricae.

The **Pino sibiricae–Abietion sibiricae** comprises dark coniferous dwarf shrub-herbaceous taiga forests that develop in zonal habitats on watersheds and river terrases of the southern and middle taiga of Western Siberia (Ermakov & Lapshina 2013, Ermakov & Martynenko 2022).

Diagnostic species: *Carex globularis*, *Ledum palustre*, *Melampyrum pratense*, *Polytrichum commune*, *Rubus arcticus*, *Sphagnum wulfianum*, in combination with species of its own order and subclass of dark coniferous forests *Gymnocarpium dryopteris*, *Maianthemum bifolium*, *Oxalis acetosella*.

In the northern part of the forest zone of Western Siberia, the dark coniferous forests of this alliance are located at the northern border of their distribution, penetrating here along the river valleys that are characterized by more favorable microclimatic conditions.

These forests are characterized by a poor floristic composition with the dominance of a small number of widely distributed boreal dwarf shrub and green moss species, and the absence of several characteristic species of taiga herbs and ferns.

The forests described in the Kazym River valley (a right tributary of the Ob River) in the southern part of the nature park are attributed to this alliance.

Pino sibiricae–Abietetum sibiricae Ermakov & Makhatkov 2011 (Table 2, rel. 35–40; Table 5, 9; Fig. 3, 4, syntaxon 5).

The association was first described in the upper basin of the Taz River in the northeastern part of the taiga zone of Western Siberia (Ermakov & Makhatkov 2011). It includes dark coniferous and mixed (*Picea obovata*, *Pinus sibirica*, *Abies sibirica*, *Larix sibirica*, *Betula* spp.) dwarf shrub-green moss forests of the taiga zone of Western Siberia.

In the southern part of the Numto Nature Park, the association is represented by the distinct impoverished variant inops, whose rank may be elevated to the level of a separate subassociation as more data accumulates.

Variant **inops** (Table 2, rel. 35–40; Table 5, 9; Fig. 3, 4, syntaxon 5).

Structure and composition. In the tree layer, which reaches a height of 20–25 m, dark coniferous species such as *Pinus sibirica*, *Picea obovata* dominate, along with varying amounts of *Betula pubescens* and *Larix sibirica*. The shrub layer is relatively well-developed and consists mainly of *Sorbus sibirica* (5–20 %), although it diminishes along the highest riverbanks. The favorable hydrothermal conditions in the river valleys contribute to a higher species diversity, with an increase in the representation of taiga herbaceous species such as *Maianthemum bifolium*, *Orthilia secunda*, *Goodyera repens*, *Trientalis europaea*, *Rubus arcticus*, as well as an increase in the number of moss species. *Dicranum fragilifolium*, *Sanionia uncinata*, *Tetraphis pellucida*, *Plagiothecium laetum*, *Lophoziopsis longidens*, *Lophozia silvicola*, and *Lepidozia reptans* are primarily associated with the valley forests within the territory of the natural park.

Distribution and ecology. These communities occur in the valleys of relatively large rivers. In the territory of the Numto Nature Park, they are described in the valley of the Kazym River. Valley dark coniferous forests exhibit higher site quality and productivity (Valeeva et al. 2008) compared to forests on watersheds.

Note. The communities of the variant inops, which is distinct from the previously described association Pino sibiricae–Abietetum sibiricae, lack several thermophilic species, primarily *Abies sibirica*, as well as East Siberian species such as *Aconitum baicalense* and *Duschekia fruticosa*. Many diagnostic species of the association and the alliance Pino sibiricae–Abietion sibiricae, such as *Gymnocarpium dryopteris*, *Padus avium*, *Rhytidiadelphus subpinnatus*, *Rosa acicularis*, *Solidago virgaurea*, and *Veratrum lobelianum*, are very rarely present or occur in low abundance within the communities of the inops variant.

Dark coniferous swampy forests and wooded swamps (sogras)

Due to the varying degree of participation of dark coniferous trees and the phytocenotic activity of taiga species (mosses, grasses, and shrubs), swampy forests and wooded swamps

Table 2. Relevés and syntaxa of the alliances Pino sibiricae–Laricion sibiricae and Pino sibiricae–Abietion sibiricae – dark coniferous and mixed North taiga forests of of zonal uplands and river valleys.

1–13 – ass. Ledo palustris–Piceetum obovatae (1); 14–34 – ass. Ledo–Pinetum sibiricae subass. typicum (2): 14–20 – var. typica (2a), 21–34 – var. Pinus sylvestris; 35–40 – ass. Pino sibiricae–Abietetum sibiricae subass. inops (3)

Association	Vaccinio uliginosi–Piceetum obovatae (1)													Ledo-Pinetum sibiricae subass. typicum (2)																					Pino sibiricae–Abietetum sibiricae (3)						Constancy and abundance				
Variant														typica (2a)							Pinus sylestris (2b)																								
Plant cover, %																																													
Trees	50	60	45	35	40	30	25	25	60	35	15	30	18	50	50	60	55	60	70	55	70	55	60	65	50	50	70	57	60	45	60	70	35	40	80	85	80	50	75	70					
Shrubs	1	20	1	34	5	20	25	20	35	30	15	10	20	5	0	0	0	15	0	65	5	20	25	13	65	60	25	20	50	42	40	30	25	1	0	0	35	0	5	10					
Dwarf shrubs and herbs	90	80	80	90	30	30	70	50	70	70	30	85	82	60	70	50	80	80	80	50	60	50	80	80	25	25	65	50	40	60	50	50	20	70	60	80	60	25	25	25					
Mosses and lichens	100	100	100	100	100	95	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	90	100	100	100	100	100	100	100	100	100	70	80	90	100	70	85					
Number of species	24	30	28	26	33	25	26	24	31	24	22	23	27	25	21	17	17	31	24	22	19	16	23	21	20	20	20	19	19	22	30	17	21	18	30	27	30	27	27	31					
Date	16.07.2019	23.07.2019	16.07.2019	15.07.2019	16.07.2019	23.07.2019	15.07.2019	15.07.2019	23.07.2019	15.07.2019	15.07.2019	15.07.2019	15.07.2019	16.08.2017	15.08.2017	15.08.2017	15.08.2017	16.08.2017	15.08.2017	20.07.2019	17.07.2019	20.07.2019	20.08.2011	17.07.2019	18.08.2011	19.08.2011	20.07.2019	17.07.2019	20.07.2019	20.07.2019	23.07.2019	17.07.2019	23.07.2019	17.07.2019	17.08.2017	17.08.2017	17.08.2017	17.08.2017	17.08.2017	17.08.2017					
Relevé nr. by author	116E19pz	250E19pz	117E19pz	101E19pz	011G19pz	098F19pz	100E19pz	001F19pz	105G19pz	001G19pz	002F19pz	002G19pz	102E19pz	027F17nu	001F17nu	002F17nu	300E17nu	329E17nu	301E17nu	067G19pz	031G19pz	063F19pz	059E11oz	141E19pz	026E11oz	029E11oz	195E19pz	142E19pz	066G19pz	196E19pz	102G19pz	032G19pz	095F19pz	031F19pz	359E17nu	362E17nu	360E17nu	048F17nu	049F17nu	052F17nu					
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	29	30	31	32	33	34	35	36	37	38	39	40	1	2a	2b	2	3
Tree layer species																																													
Larix sibirica	1	2b	1	1	1	1	+	1	2b	2b	1	2b	1	2a	+	+		2b	1	1	3	1	1	2b			2a	1	2b	2a	1		1	2b		2a	1		2a	2a	V¹	V¹	IV¹	V¹	IV²ᵃ
Picea obovata	3	3	3	2b	2b	2b	2a	2a	3	+	2a	+	1	1	3	3	2b	2a	3	+	+	1			1	+		+	+		3		2a	1	3	2b	3	2a	2a	3	V²ᵇ	V²ᵇ	IV⁺	IV¹	V³
Pinus sibirica						+								2a	2b	2a	2b	2b	2a	2b		+	3		3	1	1		1	+					2a	3	2b	1	+	2a	I	V²ᵇ	IIIʳ	IV¹	V²ᵃ
Pinus sylvestris					+	r								2b				2b	+	2b	2b	3	2b	2b	2b	3	2b	3	3	3	2b	4	2a	1	+						I	III⁺	V²ᵇ	V²ᵇ	I
Betula pubescens	2a	2a	2b	2a	2a	1	2b	2b	2a	2b	2a	2a	2a	2b	1	2a	2b	3	2b	2a	2b	1	1	2b	+	1	2b	+	2a	1	2a	2b	2a	2a	3	2b	r	3	3	1	V²ᵃ	V²ᵇ	V²ᵃ	V²ᵃ	V³
Undergrowth																																													
Betula pubescens	+	1	+	+	+		+	1	+	+	+	+	1	1							+		+	2a			1	1	+	1	+	2a		1	+						V⁺	I	IV⁺	III⁺	I
Picea obovata	+	+	+	+	1	1	1	1	+		+		+	+						1							1	+	+	+	+			1	1						V⁺	II	III	II	I
Pinus sibirica	+	+		+	r		+							+						1			1								+				1		1				II	II	I	I	II
Larix sibirica										+		+									+																				I		I	R	
Pinus sylvestris																					+						1				r												II	I	
Diagnostic species of the Vaccinio uliginosi–Piceetum obovatae																																													
Carex globularis		r			+	+	+	+	+	+	+												r		r										+	r		r	r	r	IV⁺		I	I	Vʳ
Betula nana		+		+		1	+		2b		1		1																		1		+								III⁺		I	I	
Pedicularis labradorica		+				+			+		+		+																												II				
Diagnostic species of the Pino sibiricae–Laricion sibiricae																																													
Ledum palustre	+	2b	+	3	+	2b	2b	2b	2b	2b	2a	1	2a	+	+	+	1	2b	2a	3	1	2b	2b	2b	4	4	2b	2b	3	3	+	2b	2b	+							V²ᵇ	V¹	V²ᵇ	V²ᵇ	
Empetrum hermaphroditum	1	2a	1	2a	1	+	1	2b	2b	1	1	1	2b	1	+	+	+	1	+	1	1	1	+	1		+	+	1	1	1	2b	2b	1	1							V¹	V⁺	V¹	V¹	
Vaccinium uliginosum	+	+	+	1	1	+	2a		1	2b	1	2a	1					+										+	1	1	3	1	1								V¹	I	III	II	
Cladonia stellaris		1	+	+	1	1	1	1	2b	1	2b	1	2b				+	+	+	1								1	1	1	2a	2b	3								V¹	III⁺	III	III	
Cladonia rangiferina	+	1	1	1	+		1	1	2a	1	2a	1	2a					+	+	1	+	+		+	1		1	1	1	1	1	1									V¹	III	IV⁺	IV⁺	
Cladonia arbuscula				+			+		1											1							1			1		+									II	I	II	I	
Diagnostic species of the Pino sibiricae-Abietion sibiricae and Pino sibiricae-Abietetum sibiricae																																													
Orthilia secunda																																			1		2a	+	1	+					V⁺
Trientalis europaea																																			+		1	+	1	+					V⁺
Rubus arcticus																																			+		+	1		+					IV⁺
Sorbus sibirica																																				+	3		1	2a					IV⁺
Polytrichum commune		1	+						+					+	+			+													+				3		1	2a		+	II	III	I	I	IV⁺
Sanionia uncinata							+	r				r																							+	1	+	r		r	II				V⁺
Dicranum fragilifolium															+																					+	+	+	+	r		I		R	V⁺
Lophozia silvicola	r									r		r																								r	r		r		II				III
Maianthemum bifolium																																					2b		1	1					III⁺

