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# Vegetation of Lishkmokh mire in Vodlozersky National Park, eastern Karelian republic, Russia

## Karjalan tasavallan Vodlajärven kansallispuistossa sijaitsevan Lishkansuon kasvillisuus

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The article presents the results of Finnish–Karelian co-operation in mire conservation research with the aim to study the diversity of mires in Finland and Russian Karelia on a uniform basis. The classification of mires in Finnish and Karelian schools of vegetation science has been compared. The vegetation of Lishkmokh mire has been studied using aerial photographs and field surveys. The area consists of ombrotrophic bog complexes as well as aapamires, all in a totally virgin state. As a result of the surveys, two maps of vegetation have been compiled. Results of vegetation analyses in releves have been presented in the form of tables and DCA ordination. According to the Finnish mire classification, 32 mire site types have been distinguished, which is a high number in an area of ca. 2 000 ha. On the basis of the high diversity of site types, and the occurrence of some rare plant species, e.g. *Juncus stygius, Drepanocladus vernicosus* and *Meesia triquetra* as well as some eastern species like *Rubus humulifolius* and *Polygonum bistorta*, the conservation value of Lishkmokh mire can be considered as very high.

Key words: Karelia, mire classification, mire conservation, mire vegetation

## INTRODUCTION

The Karelian school of mire science was formed by the middle 1970s. It was founded by E. Galkina, N. Pyavchenko and V. Lopatin, and developed further by G. Elina and R. Kozlova. They considered a mire as a specific natural object characterized by a constant or a long-term abundant moisture regime, predominance of hygrophilic vegetation, and peat accumulation.

Microcenosis, phytocenosis, mire sites, mire massifs and systems are major territorial objects (units) of mire vegetation in different scales (Yurkovskaya 1995). They all have boundaries and are under the influence of certain major factors that condition their characteristics and structure.

In the Finnish school of mire science, mire sites and mire complex types have been defined (Cajander 1913, Ruuhijärvi 1983, Eurola et al. 1984). Microsites have not been studied, and the idea of mire systems has only seldom been taken into account (Tolonen 1967a).

One of the main objects of investigation in both mire science schools is a mire massif (Galkina 1946) or mire complex (Cajander 1913). Mire systems are limited by mineral land and water. The basin form, as well as geological and hydrological conditions of the site, determine the characteristics and dynamics of water–mineral nutrition of mire vegetation.

Depending on the structure and dynamics of plant cover and geographical distribution of mires, 15 regional types of mire massifs are distinguished in Karelia (Yurkovskaya 1980a). In Finland, eight zones of mire vegetation are distinguished, in each zone one type of mire complex dominating. The zones have been divided into 15 subzones and sections which correspond to the regional units of Karelian mire classification (Ruuhijärvi 1982, 1983, Ruuhijärvi & Hosiaisluoma 1988).

Kats (1948) distinguished oligotrophic eccentric ridge–hollow Pechora–Onega bogs as a separate raised bog type. The river Vyg and Lake Onega (Eastern Karelia) form their distribution limit in the west and the Ural mountains in the east. The southern boundary lies approximately at a latitude of 60° N. In the north, they spread in some places as far as the polar circle, to the northern limit of the northern taiga. Communities of paludified forests formed in the mire massifs enrich the bog flora. The bogs have a slightly domed surface. In the central area, ridge–hollow and ridge–hollow–pool mire sites are formed. *Sphagnum fuscum* is dominant on the ridges (the nomenclature follows Hämet-Ahti et al. (1986) for vascular plants and Koponen et al. (1977) for bryophytes). *Sphagnum balticum* and *S. majus*, sometimes *S. lindbergii*, predominate in the hollows. *Carex pauciflora* and *Melampyrum pratense* occur rather often in the bogs. The ridges of these bogs are very forested, especially compared with the other oligotrophic *Sphagnum* bog types. The distribution of Onega–Pechora aapa mires coincides with the area of Pechora–Onega bogs. One or another mire massif type prevails within the area. They are often combined and form compound mire systems. Onega–Pechora aapamires as a type of aapamire were first distinguished and studied by Kats (1928) in the Pechora valley.