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	29	30	31	32	33	34	35	36	37	38	39	40	1	2a	2b	2	3
Lepidozia reptans																																				r			r	r					III
Rhytidiadelphus subpinnatus																																					+								I
Dicranum montanum																																				r									I
Solidago virgaurea																																						+							I
Padus avium																																							+						I
Rosa acicularis					+	+																																		+	I				I
Gymnocarpium dryopteris																																								+					I
Veratrum lobelianum																																								+					I
Diagnostic species of the Vaccinio-Piceetea																																													
Vaccinium vitis-idaea	5	5	4	4	2b	2b	4	3	3	4	2b	5	4	2b	2a	3	3	3	3	3	3	2a	4	5	2b	2b	4	3	2b	2b	3	3	2b	4	1	5	2a	2a	2a	2a	V^{4}	V^{3}	V^{3}	V^{3}	V^{2a}
Pleurozium schreberi	5	3	3	5	5	5	5	5	3	5	4	5	4	**5**	**4**	**4**	**2b**	**4**	**2b**	**5**	**5**	**5**	**3**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**4**	**4**	**3**	**5**	3	2b	4	3	3	3	V^{5}	V^{4}	V^{5}	V^{5}	V^{3}
Hylocomium splendens	1	3	4	+	1	+	1	+	3	1			2a	2b	+	2b	5	3	5			1	3	1	2a	2a	+			+	2a	+		1		4	2b		2b	3	V^{1}	V^{2b}	IV^{+}	IV^{1}	IV^{2b}
Vaccinium myrtillus	+	1	2a	1	1	1	+	1	1	+	2a	1	2a	3	4	2b	3	3	3	2b	+	3	3	+		2a	1	2b	2a	3	1	+		1	4						V^{1}	V^{3}	V^{1}	V^{2b}	I
Dicranum fuscescens	+	+	+		+	+	+	+	+	+	+	+	+	r	+	+	+	+	+	+		+		+			+	+		+	+		+	+	r	+	+	+		r	V^{+}	V^{r}	III^{+}	IV^{r}	V^{r}
Dicranum polysetum		+	1	+	+		+	+	+		+		+	+	r	+	1	2a	+	+	1		1	+	2a	2b	+	+	+		+	+	+	+	+						IV^{+}	V^{+}	V^{+}	V^{+}	I
Peltigera aphthosa		+	+	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+				+	+	+	1		+		+	1	+	1	+				+			V^{+}	V^{+}	IV^{+}	IV^{+}	I
Ptilium crista-castrensis		1					+	+		1		1	+		3			1	r		+		+	+	+								+	+	+	1	1		2b	1	III	III	III	III	V^{1}
Linnaea borealis	1		1		+									+	+	+	+	1	r		1			+		+											2a	+	+	+	II	V^{+}	II	III	IV^{+}
Diphasiastrum complanatum	+	+			+				+					+		+		1															+								II	III	I	I	
Plagiothecium laetum	r		r	r									r														r									+	+	+		r	II		I	R	IV^{+}
Goodyera repens			+											+					+																	+	+		+		I	II		I	III^{r}
Equisetum sylvaticum		+						+			+	+											1																	2a	II		I	R	I
Peltigera canina				+														1					+							+	1										I	I	II	I	
Other species																																													
Ptilidium pulcherrimum	r	r	+	r	+	+	r	+	+	+	r	r	+		+	+	+	+	+	r	r	r	+	+	+	+	+	+	+	+	+	+	+	r	r	r		+	+	r	V^{+}	V^{r}	V^{+}	V^{r}	V^{r}
Pohlia nutans	r		+	+	+		+			+	+	+	r		+	+	+	+	+		+		+	+	+			r	+					r	r	+	+		+	r	IV^{r}	IV^{r}	III	III^{r}	V^{r}
Polytrichum strictum		r			+	+	+	+	+	r			r					r	r												+				r	+		r			IV^{r}	II	I	I	III
Tetraphis pellucida																			r																	r		r	r	r		I		R	IV^{r}
Sphagnum girgensohnii																																			1			1		+					III^{r}
Peltigera sp.		r			+	+		+					+											r	+	+							r								II		II	I	
Dicranum flexicaule										+					+															+			+						r		I	I	I	I	I
Cladonia stygia						+																+	+		1						1		1								I		II	II	
Lophoziopsis longidens	r		r												r		r																			+	+				I	II		I	II
Juniperus communis		+			+	+																											+								II		I	R	
Ptilidium ciliare					+																					+			r		+										I		II	I	
Nephroma arcticum								+				+	+																		+										II		I	R	
Festuca ovina	+		r		r																																				II				I
Duschekia fruticosa																						+					1												+	+			I	I	II
Luzula pilosa			+											+				+																							I	II		I	
Melampyrum pratense					+									+				+																							I	II		I	
Lycopodium annotinum			+		+																										+					+					I		I	R	I
Sciuro-hypnum curtum																		r																			1	+				I		R	
Dicranum undulatum									+															+								+									I		I	I	
Polytrichum juniperinum																		r					r												r							I	I	I	II
Calamagrostis lapponica			r																					+																	I		I	R	

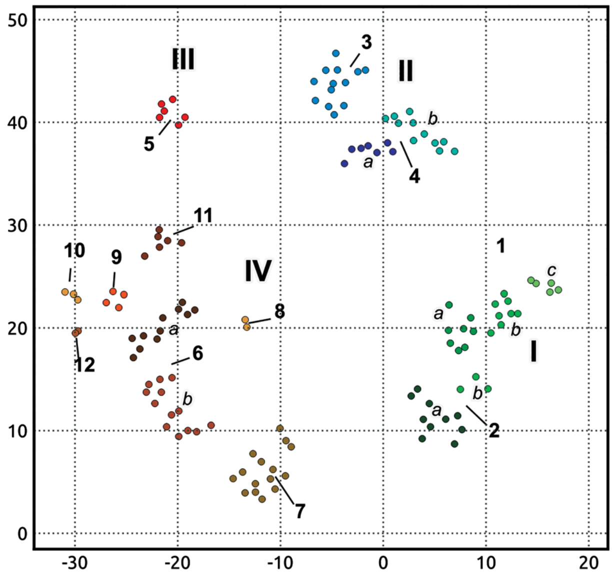

Figure 3 Ordination of the described syntaxa. Ordination is performed in the relative axes by non-linear mapping of the multidimensional feature space onto the 2D-plane by the t-SNE method (van der Maaten & Hinton 2008). 1 – ass. Cladonio arbusculae–Pinetum sylvestris: a – var. typica, b – var. Vaccinium myrtillus, c – var. Cladonia cornuta; 2 – ass. Pinetum sibiricae–sylvestris subass. ledetosum palustris: a – var. typica, b – var. Pleurozium schreberi; 3 – ass. Vaccinio uliginosi–Piceetum obovatae; 4 – ass. Ledo palustris–Pinetum sibiricae subass. typicum: a – var. typica, b – var. Pinus sylvestris; 5 – ass. Pino sibiricae–Abietetum sibiricae subass. inops; 6 – ass. Pseudobryo cinclidioidis–Pinetum sibiricae: a – var. inops, b – var. Sphagnum girgensohnii; 7 – ass. Oxycocco palustris–Pinetum sibiricae; 8 – ass. Sphagno girgensohnii–Pinetum sibiricae; 9 – ass. Sphagno fimbriati–Betuletum pubescentis; 10 – *Sphagnum fimbriatum–Betula nana* com. type; 11 – *Carex aquatilis–Betula pubescenis* com. type; 12 – *Calamagrostis purpurea–Salix dasyclados* com. type

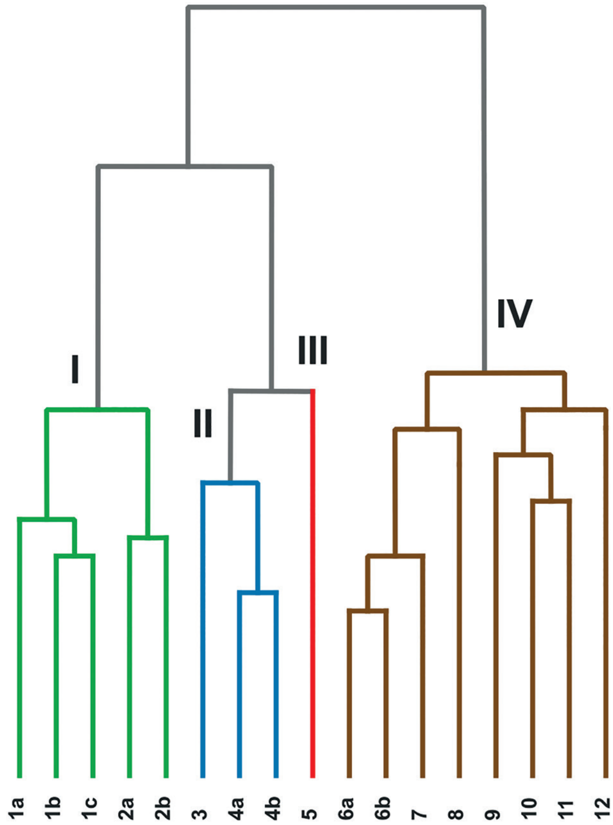

Figure 4 The similarity of syntaxa of forests and wooded swamps in Numto Nature Park represented for the northern taiga zone of Western Siberia, established by the Complete-linkage clustering (Squared Euclidean distances). I – Cladonio stellaris–Pinion sylvestris; II – Pino sibiricae–Laricion sibiricae; III – Pino sibiricae–Abietion sibiricae; IV – Sphagno fimbriati–Pinion sibiricae. The numbers of syntaxa correspond to the numbers in Fig. 3

(locally called 'sogra') on peat and peaty-gley soils closely resemble the physiognomy of forests on moderately moist and wet mineral soils within the alliance Pino sibiricae–Abietion sibiricae.

However, on the other hand, the significant presence of mire vascular species and mosses belonging to the class Scheuchzerio–Caricetea, and on later stages of development, oligotrophic ericoid dwarf shrub species and *Sphagnum* mosses from the class Oxycocco–Sphagnetea, sharply distinguishes the communities of wooded swamps from zonal dark coniferous forests on mineral soils within the alliance Pino sibiricae–Abietion sibiricae.

Therefore, it is more appropriate, in our view, to classify the communities of swampy forests and wooded swamps in northern Siberia into the separate alliance Sphagno fimbriati–Pinion sibiricae.

Sphagno fimbriati–Pinion sibiricae all. nov. (Table 3; Table 5, 10–17; Figs 3, 4, syntaxa 6–12)

The alliance includes vegetation of swampy forests, wooded swamps (sogras), and swampy low birch woodlands in the valleys of small rivers, streams, and lake basins in the subzones of the northern and middle taiga of Western Siberia.

Diagnostic species: *Calamagrostis purpurea*, *Polytrichum commune*, *Polytrichastrum longisetum*, *Rubus chamaemorus*, *Schljakovia kunzeana*, *Sphagnum centrale*, *S. fimbriatum*, *S. squarrosum*, *Warnstorfia pseudostraminea*.

Holotypus: Ass. Pseudobryo cinclidioidis–Pinetum sibiricae (Table 3, 1–24, described in this paper).

Within the territory of the Numto Nature Park, the alliance is represented by two associations that correspond to different stages of development and succeed each other as one moves away from the river or stream. Additionally, within the same alliance *Pinus sibirica* forests, dominated by *Sphagnum girgensohnii*, as well as one association and three community types of swampy low birch woodlands, are tentatively included.

Pseudobryo cinclidioidis–Pinetum sibiricae ass. nov. (Table 3, rel. 1–24; Table 5, 11–12; Fig. 2D–E, Figs 3, 4, syntaxa 6a, b)

The association includes birch–*Pinus sibirica* and birch-fir-*Pinus sibirica Calamagrostis*-herb-moss swampy woodlands and wooded swamps (sogras) on peat soils found in the valleys of small rivers and streams in the northern forest zone of Western Siberia.

Diagnostic species: *Calamagrostis purpurea*, *Calliergon cordifolium*, *Naumburgia thyrsiflora*, *Oncophorus elongatus*, *Picea obovata*, *Pseudobryum cinclidioides*, *Rubus arcticus*, *Sanionia uncinata*, *Sphagnum fimbriatum*, *S. girgensohnii*, *Viola epipsila*.

Holotypus: relevé 17 (author's number 029F22nu): KhMAO, Beloyarskiy District, Numto Nature Park, 14.08.2022, author I.V. Filippov.

Structure and composition. The tree layer is composed of *Pinus sibirica*, *Picea obovata*, and *Betula pubescens*, with varying crown density ranging from 0.3 to 0.8. The upper tree layer reaches a height of 18–20 m. The shrub layer consists of *Sorbus sibirica*, sometimes accompanied by *Duschekia fruticosa*. All rare findings of *Padus avium* are associated only with these habitats. The forest floor vegetation is differentiated based on micro-relief elements. On elevations, *Vaccinium vitis-idaea*, *Rubus chamaemorus*, *Calamagrostis purperea*, mesophilic species of taiga herbs such as *Maiantemum bifolium*, *Orthilia secunda*, *Rubus arcticus*, *Trientalis europaea*, *Viola epipsila*, and forest mosses like *Pohlia nutans*, *Sanionia uncinata*, *Oncophorus elongatus*, are found. In depressions, *Menyanthes trifoliata*, *Comarum palustre*, occasionally *Equisetum fluviatile*, *Naumburgia thyrsiflora*, and hydrophilic mosses such as *Pseudobryum cinclidioides*, *Calliergon* *cordifolium*, *Plagiomnium ellipticum*, can be found. Among the peat mosses, *Sphagnum squarrosum*, *S. fimbriatum*, and occasionally *S. centrale* are present with high constancy and often in significant abundance (up to 20 %). Various small mosses and liverworts inhabit the niches between the roots, slopes of slight elevations, fallen trees, and tree upturns.

Distribution and ecology. A distinctive feature of the communities within the association is their affinity for narrow valleys of small taiga rivers and streams that are flooded annually. The habitats are characterized by well-defined hummocky micro-relief, formed by large stem-based elevations measuring 1.5–3 m in diameter, moss-covered upturns, stumps, and fallen trees. These elevated micro-relief elements alternate with waterlogged depressions covered with a layer of loose green moss, where water accumulates on the surface. The relative elevation difference is 30–50 cm. Regarding the moss cover composition within the association, two variants have been identified: inops and Sphagnum girgensohnii.

The variant **inops** (Fig. 2D; Table 3, rel. 1–11) is characterized by a denser layer of *Calamagrostis purpurea* (20–60 %, usually 20–30 %) and a less developed moss cover dominated by *Sphagnum fimbriatum* with varying amounts of *S. squarrosum*, *S. centrale*, and *Polytrichum commune*. These communities develop directly along the river or stream channels and are regularly flooded by stagnant waters.

The variant **Sphagnum girgensohnii** (Fig. 2E; Table 3, 12–22) represents typical communities of the association. They are distinguished by a more noticeable presence of fir *Picea ibovata* (5–30 %) in the tree layer and a high consistency and significant participation of *Sphagnum girgensohnii* in the moss layer (ranging from 5 to 60 %) along with other moss species. These communities are flooded by stagnant waters less frequently and for shorter periods.

Oxycocco palustris–Pinetum sibiricae ass. nov. (Table 3, rel. 25–39; Table 5, 13; Fig. 2F, Fig. 3, syntaxon 7)

The association is characterized by a combination of species from its alliance, Sphagno fimbriati–Pinion sibiricae, along with a well-defined group of species from the class Oxycocco–Sphagnetea, with *Pinus sibirica* playing a dominant role. There is also a notable presence of species from the dark coniferous forests of the alliance Pino sibiricae–Abietion sibiricae, belonging to the class Vaccinio–Piceetea.

Diagnostic species: *Pinus sibirica*, *Ledum palustre*, *Carex magellanica* subsp. *irrigua*, *Sphagnum angustifolium*, *S. aongstroemii*, *S. centrale*, *S. fimbriatum*, *S. riparium*, *S. wulfianum*.

Holotypus: relevé 31 (author's number 041G22nu): KhMAO, Beloyarski District, Numto Nature Park, 15.08.2022, author G.N. Ganasevich.

Structure and composition. The association consists of swamp communities with a tree layer ranging from 8 to 18 m in height, typically 10 to 15 m, dominated by *Pinus sibirica*, occasionally with a minor presence of *Picea obovata*, which form the upper canopy. *Betula pubescens*, along with some *Pinus sibirica* form the low tree layer. The crown density ranges from 0.2 to 0.6, and the understory is weak. A well-defined dwarf shrub layer, reaching a height of 30 to 40 cm, is composed of *Ledum palustre* (with a projected coverage of up to 25 %) and, to a lesser extent, *Chamaedaphne calyculata*, often accompanied by *Betula nana*. *Menyanthes trifoliata* dominates among the herbaceous plants, with a coverage ranging from 10 to 60 % (sometimes less). Other less abundant but consistent species include *Carex chordorrhiza*, *Comarum palustre*, and *Equisetum fluviatile*. On tree stumps and *Sphagnum* moss hummocks, *Rubus chamaemorus*, *Vaccinium vitis-idaea*, and *Oxycoccus palustris* can be found. The moss layer consists of a combination of oligotrophic and mesotrophic *Sphagnum* mosses. Elevated micro-relief elements are colonized by *Sphagnum angustifolium*, *S. divinum*, *S. russowii*, along with some forest green moss species. The dominant species cover a large area and include *S. centrale*, *S. fimbriatum*, and *S. girgensohnii*. Less abundant but usually persistent species include *S. squarrosum*, *S. aongstroemii*, and *S. wulfianum*. In waterlogged micro-depressions, *S. riparium* and *Warnstorfia pseudostraminea* can be found. Various small mosses and liverworts inhabit the slopes of micro-elevations, tree bases, wet woody debris, and decaying tree stumps.

Distributin and ecology. The communities of the association develop in the peripheral parts of valleys, where the influence of rivers and streams is somewhat diminished.

Within the same alliance, another association has been provisionally assigned, which is represented by only two descriptions.

Sphagno girgensohnii–Pinetum sibiricae ass. prov. (Table 2, rel. 41–42; Table 5, 10; Figs 3, 4, syntaxon 8)

The association comprises *Pinus sibirica* and *Pinus sibirica*–birch swampy forests dominated by *Sphagnum girgensohnii* on poorly drained, periodically waterlogged peaty-gley soils.

Diagnostic species: *Pinus sibirica*, *Rubus chamaemosus*, *Sphagnum girgensohnii* (dom.)

Structure and composition: The tree layer is formed by a varying combination of *Pinus sibirica* and *Betula pubescens*, sometimes with a small admixture of *Pinus sylvestris* and *Picea obovata*. The average height of the tree layer is around 15–16 m. The tree canopy density is 0.5–0.6. The understory is weak, consisting of seedling regeneration of coniferous species and birch root suckers. The shrub layer is sparse and composed of low-growing *Sorbus sibirica* (1–3 m tall). In smaller abundance, shrubs like *Betula nana* and dwarf shrubs like *Ledum palustre* and *Chamaedaphne calyculata* are present. The sparser herbaceous upper sublayer, 30–40 cm in height, is formed by *Calamagrostis purpurea*, while the dominant species in the lower sublayer (15–20 cm tall) is *Rubus chamaemorus*. In smaller quantities, along the stem elevations, there are *Vaccinium vitis-idaea*, *V. myrtillus*, *Lycopodium annotinum*, and *Trientalis europaea*. The continuous moss cover consists of *Sphagnum girgensohnii* with a slight admixture (up to 10–20 %) of green forest mosses such as *Pleurozium schreberi*, *Dicranum polysetum*, and *Pohlia nutans*.

Distribution and ecology. These communities are sporadically found in the taiga zone of Western Siberia, where they develop in isolated flat depressions among taiga forests and on the periphery of large bog complexes under conditions of periodic excessive moisture on peaty-gley and podzol-gley soils.

Note. *Pinus sibirica*–dwarf shrub–*Sphagnum* forests dominated by *S. girgensohnii* have been repeatedly described in the literature within the framework of ecological-physiognomic classification (Povarnitsyn 1944, Grebenyk & Tarasov 1996, Neshataev et al. 2002).

Birch swamp and swampy low birch woodlands

Along the banks of small rivers and streams, in the flooded areas around lakes, birch swamps with dominance of *Sphagnum* mosses in the ground layer are sporadically encountered. In the studied territory of the Numto Nature Park, they are represented by one association and three community types.

Sphagno fimbriati–Betuletum pubescentis ass. prov. (Table 4, rel. 4–7; Table 5, 15; Figs 2G, 3, syntaxon 9)

The association consists of birch small woods on peat and peaty-gley soils in the flooded areas around lakes and along the banks of small streams amidst vast oligotrophic bog systems in the taiga zone of Western Siberia (Fig. 2G).

Diagnostic species: *Betula pubescens* (dom.), *Calamagrostis purpurea*, *Sphagnum fimbriatum*, *Polytrichum commune*, *Polytrichastrum longisetum*.

Structure and composition. The tree stand is typicaly single-layered, consisting of *Betula pubescens*, 5–6 (7) m high, with stem diameters of 5–10 (12) cm. Occasionally, larger birch trees up to 8–10 m in height can be found among the small woods. Tree canopy cover varies ranges from 0.2 to 0.8–0.9. The understory is represented by the root sprouts of birch and sparsely seed regeneration of *Pinus sibirica*. The shrub layer is weakly developed, consisting of scattered shrubs such as *Betula nana* and willows (*Salix lapponum*, *S. myrtilloides*), or it may be absent. In the herbaceous layer, *Calamagrostis purpurea* typically dominates (10–70 %), some-

Table 3. Relevés and syntaxa of the alliance Sphagno fimbriati–Pinion sibiricae – swampy dark coniferous forests and swamps (sogras).

1–24 – ass. Pseudobryo cinclidioidis–Pinetum sibiricae subass. typicum (1): 1–11 – var. inops (1a), 12–24 – var. Sphagnum girgensohnii (1b); 25–39 – ass. Oxycocco palustris–Pinetum sibiricae (2); 40–41 – ass. Sphagno girgensohni–Pinetum sibiricae (3)