Later, the vegetation and the stratigraphy of the peat-deposit of these mires were studied in the Komi Republic (Alekseeva 1974). Onega–Pechora aapa mires, as well as mires of the Karelian aapa type, have a concave surface. All their central area is covered by string–flark, string–pool or flark mire sites. Flarks without moss cover, with *Equisetum fluviatile*, *Menyanthes trifoliata* and *Utricularia intermedia,* are widespread. There are also hollows with *Sphagnum majus, S. annulatum* var. *porosum, Carex limosa* and *Scheuchzeria palustris*. Communities with *Sphagnum papillosum*, *Carex lasiocarpa* and *Trichophorum cespitosum* are typical on strings, hummocks and carpets. In Karelia, these mire complex types have not been studied earlier.

While carrying out geobotanic investigations within mire massifs, the sites, more homogeneous in ecology and vegetation, are distinguished and called mire facies (after Lopatin 1954) by many Russian researchers. Mire facies are not considered as phytocenotic territorial units of vegetation (Lopatin 1980). The low facies boundary is set on an active horizon (acrotelm), in swamps on the distribution boundary of living roots. The horizontal extent of facies is determined by the plant cover, i.e. on the basis of boundaries of phytocenoses or their complexes. As a whole, the term mire facies corresponds to mire site used by Finnish investigators (Ruuhijärvi 1960, Eurola 1962, Ruuhijärvi 1983, Eurola et al. 1984, 1994).

Simple and complex facies are distinguished in the Karelian mire science school. In facies of complex structure, various types of surface microforms are clearly separated: hummocks, ridges, pools and hollows, which regularly alternate in space. Here the plant cover is presented by a complex of associations of different plant formations. The surface form of simple structured facies is usually flat, and plant associations correspond to the same formation. In Finnish mire site typology, similar division is also made.

Classification of mire facies is based on the genesis of mires. In typological classification, facies of different areas which have a similar structure of plant cover and the same type of water–mineral nutrition are unified (Lopatin 1954, Elina 1968, Kozlova 1974). Major elements of spatial structure of facies plant cover are microcenosis and phytocenosis (Lopatin 1980).

Facies (mire sites) can be classified in different ways. Finnish mire scientists, for example, distinguish 25–35 types of mire sites for practical purposes such as vegetation mapping or mire assessment for forestry (e.g. Laine & Vasander 1990), and 60–80 types for more detailed research needs (Ruuhijärvi 1960, 1983, Eurola & Kaakinen 1979, Eurola et al. 1984, 1994). Galkina (1964) has described mire facies in Karelia. The characteristics and structure of mire facies of the southern White Sea coast type are given in Elina (1971) and Yurkovskaya (1970).

Data on facies composition and the structure of facies of the Karelian aapa mire massifs are given in a number of publications (Elina & Kuznetsov 1977, Antipin 1980, Kuznetsov 1980, 1982). Specialists on Karelian resources make a detailed description of facies using medicinal and berry plants (Yudina et al. 1986). Antipin (1991) gives a detailed classification and structure of oligotrophic mire facies distinguished in Karelian mires by different investigators. It is rather difficult to compare the results of these studies with the data obtained for other regions of Russia and Finland because of the lack of initial geobotanic descriptions of facies. However, the term oligotrophic in Karelian classification corresponds to ombrotrophic in the Finnish system. In Karelian classification, dystrophic sites are defined as ombrotrophic mires where accumulation and decomposition of peat seem to be in balance. Accordingly, minerotrophic sites are divided into mesotrophic and eutrophic in Karelian classification, and oligotrophic, mesotrophic and eutrophic in the Finnish school. Thus, eutrophic mire sites in Karelian classification are divided into mesotrophic and eutrophic in the Finnish school, while the Karelian mesotrophic sites correspond to oligotrophic in the Finnish system (Table 1).