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	29	30	31*	32	33	34	35	36	37	38	39	40	41	1a	1b	1	2	3
Association / Subassociation	Pseudobryo cinclidioidis–Pinetum sibiricae subass. typicum (1)																								Oxycocco palustris–Pinetum sibiricae (2)															(3)		Constancy and abundance				
Variant	inops (1a)											Sphagnum girgensohnii (1b)																																		
Plant cover, %																																														
Trees	70	60	50	60	40	40	45	60	50	30	40	30	45	55	65	70	60	80	25	20	75	70	50	50	50	50	30	50	25	30	60	20	30	15	35	40	45	40	30	60	60					
Shrubs	1	2	1	5	5	3	0	2	10	0	5	5	10	3	10	35	3	20	1	5	20	5	3	10	23	10	25	25	25	20	25	15	50	10	25	50	20	20	40	3	5					
Dwarf shrubs and herbs	70	70	40	40	60	60	50	65	40	85	60	80	70	60	70	35	60	80	85	30	50	40	60	90	50	50	75	10	80	30	50	25	30	60	60	70	60	40	35	35	30					
Mosses	80	50	60	35	80	30	80	75	70	90	90	60	90	80	80	80	60	70	95	45	85	100	80	80	100	70	95	80	95	85	90	95	100	100	95	90	0	90	95	100	100					
Number of species	27	29	31	32	27	21	25	29	35	28	27	39	42	52	55	38	48	46	35	34	50	45	55	57	50	44	54	42	39	40	47	34	35	50	35	39	37	39	38	24	27					
Date	16.08.2022	16.08.2022	16.08.2022	15.08.2022	17.08.2022	17.08.2022	15.08.2022	15.08.2022	15.08.2022	17.08.2022	17.08.2022	14.08.2022	14.08.2022	14.08.2022	20.08.2017	16.08.2017	14.08.2022	16.08.2017	14.08.2022	16.08.2017	20.08.2017	14.08.2022	14.08.2022	21.08.2017	14.08.2022	15.08.2022	14.08.2022	15.08.2022	14.08.2022	14.08.2022	15.08.2022	17.08.2022	14.08.2022	17.08.2022	14.08.2022	14.08.2022	14.08.2022	15.08.2022	17.08.2022	16.08.2022	16.08.2022					
Releve nr. by author	066G22nu	082E22nu	062F22nu	052F22nu	076G22nu	067F22nu	055G22nu	068E22nu	039V22nu	091E22nu	055V22nu	018V22nu	043E22nu	033F22nu	410E17nu	342E17nu	029F22nu	341E17nu	040E22nu	036F17nu	411E17nu	030G22nu	030F22nu	430E17nu	033G22nu	041F22nu	038E22nu	053E22nu	039E22nu	028F22nu	041G22nu	074F22nu	28aG22nu	082G22nu	017V22nu	021V22nu	016V22nu	028V22nu	058V22nu	063F22nu	067G22nu					
Tree layer species																																														
Pinus sibirica	2a	1	2a	2b	1	2b	2b	3	3	1	2a	2b	3	2b	2b	3	3	4	2b	2a	2b	3	2b	2a	2b	3	2b	3	2b	2b	3	2a	2b	2a	2a	2b	3	3	2a	**3**	**3**	V^{2a}	V^{2b}	V^{2b}	V^{2b}	2^{3}
Picea obovata	1			2b			1	1	1			1	2a	2b	2b	3	2a	2b	1	1	3	2b	2b	2b	2b	2a	+	+	+	+	+				1	2a	1	1			+	III	V^{2b}	IV^{1}	IV^{+}	1^{r}
Betula pubescens	4	4	3	2b	3	3	2b	2b	2b	3	3	1	2a	2b	3	2b	2a		1	1	3	2b	2b	2b	2a	2a	2a	2a	2a	2b	2b	2a	2a	1	2b	1	2a	2a	2b	3	2b	V^{3}	V^{2b}	V^{2b}	V^{2a}	2^{3}
Pinus sylvestris			1	1			1		1								+													+						1					2b	II	I	II	I	2^{2a}
Undergrowth																																														
Betula pubescens	2a	1	+		1		1			+	+				1	1	+		+		1	1	+		1	+	1	1	+	+	1	+	+	+			+	+	+	+	1	IV^{+}	III^{+}	III^{+}	V^{+}	2^{+}
Pinus sibirica	+	1	+		1		1	1	+	1	+						+		+		1	1			1	+	1	+	+	+	1	+	1	1			+	+	+	+	1	V^{+}	II	III^{+}	V^{+}	2^{+}
Picea obovata							+	+	+							2a	+	1			1	+	+		1	+		+	+		+		+	+				+				II	III	II	III^{+}	
Pinus sylvestris																																									+					1^{r}
Diagnostic species of the Pseudobryo cinclidioidis–Pinetum sibiricae and Sphagno fimbriati–Pinion sibiricae																																														
Calamagrostis purpurea	3	3	2b	2b	3	4	3	4	2b	4	3	2b	2a	2a	3	2b	1	2b	2b	2b	2b	1	1	4	2a	1	1	1		+	1	+	1	1	+	1	1	1	+	1	1	V^{3}	V^{2b}	V^{2b}	V^{1}	2^{1}
Sphagnum fimbriatum	3	3	1	3	3	2b	4	3	3	3	4	3	2b	1	2a		2a	1	3	1	2b	2b	2b	1	2b	+		1	2b	1	2a	2a		2a	4	2b		2b	2a			V^{3}	V^{2a}	V^{2b}	V^{2a}	
Sphagnum squarrosum	2a	2b	2b	+	2a	2a		2b	2a		1	1	2b	1	2b	2a	2a	2a	2a	1	1	2b	3	2a	1	1	2b	2b	2b		2a		1	1	1	1	1	1	2a			V^{2a}	V^{2a}	V^{2a}	V^{1}	
Schljakovia kunzeana				+		+	+	+	+	+	+	+	+	+	r		+		+		r	1	+	r	+		+	+	+	+	+	+	+	+	+	+	+	+				IV^{+}	IV^{+}	IV^{+}	V^{+}	
Warnstorfia pseudostraminea								+					1	1	r	r	+		2a		1	1	+		1	+	1	1	2a		+	2a		2b	+		+	1	2a			I	IV^{+}	III	V^{1}	
Pseudobryum cinclidioides	3	1	1		1	+				+	1	1	+	+	2a	1	1	2b	2b	2b	1	2b	1	2b	1										+	1			+			IV^{+}	V^{1}	V^{1}	II	
Calliergon cordifolium	+	+	1		1	+						1	1		2a	+	1	r	1	1	1	1	+	2b	1			1						1		+						III	V^{1}	IV^{+}	II	
Rubus arcticus	1				+							1		+	1	1	1	1	+	1	+	1	+	+	+															3	2b	I	V^{1}	III^{+}	I	2^{3}
Viola epipsila					1	+				1	1	+		+				1			r	+	+	1																		II	III^{r}	III		
Carex canescens		2a		+				+	1				+	+	+	r		r	+			1		r												+					+	II	IV^{r}	III	I	1^{r}
Galium trifidum	+											+		+			+		+			1	+	r																		I	III^{r}	II		
Naumburgia thyrsiflora				+			+	+				1		1		r	+	1	+			1	+	+																		II	IV^{+}	III		
Sphagnum girgensohnii											1	2b	3	3	2b	4	3	1	2b	2a	3	2b	2b	2b	3	2a	3	2b	2b	3	2b	1	3		+	3	3	3		**5**	**5**	I	V^{2b}	III^{2a}	V^{2b}	2^{5}
Sphagnum centrale			1	+		+				2a	1	1		+	2a				2a			+			1	1	2b	1	2b	2b	2a	+	2b	2a	2b	1	+	1	2b			III	II	III	V^{2a}	
Diagnostic species of the Oxycocco palustris–Pinetum sibiricae																																														
Betula nana									1					+					+				+			+	1	1	2a		1	1	3	2a	2a		2a	1	1		1	I	II	I	V^{1}	1^{+}
Carex magellanica subsp. *irrigua*	1		+														+								1	+	+	+	1	+	1	+	1	2a	+		+			+	+	I	I	I	V^{+}	2^{+}
Sphagnum riparium												1	1											1			1	1	1		1	+	1	1	1	+		1	+				II	I	IV^{1}	
Sphagnum russowii																										+	2b	1	2b	2a	1	1	2b			+	2b	1	1						V^{1}	
Sphagnum aongstroemii													1												1	+	1		1	+	1	+	1		1	1							I	R	IV^{+}	
Sphagnum wulfianum																		r		r						3		2b			2b							1					I	I	II	
Diagnostic species of the Oxycocco-Sphagnetea																																														
Rubus chamaemorus	1	1		1	1		1	1	1	2b	2a		1	r			1	r		r	1	1	1		1	2b	2a		1	2a	1	1	1	1	1	2a	1	1	2a			V^{1}	IV^{r}	IV^{1}	V^{1}	

Table 3. 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	29	30	31*	32	33	34	35	36	37	38	39	40	41	1a	1b	1	2	3
Ledum palustre				+				1	1				2a		r							1			2a	1	2b	2a	2a	2b	2b	+	2a	1	2b	2b	2a	2a	3		+	II	II	II	V^{2a}	1^{r}
Chamaedaphne calyculata				+									1		+		1								2a	1	1	1	1	1	1	+	2a		1	3	1	1	1	+		I	II	I	V^{1}	1^{r}
Sphagnum angustifolium										2a	2a															+	1	1	+	+	+	4	1	2a		+	+	1	3			I		I	V^{+}	
Oxycoccus palustris	+				+					1				+	r		+						+		1	+	+	+	1	1	+	1	1	1	1	+	1	1	1	1	1	II	II	II	V^{1}	2^{1}
Sphagnum divinum													+													+	+	1		+	1						1	1					I	R	III	
Diagnostic species of the Scheuchzerio-Caricetea																																														
Menyanthes trifoliata	2b	2b	2b		1	+				2b		3	4	3	2b	2a	3	3	4	1	1	2a	3	2b	2b	2b	4	4	4	2a	3	1	2b	2a	3	3	3	3	2b		+	III^{+}	V^{3}	IV^{2b}	V^{3}	1^{r}
Comarum palustre	1	1	1	1	1	1	1	1	1	1	1	2a	1	1	2a	2a	+	1	2b	r	2a	1	+	2b	1	+	1	+	1	+	1	2a	1	2a	2a	1	1	1	1	+		V^{1}	V^{1}	V^{1}	V^{1}	1^{r}
Carex chordorrhiza	1								1	+	+		+	+			+				r				1	+	+	+	+	+	1	1	1	1	+	1	+			+	+	II	II	II	V^{+}	2^{+}
Andromeda polifolia		+		+						+							+						+		1		r					2a		+					1			II	I	II	II	
Diagnostic species of *the* Vaccinio-Piceetea																																														
Sorbus sibirica	+	+	+	+	1	1		+		+	1	1	+	1		2a	+	2b	+	1	2a	1	1	2a	1	+														1	1	V^{+}	V^{1}	V^{+}	I	2^{1}
Trientalis europaea	1	1	+	+	1	+	1	+	+	1	1	1		+	+	+	+	1	+	r	r	+	+	+		+	+					+		1						+		V^{1}	V^{+}	V^{+}	II	1^{r}
Vaccinium vitis-idaea		1					+	1	1			1	1		1	r	1	1	+	r	+	1	+	+	1	1		2a	1	+	2a		+		1	1	1	1	+	+		II	V^{+}	IV^{+}	V^{1}	
Pleurozium schreberi		+		1	2a		+	1	1	+	1						+	1					+		1	+	2b		+	+	1	+	1	1			1	1	1	2a	1	IV^{+}	II	III	V^{1}	2^{2a}
Polytrichum commune	1	3		1	+		1	1	2a	+	+			+						r	1	1	+		1	+		+		+	1		1				+	1	1	+		V^{1}	II	III^{+}	IV^{+}	1^{r}
Dicranum fuscescens		+							+												r					+			+	+	+								+			I	I	I	II	
Vaccinium myrtillus													+													+										1				+			I	R	I	1^{r}
Lycopodium clavatum		+																																					+	+	+					2
Lycopodium annotinum																																+		+						+	+					2
Other species																																														
Pohlia nutans		+		+	+	+	+		+	+	+	+	+	+	r	r	+	1	+	r	r	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+		+		+	IV^{+}	V^{+}	V^{+}	V^{+}	1^{r}
Sanionia uncinata		+	+	+	+	+	+	+	+	+	+			+	1	1	+	1	+	r	r	1	+	1	+		+							+	+	+					+	V^{+}	V^{+}	V^{+}	II	1^{r}
Aulacomnium palustre			1		+	+			+		1	1	+		r		+			r			+				1		1	+		+	1	2a	1			1	+	+	1	III	III	III	IV^{+}	2^{1}
Ptilidium pulcherrimum	+	+		+	+		+		1	+	1	+	+	+			+	r			r		+		+	+	+			+		+		+				+	1	+		IV^{+}	III^{r}	IV^{+}	III^{+}	1^{r}
Lophozia silvicola			+	+				+	+	+		+	+	+	r		+	r			r	+			+	+	+	+	+	+	+		+	+		+	+					III	IV^{r}	III^{r}	IV^{+}	
Polytrichum strictum		+			+		+	+	1	+	+																r				+			1				+	1		1	IV^{+}		II	II	1^{+}
Tetraphis pellucida													+	+	r		+	r			r		+		1	+	+	+		+	+			+				+	+				III^{r}	II	IV^{+}	
Equisetum fluviatile												1	+	+	r		+	r	1			1	+		+		+		+	+		+	+	1	+		+		+				IV^{+}	II	IV^{+}	
Lepidozia reptans													+	+	r			r				1	+		1	+	+	+		+	+					+	+	+					III	II	IV^{+}	
Calypogeia integristipula													+		r	r	+	r			r			r			+	+	+		+					+	r	+					III^{r}	II	III	
Carex aquatilis				1		+			1					+			+		+				1			+	+	+										1				II	II	II	II	
Straminergon stramineum				r								+	+		r								+				+		+	+	1		+	1			+	+			+	I	II	II	III^{+}	1^{r}
Oncophorus elongatus								+	+			+		+	r	r	+	r			r	+	+	r	+		+								+		r					I	IV^{r}	III	II	
Warnstorfia fluitans									1			1	+				+								1	+		+			+		1	+	1		+					I	II	I	III^{+}	
Scapania irrigua			+				+					+		+	r		r				r	+	+					+	+							1						I	III^{r}	II	II	
Plagiothecium svalbardense										+	r											+				+	+	+		+	1			+				+	+			I	I	I	III^{+}	
Dicranum fragilifolium														+				r							+	+	+			+	+					+		+					I	I	III	
Cephalozia bicuspidata													+		r	r	r	r			r		r	r			r		r		+												IV^{r}	II	II	
Cephalozia lunulifolia														r							r				+	r	r		+		+		+				r						I	I	III	
Blepharostoma trichophyllum															r		r	r	r		r		r	r			r				+												III^{r}	II	I	
Gymnocolea inflata							+	1	+				+								r							+														II	I	II	I	
Orthilia secunda								+						+		1		r					+	+	+																	I	II	II	I	
Carex rostrata			+											+									r				+							2a								I	I	I	I	
Scapania paludicola			+	+		+		+	+					+																		+							1			III	I	II	I	
Epilobium palustre			+			+								+			+		+			1	+												r							I	II	II	I	
Carex lasiocarpa																											+	r				+													II	
Eriophorum vaginatum																									+														+						I	
Pellia neesiana			+		+							+		+					+															1	+							I	II	II	I	
Tritomaria exsectiformis									+				+		r		+				r				+											r						I	II	II	I	
Polytrichastrum longisetum		+												+		r		+			+			r	+																	I	II	II		
Pyrola minor	+													+			+			r			+		+																	I	II	II	I	
Helodium blandowii			1			r									r								+	r										1								I	II	II	I	
Plagiomnium ellipticum			+															r		r	r			r																		I	II	II		
Lophoziopsis longidens				r									+	+											+		+			+												I	I	I	II	
Plagiothecium denticulatum			r												r	r		r			r	+																				I	II	II		

Table 3. 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	29	30	31*	32	33	34	35	36	37	38	39	40	41	1a	1b	1	2	3
Solidago virgaurea												+		+	r		+					+	+																				III	II		
Cacalia hastata												1				r			+			1	+	r																			III	II		
Maianthemum bifolium																1		1		1				+																			II	I		
Pohlia proligera																		r		r	r			r																			II	I		
Chiloscyphus pallescens															r				r				+												r								II	I	I	
Dicranella heteromalla															r	r					r		+																				II	I		
Ceratodon purpureus																		r		r		+		r																			II	I		
Parnassia palustris												+		+								+		1																			II	I		
Duschekia fruticosa															2a	2b								1																			II	I		
Calypogeia muelleriana													r		r													+									+						I	I	I	
Chiloscyphus polyanthos															r				+					r														+					II	I	I	
Sphagnum warnstorfii	1		2a																															2a	+							I		I	I	
Corallorrhiza trifida	+		+		+																																					II		I		
Vaccinium uliginosum		+	+	1																																						II		I		
Brachythecium mildeanum			+									+			r																															
Moneses uniflora														+				r							+																		I	I	I	
Lophozia longiflora															r						r			r																			II	I		
Peltigera aphthosa							+	+								r																										I	I	I		
Ptilidium ciliare													+	+													r																I	I	I	
Bryum capillare																			+			1		r																			II	I		
Scapania mucronata													r										r		+											r							I	I	I	
Sphagnum obtusum																													1						+				1						II	
Polytrichum juniperinum		+												r										r						+												I	I	I	I	
Sphagnum fallax													+												1								+			+							I	R	II	
Salix lapponum				+											r					r																						I	I	I		
Sphagnum subsecundum																																+		1					+						II	
Polytrichum jensenii	+			+																																+						I		I	I	

times forming patches with *Menyanthes trifoliata* and *Comarum palustre*. Sedges, such as *Carex chordorrhiza*, *C. canescens*, and occasionally *C. aquatilis*, are present in low abundance. The moss layer is patchy and includes species such as *Calliergon cordifolium*, *Polytrichum commune*, and *Polytrichastrum longisetum*, while *Sphagnum fimbriatum* and *S. squarrosum* play a significant role among the *Sphagnum* mosses, and occasionally *Sphagnum angustifolium* occurs in low abundance.

Distribution and ecology. These communities develop in narrow strips, approximately 20–30 m wide, along the banks of small rivers and streams. They are regularly flooded during the snowmelt and spring floods. The peat layer does not exceed 1 m in thickness and is underlain by sand.

Community type **Sphagnum fimbriatum–Betula nana** (Table 4, rel. 1–3; Table 5, 14; Figs 3, 4, syntaxon 10).

This type includes *Betula nana* shrub thickets with a moss layer dominated by *Sphagnum fimbriatum* in the flooded parts of valleys of small rivers and streams.

Structure and composition. The tree layer is represented by rare trees of *Betula pubescens*, reaching heights of 2–3 m. The shrub layer, with a cover of 10–40 %, consists of *Betula nana*. In low abundance (1–5 %), dwarf shrubs such as *Andromeda polifolia* and *Chamaedaphne calyculata* can be found. The herbaceous layer is dense (60–70%) and two-tiered. The upper sublayer, 40–50 cm in height, is formed by *Calamagrostis purpurea*, while the lower sublayer is dominated by *Comarum palustre* with a slight mixture of *Carex rostrata*, *C. chordorrhiza*, *Galium trifidum*, and *Naumburgia thyrsiflora*. The moss layer (50–100 %) is predominantly composed of *Sphagnum fimbriatum*. In lower abundance but with high consistancy *Calliergon cordifolium*, *Pseudobryum cinclidioides*, *Polytrichum commune*, and *Sphagnum squarrosum* occur.

Distribution and ecology. Despite the absence of a well-developed tree layer, in terms of habitat ecology and floristic composition, the flooded dwarf birch (*Betula nana*)-*Sphagnum* thickets in the valleys of rivers and streams are similar to other communities of birch-*Sphagnum* swamps.

Community type **Carex aquatilis–Betula pubescens** (Table 4, rel. 8–13; Fig. 2H; Table 5, 16; Figs 3, 4, syntaxon 11)

Sedge (*Carex aquatilis*)-*Clalamagrostis*-*Sphagnum* swampy low birch woodlands in river floodplains and lake depressions of the northern taiga zone of Western Siberia.

Structure and composition. The birch tree layer reaches up to 5-8(10) m high. The crown density varies within a wide range (0.2–0.6). In the lower understory, there is sometimes a minor presence of young *Pinus sibirica* and *Picea obovata*. The microrelief is hummocky and swampy, formed by tree-root mounds. The relative height difference is around 15–20 (25) cm. Shrub species present include *Betula nana* and *Salix lapponum*. The dense herbaceous layer is 50–70 %. The lower sublayer, if present, is dominated by *Rubus chamaemorus*, the middle sublayer by *Carex aquatilis*, and the upper sublayer is predominantly occupied by *Calamagrostis purpurea*. The moss layer is of heterogeneous composition dominated by *Sphagnum fallax*, *S. fimbriatum*, and *S. girgenshonii*. They are often accompanied by *Polytrichum commune*, *Sphagnum angustifolium*, and *S. russowii*.

Distribution and ecology. Communities of this type are formed on peat soils in regularly flooded river backwaters and inter-ridge depressions in floodplains, in the inundation zone around large lakes, and along the channels of intrabog streams.

Note. As more relevés accumulate, the rank of this community type may be elevated to an association.

Community type **Calamagrostis purpurea–Salix dasyclados** (Table 4, rel. 14–15; Table 5, 17; Figs 3, 4, syntaxon 12)

Structure and composition. The tree layer is uneven (crown density: 0.2–0.7) and consists of *Betula pubescens* with a significant presence of tall willow (*Salix dasiclados*) reaching a height of 5–7 m. The shrub layer accounts for 3–20 % and is composed of undergrowth of the same willow species with some *Salix lapponum*. The herbaceous layer is do-

Table 4 . Relevés and community types of the alliance Sphagno fimbriati–Pinion sibiricae – birch low woodlands and swamps.

1–3 – *Sphagnum fimbriatum–Betula nana* community type (1); 4–7 – ass. prov. *Sphagnum fimbriatum–Betula pubescens* (2); 8–13 – *Carex aquatilis–Betula pubescens* community type (3); 14–15 – *Calamagrostis purpurea–Salix dasyclados* community type (4)

Community type	**(1)**			**(2)**				**(3)**						**(4)**		**Constancy and abundance**			
Plant cover, %																			
Trees	2	0	3	25	25	70	70	60	50	50	65	35	15	70	20				
Shrubs	20	25	10	2	2	10	10	50	0	0	0	0	3	3	20				
Dwarf shrubs and herbs	70	70	60	90	80	70	85	50	60	70	60	70	70	95	60				
Mosses	100	70	50	50	40	80	75	70	100	100	100	100	90	30	10				
Number of species	19	18	18	16	31	19	30	20	13	18	18	16	28	20	21				
Date	15.08.2022	15.08.2022	16.08.2022	15.08.2022	16.08.2022	19.08.2017	15.08.2017	19.08.2017	18.08.2022	18.08.2022	18.08.2022	18.08.2022	17.08.2017	18.08.2017	18.08.2017				
Relevé nr. by authors	045G22nu	031V22nu	044F22nu	056E22nu	049V22nu	401E17nu	304E17nu	402E17nu	083F22nu	092G22nu	108E22nu	067V22nu	363E17nu	382E17nu	069F17nu				
Relevé nr. in the table	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**1**	**2**	**3**	**4**
Cluster in Fig. 4	**14**	**14**	**14**	**15**	**15**	**15**	**15**	**16**	**16**	**16**	**16**	**16**	**16**	**17**	**17**	**14**	**15**	**16**	**17**
Tree layer species																			
Betula pubescens				**2b**	**2b**	**4**	**4**	**3**	**3**	**3**	**4**	**3**	**2b**	**4**	**2b**		4^{3}	V^{3}	2^{3}
Pinus sibirica					+					1			1				1	II	
Picea obovata				+													1		
Undergrowth																			
Betula pubescens	1		+		+	2a	+		1	1	+					2^{+}	3^{+}	III^{r}	
Pinus sibirica					+	1	+		1	1	+	+					3^{+}	IV^{+}	
Pinus sylvestris										1	+		r					III	
Betula tortuosa								1		1								II	
Diagnostic species of the *Sphagnum fimbriatum-Betula nana* com. type																			
Betula nana	**2b**	**3**	**2a**	1			+	3								3^{2b}	2^{r}	I	
Diagnostic species of the *Sphagno fimbriati-Betuletum pubescens* and *Sphagno fimbriati–Pinion sibiricae*																			
Calamagrostis purpurea	**4**	**3**	**3**	**4**	**4**	**3**	**4**	3	1	2a	+		4	5	3	3^{3}	4^{4}	V^{2a}	2^{4}
Sphagnum fimbriatum	5	3	3	1	3	3	2b	3	3	4	3	3				3^{3}	4^{3}	V^{3}	
Polytrichum commune		1			1	2b	2b	2b	1	2a	1		1			1	3^{2a}	V^{1}	
Sphagnum squarrosum	1	1	2a	2b	2a	2a	3									3^{1}	4^{2a}		
Pseudobryum cinclidioides	1	1	+	2a	1		+							+	1	3^{1}	3^{+}		2^{+}
Polytrichastrum longisetum					+	1	1	+					+	r			3^{+}	II	1
Warnstorfia pseudostraminea						r		1						+			1	I	1^{r}
Diagnostic species of the *Carex aquatilis-Betula pubescens* com. type																			
Carex aquatilis	1	+	1	1				2a	1	+	3	3	1	+	+	3^{1}	1	V^{2a}	2^{+}
Sphagnum angustifolium					+	2a		2a	1	1	2a	1	1				2^{r}	V^{1}	
Rubus chamaemorus					1				4	4	2b	1	r				1	V^{2a}	
Sphagnum fallax				+					3	2a	3	3	2b				1	V^{3}	
Sphagnum russowii									2a	2a	+	1	2a					V^{2a}	
Diagnostic species of the *Calamagrostis purpurea-Salix dasyclados* com. type																			
Salix dasyclados														2a	2b				2^{2a}
Epilobium palustre														+	+				2^{+}
Stellaria longifolia														+	+				2^{+}
Bryum cyclophyllum														+	+				2^{+}
Drepanocladus polygamus														1	+				2^{+}
Viola epipsila														1	+				2^{+}
Diagnostic species of the *Sphagno-Caricion canescentis*																			
Carex canescens			+		+	+	1	r								1	3^{+}	I	
Sphagnum riparium		1				1				1	2a	1				1	1	III^{+}	
Galium trifidum	+		+	+										r	r	2^{+}	1		2^{r}
Sphagnum obtusum		2a					r									1	1		
Diagnostic species of the *Scheuchzerio-Caricetea*																			
Comarum palustre	1	2b	2a	4	1		+	1						2a	1	3^{2a}	3^{+}	I	2^{2a}
Oxycoccus palustris	+	1			+				+		+					2^{+}	1	II	
Carex chordorrhiza	1	+				r	+						r			2^{+}	2	I	
Carex rostrata	+	+	1							1			r			3^{+}		II	
Andromeda polifolia	+	+			+											2^{+}	1		
Menyanthes trifoliata					2a	3											2^{+}		
Other species																			
Calliergon cordifolium	1	+	1	2b	1	r	1	1						2b	1	3^{1}	4^{1}	I	2^{2a}
Naumburgia thyrsiflora	1	1	+	+			r	+						1	r	3^{1}	2	I	2^{+}
Pohlia nutans					+			2a	r		r		r		r		1	IV^{r}	1
Chamaedaphne calyculata	1	1	+	+				1					1			3^{1}	1	II	
Salix lapponum			+				1	2a					+	1		1	1	II	1^{+}
Trientalis europaea	1				1	2a	1									1	3^{1}		
Sanionia uncinata				+	+									1	r		2^{r}		2^{+}
Polytrichum strictum					+					1	+	+					1	3^{r}	
Aulacomnium palustre					+	r	+						r				3^{+}	I	
Pyrola minor					1	r	r								r		IV^{r}		1
Schljakovia kunzeana													+		r			I	1
Polytrichum swartzii							1	1					r				1	II	