The present study is a part of the Finnish–Karelian co-operation in mire conservation research. The general goal of the project, covering the period 1992–1996, was to study the diversity of mires in Finland and in Karelia to obtain uniform knowledge about the area where the natural conditions influencing the development of mires are more or less similar. Another aim was to study the state of mire nature and mire conservation: how well do the East Fennoscandian nature reserves protect the diversity of mires in the area? As a conclusion, the project aimed at producing information as a basis of joint mire conservation assessment and planning for the national park. To produce joint information, a common understanding of the classification of mire systems, complexes and site types is necessary. Therefore, joint field work was conducted annually since 1992, and two joint seminars were arranged (Botch & Kuznetsov 1991, Heikkilä 1995).

The aim of this study was to compare the Finnish and the Karelian field methods and vegetation classification, to study the structure and the composition of peat deposits in some typical mires of the Vodlozerski National Park, and to assess their biodiversity. The data will be used for the functional zoning of the national park. It is projected to organize a network of excursion routes and to reserve territories for preserving typical and unique landscapes, and the flora and fauna of the taiga zone of the European North.

## MATERIALS AND METHODS

### Study area

The Vodlozersky national park is one of the largest in Russia and Europe. It was established in 1991. It is on the territory of eastern Karelia (Pudozh district) and the western part of the Ark-

Table 1. Correspondence of different nutrient levels in Finnish and Karelian schools of mire research.

*Taulukko 1. Ravinteisuustasojen vastaavuus karjalaisessa ja suomalaisessa suontutkimuskoulukunnassa.*

| Karelian – *Karjalainen* | Finnish – *Suomalainen* |
|---|---|
| Dystrophic, Oligotrophic | Ombrotrophic |
| Mesotrophic | Oligotrophic |
| Eutrophic | Mesotrophic, Eutrophic |

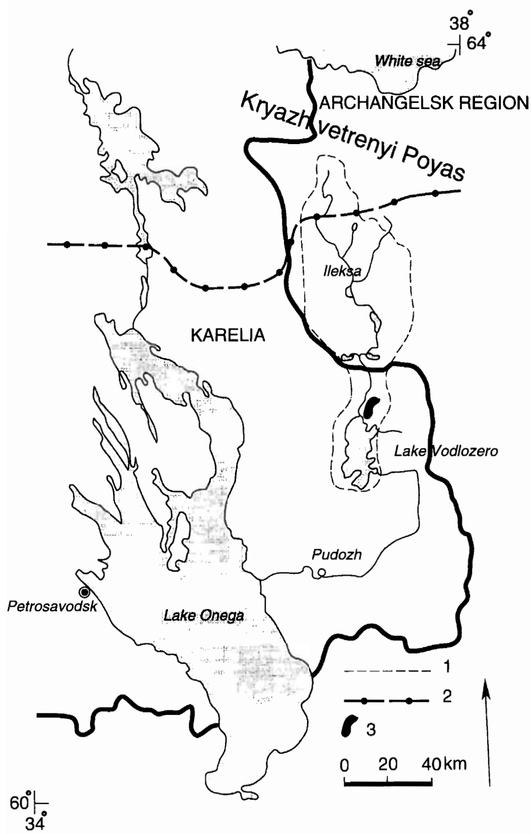



Fig. 1. Location of the National Park Vodlozersky. 1) The boundary of the national park, 2) The boundary between northern and middle subzones of taiga, 3) Lishkmokh mire.

*Kuva 1. Vodlajärven kansallispuiston sijainti. 1) Kansallispuiston raja, 2) Pohjoistaigan ja keskitaigan raja, 3) Lishkansuo.*

hangelsk region (Onega district). About two thirds of the park's area is in the Arkhangelsk region (Fig. 1). The park was founded to preserve a unique area of the taiga zone of northern Europe and revive the cultural–historical heritage of the Russian North. Mires make up about 40% of its territory.