Table 5. Synoptic table of syntaxa of the class **Vaccinio–Piceetea**

Syntaxa number in Fig. 3 and 4	1a	1b	1c	2a	2b	3	4a	4b	5	8	6a	6b	7	10	9	11	12
Number in the table	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Diagnostic species of the Cladonio arbusculae–Pinetum sylvestris																	
Pinus sylvestris	**V^{3}**	**V^{3}**	**V^{3}**	**V^{3}**	**V^{3}**	I	III^{+}	V^{2b}	I	1^{+}	II	I	I			III	
Flavocetraria nivalis	IV^{+}	IV^{+}	II														
Cladonia sulphurina	II	III^{r}	V^{1}	II	II	I											
Diagnostic species of the variant Cladonia cornuta																	
Cladonia deformis	II	IV^{r}	V^{+}	III	II	I											
Cladonia cornuta	II	V^{+}	V^{2b}	IV^{+}	II	I		I									
Cladonia crispata		IV^{r}	V^{2b}	II	II	I	I										
Cladonia uncialis	II	V^{r}	III														
Cladonia coccifera		IV^{+}	IV^{+}														
Cladonia gracilis	I	V^{+}	V^{2b}				I										
Cladonia cariosa			V^{+}														
Polytrichum juniperinum	I	II	V^{r}	I			I	I	I	1^{r}	I	I	I				
Dagnostic species of the Cladonio stellaris–Pinion sylesrtris																	
Cladonia stellaris **P. s.-L. s.**	V^{5}	V^{5}	V^{1}	V^{3}	V^{1}	V^{1}	III^{+}	III									
Cladonia rangiferina **P. s.-L. s.**	V^{2a}	V^{2a}	IV^{1}	V^{2b}	V^{1}	V^{1}	III	IV^{+}									
Empetrum hermaphroditum **P. s.-L. s.**	IV^{+}	IV^{r}	V^{+}	V^{+}	V^{r}	V^{1}	V^{+}	V^{1}		1^{r}			I				
Cetraria islandica	IV^{+}	IV^{+}	II	IV^{+}	III	I		I									
Cladonia arbuscula	IV^{+}	V^{+}	V^{+}	V^{+}	III												
Diagnostic species of the Vaccinio–Piceetea																	
Pinus sibirica **P. s.-L. s.**	I	IV^{r}		V^{2a}	V^{1}	III	V^{2b}	III^{+}	V^{2a}	**2^{3}**	V^{2a}	V^{2b}	V^{2b}		IV^{+}	V^{+}	
Vaccinium vitis-idaea	V^{2b}	V^{2a}	V^{2b}	V^{3}	V^{2b}	V^{4}	V^{3}	V^{3}	V^{2a}	1^{r}	II	V^{+}	V^{1}		II		
Pleurozium schreberi	V^{+}	V^{+}	V^{1}	V^{2b}	V^{5}	V^{5}	V^{4}	V^{5}	V^{3}	1^{2a}	IV^{+}	II	V^{1}			I	
Ledum palustre **P. s.-L. s.**	II	IV^{1}	II	**V^{3}**	**V^{3}**	**V^{2b}**	V^{1}	V^{2b}		1^{r}	II	II	V^{2a}			I	
Vaccinium myrtillus	II	V^{+}		V^{1}	V^{1}	V^{1}	V^{3}	V^{1}	I	2^{r}		I	I			II	
Dicranum fuscescens	I	II	III	III	II	V^{+}	V^{r}	III^{+}	V^{r}		I	I	II				
Dicranum polysetum	III^{r}	IV^{r}	V^{+}	V^{+}	V^{1}	IV^{+}	V^{+}	V^{+}	I								
Diagnostic species of the Vaccinio uliginosi–Piceetum obovatae and Pino sibiricae–Laricion sibiricae																	
Vaccinium uliginosum **P. s.-L. s.**	I	II		III^{r}		V^{1}	I	III			II				II		
Carex globularis		II		II	III	IV^{+}		I	V^{r}								
Cladonia stygia		III	II	II	IV^{+}	I		II									
Picea obovata	II			I	II	V^{2b}	V^{2b}	IV^{+}	V^{3}	1^{r}	III	V^{2b}	V^{+}		II		
Larix sibirica	II		III			V^{1}	V^{1}	IV^{1}	IV^{2a}								
Hylocomium splendens	I					V^{1}	V^{2b}	IV^{+}	IV^{2b}				I				
Peltigera aphthosa					II	V^{+}	V^{+}	IV^{+}	I		I	I					
Ptilium crista-castrensis			II		II	III	III	III	V^{1}				I				
Linnaea borealis						II	V^{+}	II	IV^{+}			I					
Diagnostic species of the Pino sibiricae–Abietion sibiricae and Pino sibiricae–Abietetum sibiricae																	
Sorbus sibirica									IV^{+}	2^{1}	V^{+}	V^{1}	I				
Trientalis europaea									V^{+}	1^{r}	V^{1}	V^{+}	II	II	IV^{1}		
Rubus arcticus									IV^{+}		I	V^{1}	I	II			
Orthilia secunda									V^{+}		I	II	I				
Dicranum fragilifolium							I		V^{+}			I	III				
Maianthemum bifolium									III^{+}			II					
Goodyera repens						I	II		III^{r}								
Diagnostic species of the Sphagno girgensohnii–Pinetum sibiricae																	
Lycopodium annotinum						I		I	I	2^{+}			I				
Lycopodium clavatum										2^{+}	I		I				
Diagnostic species of the Pseudobryo cinclidioidis–Pinetum sibiricae and Sphagno fimbriati–Pinion sibiricae																	
Calamagrostis purpurea									II	2^{1}	**V^{3}**	**V^{2b}**	**V^{1}**	**V^{3}**	**V^{4}**	**V^{2a}**	**V^{4}**
Sphagnum girgensohnii									II^{r}	**2^{5}**	I	V^{2b}	V^{2b}			I	
Sphagnum fimbriatum											V^{3}	V^{2a}	V^{2a}	V^{3}	V^{3}	V^{3}	
Sphagnum squarrosum											V^{2a}	V^{2a}	V^{1}	V^{1}	V^{2a}		
Pseudobryum cinclidioides											IV^{+}	V^{1}	II	V^{1}	IV^{+}		V^{+}
Warnstorfia pseudostraminea											I	IV^{+}	V^{1}		II	I	III^{r}
Schljakovia kunzeana									I		IV^{+}	IV^{+}	V^{+}			I	III
Carex canescens									I	1^{r}	II	IV^{r}	I	II	IV^{+}	I	
Calliergon cordifolium											III	V^{1}	II	V^{1}	V^{1}	I	V^{2a}
Naumburgia thyrsiflora											II	IV^{+}		V^{1}	III	I	V^{+}
Galium trifidum											I	III^{r}		IV^{+}	II		V^{r}
Carex aquatilis											II	II	II	V^{1}	II	V^{2a}	V^{+}
Polytrichastrum longisetum									I		I	II			IV^{+}	II	III
Diagnostic species of the Oxycocco palustris–Pinetum sibiricae																	
Carex magellanica subsp.*irrigua*										2^{+}	I	I	V^{+}		II		
Sphagnum centrale											III	II	V^{2a}				
Sphagnum aongstroemii												I	IV^{+}				
Sphagnum russowii													V^{1}			V^{2a}	
Sphagnum angustifolium ***Ox-Sph***											I		V^{+}		III^{r}	V^{1}	
Sphagnum riparium												II	IV^{1}	II	II	III^{+}	
Diagnostic species of the community types																	
Betula nana		II				III^{+}		I		1^{+}	I	II	V^{1}	**V^{2b}**	III^{r}	I	
Carex rostrata ***Sch-Car***											I	I	I	V^{+}		II	
Calamagrostis neglecta														IV^{+}			
Salix myrtilloides															III^{r}		
Sphagnum fallax												I	II		II	V^{3}	
Salix dasyclados											I	I					V^{2a}
Epilobium palustre											I	II	I				V^{+}
Drepanocladus polygamus												I					V^{+}
Stellaria longifolia											I						V^{+}
Bryum cyclophyllum												I					V^{+}

Table 5. Continued.

Syntaxa number in Fig. 3 and 4	1a	1b	1c	2a	2b	3	4a	4b	5	8	6a	6b	7	10	9	11	12
Number in the table	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Viola epipsila											II	III^{r}					V^{+}
Plagiomnium ellipticum											I	II					III^{+}
Diagnostic species of the Scheuchzerio-Caricetea																	
Comarum palustre										1^{r}	V^{1}	V^{1}	V^{1}	V^{2a}	IV^{+}	I	V^{2a}
Carex chordorrhiza										2^{+}	II	II	V^{+}	IV^{+}	III	I	
Menyanthes trifoliata										1^{r}	III^{+}	V^{3}	V^{3}		III^{+}		
Andromeda polifolia		I								1^{r}	II	I	II	IV^{+}	II		
Straminergon stramineum										1^{r}	I	II	III^{+}		II		
Equisetum fluviatile												IV^{+}	IV^{+}			I	III
Diagnostic species of the Oxycocco-Sphagnetea																	
Rubus chamaemorus									I	2^{3}	V^{1}	IV^{r}	V^{1}		II	V^{2a}	
Chamaedaphne calyculata				I						1^{r}	I	II	V^{1}	V^{1}	II	II	
Oxycoccus palustris										2^{1}	II	II	V^{1}	IV^{+}	II	II	
Constant species																	
Betula pubescens	IV^{+}	II	III	V^{1}	V^{1}	V^{2a}	V^{2b}	V^{2a}	V^{3}	2^{3}	V^{3}	V^{2b}	V^{2a}	IV^{+}	V^{3}	V^{3}	V^{3}
Pohlia nutans	III	IV^{r}	V^{r}	III	II	IV^{r}	IV^{r}	III	V^{r}	1^{r}	IV^{+}	V^{+}	V^{+}		II	IV^{r}	III
Ptilidium pulcherrimum	III			III	V^{r}	V^{+}	V^{r}	V^{+}	V^{r}	1^{r}	IV^{+}	III^{r}	III^{+}		II	I	
Other species																	
Polytrichum strictum	I	II		II		IV^{r}	II	I	III	1^{+}	IV^{+}		II		II	III^{r}	
Polytrichum commune				I		II	III	I	IV^{+}	1^{r}	V^{1}	II	IV^{+}	II	IV^{2a}	V^{1}	
Sanionia uncinata						II			V^{+}	1^{r}	V^{+}	V^{+}	II		III^{r}		V^{+}
Aulacomnium palustre									II	2^{+}	III	III	IV^{+}		IV^{+}	I	
Lophozia silvicola						II			III		III	IV^{r}	IV^{+}			I	
Tetraphis pellucida				I			I		IV^{r}			III^{r}	IV^{+}				
Plagiothecium svalbardense						II		I	IV^{+}		I	I	III^{+}				
Lepidozia reptans									III			III	IV^{+}				
Scapania irrigua											I	III^{r}	II		II		
Warnstorfia fluitans											I	II	III^{+}	II	II		
Pyrola minor											I	II	I		IV^{r}		III
Salix lapponum											I	I		II	II	II	III^{+}
Oncophorus elongatus											I	IV^{r}	II				
Blepharostoma trichophyllum												III^{r}	I				
Calypogeia integristipula												III^{r}	III				
Cephalozia bicuspidata												IV^{r}	II				

minated by *Calamagrostis purpurea* with a mixture of *Carex aquatilis*. In low abundance, *Comarum palustre*, *Viola epipsila*, *Epilobium palustre*, *Galium trifidum*, and *Stellaria longifolia* are present. In sparse moss cover (10–30 %) under the dense herbaceous layer *Pseudobryum cinclidioides*, *Drepanocladus polygamus*, *Calliergon cordifolium*, and *Bryum cyclophyllum* occur.

Distribution and ecology. This type of community is found in birch-willow-*Sphagnum* swamp that was formed in a flat peat-filled basin of a former lake. The micro-relief is characterized by distinct hummocks formed by tussocks of sedges, covered with dense layer of *Calamagrostis*.

Prodromus of the forest and forest like vegetation of the class Vaccinio–Piceetea

The prodromus of the forest vegetation class Vaccinio-Piceetea provides a brief overview of the phytocenotic diversity of upland forests on mineral soils and swampy forests and wooded swamps with well-developed tree layer on peat soils in the Numto Nature Park.

Class
Order
Alliance
Association / Community type
Subassotiation
Variant

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

Pinetalia sylvestris Oberd. 1957

Cladonio stellaris–Pinion sylvestris K.-Lund ex Ermakov & Morozova 2011

Cladonio arbusculae–Pinetum sylvestris (K.-Lund 1967) Ermakov et Morozova 2011

typicum

typica

Vaccinium myrtillus

Cladona cornuta

Pinetum sibiricae–sylvestris ledetosum palustris Makhatkov & Ermakov 2010

typica

Pleurozium schreberi

Ledo palustris–Laricetalia cajanderi Ermakov in Ermakov et Alsynbaev 2004

Pino sibiricae–Laricion sibiricae Ermakov in Ermakov et Alsynbaev 2004

Vaccinio uliginosi–Piceetum obovatae **ass. nov.**

Ledo palustris–Pinetum sibiricae Ermakov et Makhatkov 2011

typica

Pinus sylvestris

Piceo obovatae–Pinetalia sibiricae Ermakov 2013

Pino sibiricae–Abietion sibiricae Ermakov in Ermakov et Lapshina 2013

Pino sibiricae–Abietetum sibiricae Ermakov & Makhatkov 2011

inops

Sphagno fimbriati–Pinion sibiricae **all. nov.**

Pseudobryo cinclidioidis–Pinetum sibiricae **ass.nov.**

inops

Sphagnum girgensohnii

Oxycocco palustris–Pinetum sibiricae **ass.nov.**

Sphagno girgensohnii–Pinetum sibiricae ass. prov.

Sphagno fimbriati–Betuletum pubescens ass. prov.

Sphagnum fimbriatum–Betula nana com. type

Carex aquatilis–Betula pubescentis com. type

Calamagrostis purpurea–Salix dasiclados com. type

DISCUSSION

We assign the vegetation of zonal dark coniferous and mixed forests of drained habitats on loamy soils, as well as pine forests on sandy soils, and swampy forest and wooded swamps with a well-developed tree layer in the Numto Nature Park, to the class Vaccinio–Piceetea.

The communities of pine lichen forests and dwarf shrub–lichen–green moss forests on dry sandy soils fully correspond to the previously described associations Cladonio arbusculae–Pinetum sylvestris and Pinetum sibiricae–sylvestris (Pinetalia sylvestris: Cladonio stellaris–Pinion sylvestris), which include all lichen and dwarf shrub-green moss–lichen pine woodlands within the subzone of northern taiga in Western Siberia. The assotiation Cladonio arbusculae–Pinetum sylvestris first described in Scandinavia (Kielland-Lund 1976) is widespread in the northern part of European Russia (Yermakov & Morozova 2011). It is also commonly found on dry sandy soils of river terraces and elevations of sandy fluvioglacial plains in the subzone of the middle and northern taiga of Western Siberia. The pine forests of the ass. Pinetum sibiricae–sylvestris, occupying moister and colder sandy soils, exhibit some specificity due to the constant presence of *Pinus sibirica* and *Carex globularis*, which are absent in Europe, and a more abundant occurrence of the moss *Pleurozium schreberi* in the forest floor, along with shrubby lichens. These forests are widely distributed mainly in the northern part of the forest zone of Western Siberia, with a slight penetration into the northeastern part of the European region.

More significantly the zonal dark coniferous and mixed forests in the northern part of Western Siberia differ from their northern taiga counterparts in the European part of Russia primarily in terms of the composition of tree species. The alliance Pino sibiricae–Laricion sibiricae (Ledo palustris–Laricetalia cajanderi) comprises the zonal communities of dark coniferous and mixed forests (*Pinus sibirica*, *P. sylvestris*, *Picea obovata*, *Larix sibirica*, *Betula pubescens*) in drained habitats of flat watersheds (uplands) on moderately moist clayey soils in the northern taiga and forest-tundra of Western Siberia. Within this alliance, we assign two associations: Ledo palustris-Pinetum sibiricae and Vaccinio uliginosi–Piceetum obovatae ass. nov.

In more favorable microclimatic conditions of river valleys, highly productive dark coniferous forests develop. Despite the absence of *Abies sibirica* and a reduced species composition of the ground cover, we classified them as the special variant inops within the ass. Pino sibiricae–Abietetum sibiricae (Pino sibiricae–Abietion sibiricae), which was previously described in the upper basin of the Taz River in the northeastern taiga zone of Western Siberia (Neshataev et al. 2002; Ermakov & Makhatkov 2011).

Based on the degree of dark conifers participation in the tree stand and the phytocoenotic activity of taiga species (mosses, grasses and shrubs), swampy forests and wooded swamps (sogres) on peat and peat-gley soils are physiognomically similar to the forests on drained moderately moist mineral soils.

In the southern part of Western Siberia, such boreal swampy forests and wooded swamps, vicariously replacing European alder swamps in continental Eastern Europe and Siberia, are considered as part of the specific order Calamagrostio purpureae–Piceetalia obovatae Lapshina 2010 within the class Alnetea glutinosae (Lapshina 2010, Lashchinsky et al. 2014, Lashchinsky & Pisarenko 2016). The justification for this decision lies in the consistent presence of diagnostic and affinitive species from the European class of alder forests, such as *Salix cinerea*, *S. pentandra*, *Frangula alnus*, *Ribes nigrum*, *Carex elongata*, *Calamagrostis canescens*, *Naumburgia thyrsiflora*, *Galium palustre*, *Calla palustris*, *Thelypteris palustris*, *Dryopteris cristata*, and *Sphagnum squarrosum*, in the vegetation cover of such swamps.

Northern taiga swampy forests and wooded swamps (sogras), exclusively located in the valleys of small rivers and streams, significantly differ in their floristic composition from the nutrient-rich wooded swamps of the southern part of the forest zone of Western Siberia. In the north, their habitats tend to be flooded or waterlogged in spring and summer by river and stream water, while their mineral nutrition throughout the year is provided by non-carbonate groundwater. As a result, not only thermophilic (temperate) representatives of the class Alnetea glutinosae are absent in their composition but also the vast majority of mineral-demanding diagnostic species described in the southern part of Western Siberia (Lapshina 2010). However, typical boreal species such as *Pinus sibirica*, *Picea obovata*, *Vaccinium vitis-idaea*, *Sorbus sibirica*, *Maianthemum bifolium*, *Pleurozium schreberi*, *Rubus arcticus*, and *Trientalis europaea* are preserved in their composition.

On the other hand, the significant presence of diagnostic species of mire vascular plants and mosses from the class Scheuchzerio–Caricetea, and in later stages of development, oligotrophic dwarf shrub species and *Sphagnum* mosses from the class Oxycocco–Sphagnetea, distinctly differentiates wooded swamp communities from zonal dark coniferous forests on mineral soils. Therefore, these communities can only be tentatively assigned to the alliance Pino sibiricae–Abietion sibiricae based on the dominant role of *Pinus sibirica* and *Picea obovata* in the tree layer and the presence of taiga herbaceous and moss species in ground cover.

At the current level of phytocenotic knowledge, we consider it more appropriate to distinguish the vegetation communities of swampy forest and wooded swamps in the northern regions of Siberia as a separate alliance, Sphagno fimbriati–Pinion sibiricae all. nov. Within the alliance, the associations Pseudobryo cinclidioidis–Pinetum sibiricae and Oxycocco palustris–Pinetum sibiricae correspond to different stages of development and replace each other in space as they move away from the river.

Within the same alliance, the tentatively assigned association Sphagno girgensohnii–Pinetum sibiricae includes communities, which are sporadically found throughout the taiga zone of Western Siberia and the north-eastern part of European Russia (Povarnitsyn 1944, Krylov 1961, Sambuk 1932), without occupying large areas anywhere. The synthesis and analysis of all available data collected within the dominant approach will provide a more comprehensive characterization of this syntaxon in the future.

The placement of birch swamp and swampy low birch–*Sphagnum* vegetation on poor acidic peat soils is still discussed within the system of higher syntaxa. In the Numto Nature Park, these birch swamps are represented by the provisional association Sphagno fimbriati–Betuletum pubescentis and three community types. On one hand, they show weak differentiation from the above-mentioned northern taiga communities of swampy forest and wooded swamps dominated by dark coniferous species in the tree layer, within the alliance Sphagno fimbriati–Pinion sibiricae, with which they share the constant presence of diagnostic species of the alliance: *Calamagrostis purpurea*, *Polytrichastrum longisetum*, *Schljakovia kunzeana*, *Sphagnum fimbriatum*, *S. squarrosum*, and *Warnstorfia pseudostraminea*. On the other hand, these community types lack or have very weak representation (constancy of I and II classes) of species typically found in dark coniferous and mixed forests of the class Vaccinio–Piceetea. This is due to the ecological conditions of their habitats in the zone of periodic flooding by poor waters from taiga rivers and lakes.

In system of floristic classification of vegetation in Europe, similar communities of birch swamps on mesotrophic peat are classified under the class Alnetea glutinosae Br.-Bl. et Tx. ex Weshoff et al. 1946, the order Sphagno–Betuletalia pubescentis Scamoni et Passarge 1959, and the alliance Betulion pubescentis Lohmeyer et Tx. ex Oberd. 1957 (Mucina et al. 2016).

However, we placed the communities of birch swamp forests and swampy sedge-*Sphagnum* low-birch woodlands on moderately poor acidic peat in the northern part of the forest zone of Western Siberia under the alliance Sphagno fimbriati–Pinion sibiricae of the order Piceo obovatae–Pinetalia sibiricae. We consider them within the class Vaccinio–Piceetea, taking into account the complete absence of species from the class Alnetea glutinosae in these communities.

As more data on the phytocenotic diversity of birch swamps and swampy low birch-*Sphagnum* vegetation of poor mesotrophic peat in the European part of Russia and Western Siberia are available, the affiliation of these communities to the alliance Sphagno fimbriati–Pinion sibiricae may be revised. It is more justified to classify them within the alliance Betulion pubescentis of the order Sphagno–Betuletalia pubescentis, while relocating the latter to the class of boreal forests, Vaccinio–Piceetea, despite the absence or weak presence of boreal coniferous species in the tree layer.

The current state of the order Sphagno–Betuletalia pubescentis and the alliance Betulion pubescentis within the class Alnetea glutinosae, which mainly includes European eutrophic alder and birch–willow swamp forests regularly flooded by nutrient-rich water appears somewhat artificial.

To confirm and visualize the classification results, an ordination of the identified syntaxa was performed using the t-SNE (t-distributed stochastic neighbor embedding) method (Fig. 3). This method allows for the visual representation of multidimensional feature space as compact clusters, corresponding to the syntaxa, but it does not provide a quantitative assessment of the similarity between them. The hierarchical clustering method was employed to determine the degree of similarity between the identified syntaxa and visualize the classification results in the form of a dendrogram (Fig. 4).

The statistical analysis of vegetation relevés confirmed the distinct species composition and structure of birch swamps and swampy low birch woodlands, which are separated at a high level from the swampy forest and wooded swamps of the alliance Sphagno fimbriati–Pinion sibiricae that includes dark coniferous species in the tree layer. However, within the class Vaccinio–Piceetea, both of these relevés groups form a distinct and well-differentiated cluster at the order level. They differ sharply from the zonal northern taiga dark coniferous and mixed forests (order Ledo palustris–Laricetalia cajanderi) and pine forests (order Pinetalia sylvestris) on mineral soils.

The dark coniferous forest communities of the ass. Pino sibiricae–Abietetum sibiricae (Piceo obovatae–Pinetalia sibiricae: Pino sibiricae–Abietion sibiricae) rare in the northern taiga subzone, represented by a small number of relevés, did not form a separate cluster (Fig. 4).

CONCLUSIONS

During the first stage of vegetation survey in the Numto Nature Park, located in the southern part of the northern taiga subzone of Western Siberia, a syntaxonomic diversity of zonal dark coniferous and mixed forests on on loamy soils, pine forests on sandy soils, as well as swampy forest and wooded swamps with a well-developed tree layer on peat deposits, has been established.

On processing the relevé tables 9 associations, 2 subassociations, 10 variants, and 3 community types were distinguished and assigned to 4 alliances and 3 orders within the class Vaccinio–Piceetea. Five associations were described for the first time, including 2 provisional ones. A new alliance, Sphagno fimbriati–Pinion sibiricae all. nov., was proposed within the class Vaccinio–Piceetea, compriing vegetation of swampy forest and wooded swamps in the valleys of small rivers and streams in the northern and middle taiga of Western Siberia. The communities of birch swamps and swampy sedge-*Sphagnum* low birch woodlands were preliminarily assigned to this alliance, despite the limited presence of dark coniferous species in the tree layer. Further accumulation of new data will allow for a more informed determination of their placement within the higher units of the class Vaccinio–Piceetea.

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LITERATURE CITED

Ermakov, N. & I. Makhatkov 2011. Classification and ordination of north boreal light-coniferous forests of the West Siberian Plain. *Plant Biosystems – An International Journal Dealing with all Aspects of Plant Biology* 145(1):199–207.