The territory of the park extends from the north to the south for 150–160 km and from the west to the east for 40–50 km. The total area of the park makes up 467 thousand hectares.

The climate of the region is moderate–continental. The annual average air temperature is about + 1.5°C. The average temperature in January is – 11.5°C, in July + 16°C. Annual precipitation is 650–700 mm; about 55% occurring in the warm period of the year (May–September).

Evatransporation makes up 300–350 mm (Semenov et al. 1983). The amount of precipitation and evaporation increases from the north to the south. A late protracted spring and long autumn is characteristic of the region. The length of the growth period is 140–150 days, and the period of active vegetation is 100–110 days long (Romanov 1961). The average snow cover is 60–65 cm thick, and is usually formed in early November, melting in late April.

The national park of Vodlozero lies in the eastern part of the Baltic crystalline shield. The crystalline basement is covered practically everywhere by a bulk of loose quarternary glacial sediments (Iljin et al. 1992).

The southern slopes of the mountain-ridge Kryazh Vetrenyi Poyas (Windy Belt) are in the northern part of the park. The absolute maximum heights in this region of the park reach 300 m above sea level.

The major part of the park's territory is a very highly paludified hilly plain, the surface of which is inclined from the north to the south towards Lake Vodlozero. Drumlin moraine plains, hilly and hilly–ridge moraine plains, dome–ridge-annular formations, glacial-dividing heights as well as different forms of glaciofluvial relief are present here (Iljin et al. 1992). The absolute heights vary from 200 m (foot of the Windy Belt ridge) to 140 m in Lake Vodlozero.

Soils in the park are mainly poor sandy and loam illuvial-iron–humus and surface-gley podzols. Peat and peat–gley soils are formed in paludifield sites (Panov et al. 1980).

The number of plant species in the region is rather low and differs from other regions of Karelia in the presence of eastern plant species (Tsinzerling 1934, Yakovlev & Voronova 1959). These include, for example, *Larix sibirica*, *Cornus alba, Salix pyrolifolia, Trisetum sibiricum, Rubus humulifolius, Alchemilla sarmatica* and *Clematis alpina* subsp. *sibirica*.

Two latitudinal subzones, the northern and middle taiga, intersect the park. The northern taiga forests cover ca. 10 % of the park area in the northern part of the park (Fig. 1). They are formed by communities of *Pinetum empetroso–vacciniosum* and *Piceetum empetroso–myrtillosum*. Mire dwarf-shrubs *Ledum palustre, Empetrum nigrum, Betula nana* and *Vaccinium uliginosum* are present in the plant cover of these forests. In the subzone of middle taiga, mire dwarf-shrubs are not found in the forests or they are very rare. There the forests are formed by associations of *Pinetum vacciniosum, Pinetum myrtillosum* and *Piceetum myrtillosum*. The spruce-dominated taiga forests cover ca. 40% of the park's territory.

Mires, equally with forests and water ecosystems, are an integral part of the park's natural landscape. The degree of paludification is 40%, and the total mire area is 230 000 ha. The park's mires belong to the Pechora–Onega type of oligotrophic ridge–pool bogs (Kats 1948). The peculiar features of this bog type are: 1) a high degree of paludification, 2) predominance of oligotrophic (raised) bogs and slightly decomposed *fuscum*-peat in their deposits, and 3) the prevalence of communities with *Sphagnum fuscum*, lichens, *Sphagnum balticum* and *Scheuchzeria palustris*. When compared with the Finnish classification of mire complexes, eccentric bogs are typical in the southern part of the park, and southern aapamires of Pohjanmaa type elsewhere (Ruuhijärvi 1983)

The first research of the park's mire ecosystems was carried out in 1987 by Dr. V. K. Antipin and P. N. Tokarev. Four major types of mire massifs were distinguished (Table 2). In the process of the development during the Holocene, most of the park's mires were combined together and mire systems consisting of different mire massif types were formed. The Lishkmokh mire is an example of such a mire system. It consists of large aapamires and eccentric bogs. In the margins there are pine mires. The mire area totals 2 050 ha (Fig. 1).

The Lishkmokh mire's basin was formed in the post-glacial period and presents a shallow depression (of 2–3 m depth) in the lake-glacial plain. The bottom of the mire basin is composed of sands and sandy loams. In the western and eastern parts the basin is fringed with two morain ridges, 5–6 m above the mire surface.

In addition to the Lishkmokh mire, a small (ca. 30 ha) rich fen beside the river Ileksa was studied. It is situated below a sandy terrace and groundwater surfaces in the forms of springs and seepage in many places. There are open and wooded spring mires of different types. Closer to the river there are also spruce mires with a marked influence of floods, with abundant *Carex rhynchophysa*. Also the vegetation of a mire complex on the western side of the river facing the Lishkmokh mire was studied, but not mapped, in detail.

## Methods

In studying the vegetation and structure of the Lishkmokh mire, both the field methods and black-and-white aerial photographs (scale 1:11 000), which are traditional and similar meth-

Table 2. Types of mire massifs in the National park Vodlozersky (nomenclature by Yurkovskaya 1980a).

*Taulukko 2. Vodlajärven kansallispuiston suoyhdistymätyypit (nimistö Yurkovskayan 1980a mukaan).*

| Type of mire massif<br>*Suoyhdistymätyypit* | Total area – *Pinta-ala*<br>1 000 ha | % | Prevalent mire sites<br>*Yleisimmät kasvupaikkatyypit* |
|---|---|---|---|
| Oligotrophic eccentric ridge-hollow Pechora–Onega bog | 103.5 | 45 | *Pineto–Sphagneta fusci + Sphagneta baltici; Pineto–Sphagneta fusci* +pools |
| Oligotrophic pine–dwarf shrub–cotton grass–*Sphagnum* north-eastern-European bog | 23.0 | 10 | *Pineto–Sphagneta angustifolii*<br>*Pineto–Sphagneta fusci* |
| Onega–Pechora aapa mire | 80.5 | 35 | *Cariceta + Sphagneta; Sphagneta papillosi + Cariceta; Sphagneta papillosi + Sphagneta fusci; Cariceta* |
| Mesotrophic herb–*Sphagnum* mire | 23.0 | 10 | *Sphagneta fallaxi* |
| Total | 230.0 | 100 | |

ods in the Finnish and Karelian mire science schools, were used.

Mire sites (or mire facies) were first distinguished according to the method of Galkina (1962) on the basis of the deciphering features. Most of them were studied in the field. The forms of mire site microrelief were revealed in the course of geobotanic description. Dominant plant communities were distinguished for each microrelief form and described in the field. Species composition of the plants and the cover percentage of each plant species were described. The Karelian participants made vegetation descriptions estimating the cover percentages in an area of 100 $m^2$ separately for different microrelief levels, while the Finnish participants prepared descriptions for five randomly placed quadrats of 1 $m^2$ in each mire site using the cover percentage scale of Heikkilä (1987).

To compare the results of the vegetation studies, DCA ordination of joint materials was made. To minimize the influence of different sizes of sample plots and different scales in estimating percentage cover, log-transformation and downweighting of rare species were made, using the latest version of DCA (Hill 1979, Oksanen & Minchin 1997).

A map of mire sites was made on the basis of aerial photographs of the mire, generalized in the scale 1:50 000, according to both Karelian and Finnish schools.

The hydrological map was compiled according to Ivanov's method (1975) in the scale 1:50 000. The mire hydrological network is rather easily traced in aerial photographs.