Ermakov, N. & I. Makhatkov 2011.Classification of northern boreal dark coniferous forests of the West Siberian Plain. *Annali di Botanica* 1:29–36.

Ermakov, N. & O. Morozova 2011. Syntaxonomocal survey of boreal ologotrophoc pine forests in northern Europe und Western Siberia. *Applied Vegetation Science* 14:524–536.

Ermakov, N.B. & E.D. Lapshina 2013. Syntaxa dark coniferous forests from southern taiga of West-Siberian Plain. *Vestnik Novosibirskogo gosudarstvennogo universiteta. Seriya Bioogiya, Klinicheskaya Meditsyna* 11(1):75–82 (in Russian). [Ермаков Н.Б., Лапшина Е. Д. 2013. Синтаксоны темнохвойных лесов из южной тайги Западно-Сибирской равнины // Вестник Новосибирского гос. ун-та. Сер. Биология, клинич. медицина. Т. 11, вып. 1. С. 75–82].

Ermakov, N.B. & V.B. Martynenko 2022. The higher units of dark coniferous forests of eastern part of Europe, Southern Urals and Western Siberia in the Braun-Blanquet system. *Rastitel'nost' Rossii* 44: 76–96 (in Russian with English summary). [Ермаков Н.Б., Мартыненко В.Б. 2022. Высшие единицы темнохвойных лесов восточной части Европы, Южного Урала и Западной Сибири в системе Браун-Бланке // Растительность России. № 44. С. 76–96].

Grebenyuk, G.N. & A.I. Tarasov 1996. *Types of Pinus sibirica forests of the Vakh River basin*. Izdatel'stvo Nizhnevartovskogo ped. instituta, Nizhnevartovsk (in Russian). [Гребенюк Г.Н., Тарасов А.И. 1996. Типы кедровых лесов бассейна реки Вах. Нижневартовск: Изд-во Нижневартовского пед. ин-та. 92 с.].

Ignatov, M.S., O.M. Afonina, E.A. Ignatova, A.A. Abolina, T.V. Akatova, E.Z. Baisheva, L.V. Bardunov et al. 2006. Check-list of mosses of East Europe and North Asia. *Arctoa* 15:1–130 (in Russian with English summary). [Игнатов М.С., Афонина О.М., Игнатова Е.А., Аболиня А.А., Акатова Т.В., Баишева Э.З., Бардуов Л.В. и др. 2006. Список мхов Восточной Европы и Северной Азии // Arctoa. Т. 15. С. 1–130].

Il'ina I.S., E.I. Lapshina & N.N. Lavrenko 1985. *Vegetation of the West Siberian Plain*. Nauka, Novosibirsk (in Russian). [Ильина И.С., Лапшина Е.И., Лавренко Н.Н. 1985. Растительный покров Западно-Сибирской равнины. Новосибирск: Наука. 251 с.].

Konstantinova, N.A., V.A. Bakalin, E.N. Andrejeva, A.G. Bezgodov, E.A. Borovichev, M.V. Dulin & Yu.S. Mamontov 2009. Checklist of liverworts (Marchantiophyta) of Russia. *Arctoa* 18:1–64.

Krylov, G.V. 1961. *Forests of Western Siberia*. Izdatel'stvo AN SSSR, Moscow, 256 c. (in Russian). [Крылов Г.В. 1961. Леса Западной Сибири. М.: Изд-во АН СССР. 256 с.].

Lapshina, E.D. 2010. *Vegetation of bogs in the south-east of Western Siberia*. Redaktsionno-izdatel'skiy tsentr NGU, Novosibirsk, 168 pp. (in Russian). [Лапшина Е.Д. 2010. Растительность болот юго-востока Западной Сибири. Новосибирск: Редакционно-издательский центр НГУ. 168 с.].

Lavrinenko, O.V. & I.A. Lavrinenko 2015. Communities of the class Oxycocco–Sphagnetea Br.-Bl. et R. Tx. 1943 in the East European tundras. *Rastitel'nost' Rossii* 26:55–84 (in Russian with English summary). [Лавриненко О.В., Лавриненко И.А. 2015. Сообщества класса Oxycocco–Sphagnetea Br.-Bl. et R. Tx. 1943 в восточноевропейских тундрах // Растительность России. № 26. С. 55–84].

Lavrinenko, O.V., N.V. Matveyeva & I.A. Lavrinenko 2016. Communities of the class Scheuchzerio–Caricetea nigrae (Nordh. 1936) Tx. 1937 in the East European tundras. *Rastitel'nost' Rossii* 28:55–88 (in Russian with English summary). [Лавриненко О.В., Матвеева Н.В., Лавриненко И.А. 2016. Сообщества класса Scheuchzerio–Caricetea nigrae (Nordh. 1936) Tx. 1937 в восточноевропейских тундрах // Растительность России. № 28. С. 55–88].

Matveyeva, N.V. 2006. Vegetation of the southern part of Bolshevik Island (Severnaya Zemlya Archipelago). *Rastitel'nost' Rossii* 8:3–87 (in Russian). [Матвеева Н.В. 2006. Растительность южной часть острова Большевик (архипелаг Северная Земля) // Растительность России. № 8. С. 3–87].

Makhatkov, I.D. & N.B. Ermakov 2010. The associations of the oligotrophic pine forests (Pinetum sibiricae–sylvestris) in the north boreal subzone of West Siberian Plain. *Vestnik Novosibirskogo gosudarstvennogo universiteta. Seriya Biologiya, klinicheskaya meditsyna* 8(3):152–159 (in Russian). [Махатков И.Д., Ермаков Н.Б. 2010. Ассоциация олиготрофных сосновых лесов (Pinetum sibiricae–silvestris) подзоны северной тайги Западно-Сибирской равнины // Вестник НГУ. Сер. биология, клиническая медицина. Т. 8, № 3. 152–159].

Maaten, L.V.D. van der. & G. Hinton 2008. Visualizing Data using t-SNE. *Journal of Machine Learning Research* 9: 2579–2605.

Mirkin, B.M. & L.G. Naumova 1998. *Vegetation science (history and current state of basic concepts)*. Gilem, Ufa, 410 pp. (in Russian). [Миркин Б.М., Наумова Л.Г. Наука о растительности (история и современное состояние основных концепций). Уфа: Гилем. 410 с.].

Moskovchenko, D.V. (ed.) 2017. *Park Numto: Nature and cultural heritage*. "Surgutneftegaz", Reklamno-izdatel'ski informatsionnyi centr "Neft' Priob'ya", Surgut, 150 pp. (шп Russian). [Парк Нумто. Природа и историко-культурное наследие / под ред. Д.В. Московченко. Сургут: ОАО "Сургутнефтегаз", Рекламно-издательский центр "Нефть Приобья". 2017. 150 с.].

Mucina, L., H. Bültmann, K. Dierßen, J.-P. Theurillat, T. Raus, A. Čarni, K. Šumberová, et al. 2016. Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. *Applied Vegetation Science* 19(1):3–264.

Neshataev, V.Yu. (ed.) 2002. *Vegetation, flora and soils of the Verkhne-Tazovskii State Reserve*. State natural reserve Verkhne-Tazovskii, Saint-Petersburg, 154 pp. (in Russian with English summary). [Растительность, флора и почвы Верхне-Тазовского государственного заповедника / под ред. В.Ю. Нешатаева. СПб: Государственный природный заповедник "Верхне-Тазовский". 2002. 154 с.].

Povarnitsyn, V.A. 1944. *Stone Pine forests of USSR* . Izdatel'stvo Sibirskogo Lesnogo Instituta, Krasnoyarsk, 220 pp. (in Russian). [Поварницын В.А. 1944. Кедровые леса СССР. Красноярск: Изд-во Сиб. лесн. ин-та. 220 с.].

Smagin, V.A. 1999. Vegetation of mesotrophic swamps, aapa bogs, erseys of lumpy bogs of northern European Russia. *Botanicheskii Zhurnal* 87(7):80–96 (in Russian). [Смагин В.А. 1999. Растительность мезотрофных топей, мочажин аапа-болот, ерсеев бугристых болот севера европейской России // Ботанический журнал. Т. 84, № 7. С. 80–96].

Sambuk, F.V. 1932. Pechora forests: Geobotanical essay. *Trudy Botanicheskogo Muzeya AN SSSR* 24:63–250 (in Russian). [Самбук Ф.В. 1932. Печерские леса: Геоботанический очерк // Тр. Ботан. музея АН СССР. Вып. 24. С. 63–250].

Shalatonov, E.N. 2004. Dwarf shrub-moss-lichen bogs of the Numto Nature Park. *Vestnik Ekologii, Lesovedeniya I Landshaftovedeniya* 5:144–147 (in Russian). [Шалатонов Е.Н. 2004. Кустарничково-мохово-лишайниковые болота природного парка Нумто // Вестник экологии, лесоведения и ландшафтоведения. Вып. 5. С. 144–147].

Shalatonov, E.N. 2009. Features of the swamps of the southwestern part of the Numto Nature Park. *Vestnik Ekologii, Lesovedeniya I Landshaftovedeniya* 9:191–194 (in Russian). [Шалатонов Е.Н. 2009. Особенности болот юго-западной части природного парка Нумто // Вестник экологии, лесоведения и ландшафтоведения. Вып. 9. С. 191–194].

Shalatonov, E.N. & D.V. Moskovchenko 2007. Typology and dynamics of marsh ecosystems of the Northern taiga of Western Siberia under the influence of the oil and gas complex (on the example of the Numto Nature Park). *Sibisrkii Ekologicheskiy Zhurnal* 6:933–943 (in Russia, English summary). [Шалатонов Е.Н., Московченко Д.В. 2007. Типология и динамика болотных экосистем северной тайги Западной Сибири в условиях воздействия нефтегазового комплекса (на примере природного парка Нумто) // Сибирский экологический журнал. № 6. С. 933–943].

Theurillat, J.-P., W. Willner, F. Fernández-González, H. Bültmann, A. Čarni, D. Gigante, L. Mucina & H. Weber 2021. International code of phytosociological nomenclature. 4th ed. *Applied Vegetation Science* 24(1):1–62.

Tolpysheva, T.Yu. & E.A. Shishkonakova 2022. Results and prospects of studying lichens of the Numto Nature Park. In: *The current state and prospects for the development of the nature protected areas network in industrially developed regions. Proceedings of the 2nd Russian Conference dedicated to the 25th anniversary of the Numto Nature Park*, pp. 116–122, Assorti, Yekaterinburg (in Russian). [Толпышева Т.Ю., Шишконакова Е.А. 2022. Итоги и перспективы изучения лишайников природного парка Нумто // Современное состояние и перспектива развития сети особо охраняемых природных территорий в промышленно развитых регионах: Материалы II Всероссийской конференции, посвященной 25-летию природного парка Нумто. Екатеринбург: Ассорти. С. 116–122].

Valeeva, E.I., D.V. Moskovchenko & S.P. Aref'ev 2008. *Numto Park Natural Complex*. Nauka, Novosibirsk, 208 pp. (in Russian). [Валеева Э.И., Московченко Д.В., Арефьев С.П. Природный комплекс парка Нумто. Новосибирск: Наука. 280 с.].

Valeeva, E.I., V.A. Glazunov, E.A. Shishkonakova, E.A. Ignatova & T.Yu. Tolpysheva 2017. Flora composition. Rare, protected species. In: *Park Numto: Nature and cultural heritage* (D.V. Moskovchenko, ed.), pp. 20–43, "Surgutneftegaz", Reklamno-izdatel'ski informatsionnyi centr "Neft' Priob'ya", Surgut (in Russian). [Валеева Э.И., Глазунов В.А., Шишконакова Е.А., Игнатова Е.А., Толпышева Т.Ю. 2017. Флористический состав. Редкие, подлежащие охране виды // Парк Нумто. Природа и историко-культурное наследие / под ред. Д.В. Московченко. Сургут: ОАО "Сургутнефтегаз", Рекламно-издательский центр "Нефть Приобья". С. 20–43].

Westhoff, V. & E. van der Maarel 1978. The Braun-Blanquet approach. In: *Classification of plant communities* (R.H. Whittaker, ed.), pp. 287–399, The Hague.

Zverev, A.A. *2007. Information technology in vegetation research.* Izdatel'stvo Tomskogo gosudarstvennogo universiteta, Tomsk, 304 pp. (in Russian). [Зверев А.А. Информационные технологии в иссследованиях растительного покрова. Томск: Изд. Томского государственного университета. 304 с.]..