In order to study the past dynamics of mire vegetation, peat samples were taken for analysis of the botanic composition and the degree of decomposition. The cores were taken from peat deposits in three places in the dominant mire sites (*sensu* Karelian school): oligotrophic *Pineto–Sphagneta fusci* + *Sphagneta baltici*, mesotrophic *Sphagneta fallaxi* + pools and mesotrophic *Sphagneta* + *Cariceta*. The sampling was carried out in different microrelief forms of the mire sites using the INSTORF's bore, which is also called the Russian peat corer (Tolonen 1967b). The macrosubfossil analyses of peat were done in the Laboratory of Mire Ecosystems at the Biological Institute of the Karelian Research Center, the Russian Academy of Sciences, by N. Stoikina.

## RESULTS AND DISCUSSION

### Conditions determining the hydrological characteristics of the mire

The actual surface elevations of the Lishkmokh mire are 145 m in its northern and central parts and 146–147 m in its southern end. In the southern part of the mire basin lies the water divide (147.5 m above sea level). It divides the soil-groundwater and surface water runoff in two directions: northern and southern (Fig. 2).

Northward the central runoff is to Lake Lishkozero, the Novguda stream and then to the river Ileksa. According to the classification of Galkina (1959), this mire area belongs to the class of effluent basin. Here, the underground and deluvial water comes along the whole widened margin of the mire and the discharge is only through its narrowed northern part. This type of intake and runoff may cause periodic water stagnation, especially during summer and autumn floods. Besides, despite the significant gradient of the mire surface, the runoff is retarded by the presence of mineral islands and a rise of the basin mineral bottom in the narrowed area of the mire. As a result, running-water and slight running-water swamps are formed in the central area, and stagnant-water swamps in the western marginal areas (Fig. 2).

The southern part of the Lishkmokh mire belongs to the class of lakeside floodplains (Galkina 1959). Lake Gauzhozero (area ca. 300 ha), linked with the river Ileksa by the stream Gauzha, determines the hydrologic regime. The lake has a drainage effect on this area. Radial mesotrophic running-water swamps with oligotrophic (*sensu* Karelian classification) bogs between them are formed in the southern part of the mire. Summer and autumn floods of the river Ileksa, when the water level rises up to 2 metres, cause waterlogging of the lake's shoreline and the formation of stagnant swamps (Fig. 2).

### The mire complexes of the Lishkmokh mire

The Lishkmokh mire is a compound mire system (or complex *sensu* Ivanov 1975) including two types of mire massifs (or mire complexes *sensu*

Ruuhijärvi 1983): oligotrophic eccentric ridge–hollow Pechora–Onega bog and Onega–Pechora aapamire. The bog is situated in the southern part of the mire where oligotrophic ridge–hollow mire sites predominate. Here, the hydrologic regime depends on the water table fluctuations in the Gauzhozero lake which is the intake of surface and soil–underground runoff from this area of the mire system. An Onega–Pechora aapa mire has been formed in the northern part of the system. The mire massifs are combined together into a single system and the watershed line is a conventional boundary there at present (Fig. 2).

According to the Finnish classification of mire complexes (Ruuhijärvi 1983), the northern part of the Lishkmokh mire greatly resembles the southern aapamires of Pohjanmaa type, and the southern part of the nearby Lake Gauzhozero eccentric bogs of the Finnish Lake District.

## Vegetation of the Lishkmokh mire

In the Lishkmokh mire, vegetation patterns were preliminarily delimited using aerial photographs. In the field, the boundaries were confirmed and site types were defined. This was done independently according to the Karelian and Finnish schools. Fifteen types of mire sites were distinguished in the mire system of the Lishkmokh mire according to the Karelian classification (Fig. 3, App. 1) and they are dealt with in the following chapters. They are united in four groups according to the plant cover and water–mineral nutrition: fens, flark fens, swamps and bogs. According to the Finnish mire site classification (Ruuhijärvi 1983), 20 site types were found in the Lishkmokh mire. They belong to bogs, fens and combination site types. No spruce mires or rich fens were found. In addition, 12 more site types, mainly rich fens and spruce mires were distinguished in the small mire between the Lishkmokh mire and the river Ileksa (Fig. 4). In the rich fens, the rare moss species *Drepanocladus vernicosus* and *Meesia triquetra* were found, as was the eastern vascular plant species *Polygonum bistorta* in the rich fen, and *Rubus humulifolius* and very abundant *Carex rhynchophysa* in the spruce mires.

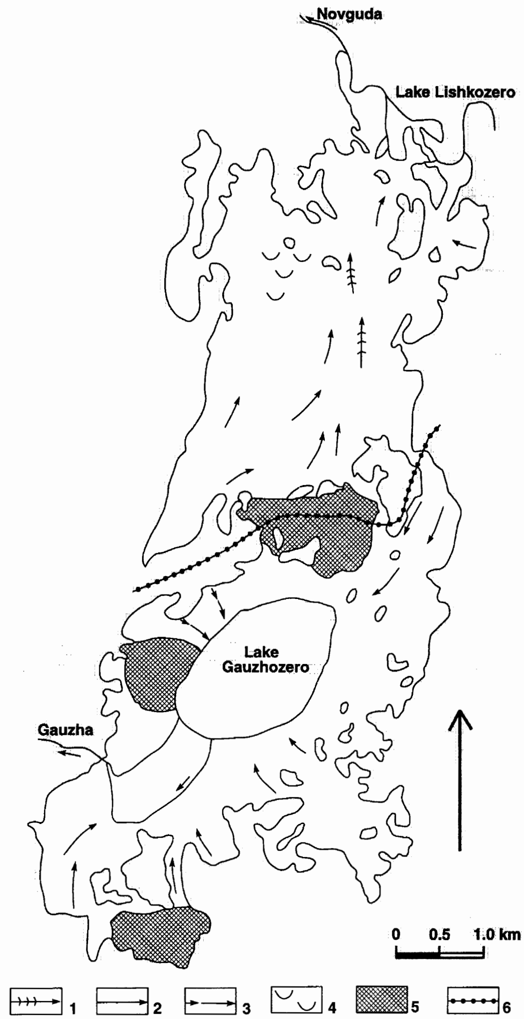



Fig. 2. Hydrological map of the Lishkmokh mire: 1) mesotrophic and meso-eutrophic patterned water tracks, 2) mesotrophic and meso-oligotrophictrophic featureless water tracks, 3) oligotrophic water tracks, 4) pools, 5) ombrotrophic sites, 6) water divide.

*Kuva 2. Lishkansuon hydrologinen kartta: 1) mesotrofiset ja mesoeutrofiset vedenvirtausjuotit, joissa on rimpi- ja jännerakenne, 2) mesotrofiset ja meso-oligotrofiset rakenteettomat vedenvirtausjuotit, 3) oligotrofiset vedenvirtausjuotit, 4) avovesirimmet, 5) keidassuot, 6) vedenjakaja.*

### *Fens*

This group includes mire sites of simple structure with rather homogeneous plant cover and slight surface differentiation by microrelief elements.


Novguda
Lake Lishkozero
Lake
Gauzhozero
Gauzha
0 0.5 1.0 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

These mire sites have a similar (smooth) surface pattern on black-and-white aerial photographs and the pattern tone ranges from grey to dark grey, nearly black.

Mesotrophic *Herbeto–Sphagneta* (HS) mire sites are found only in the northern mire area, where they form strips along the Novguda river and Lishkozero lake. They are inundated during the spring flood. The inundation period is not long and does not hamper the *Sphagnum* cover development. Communities with *Sphagnum obtusum* and *S. papillosum* prevail in the plant cover. *Sphagnum centrale* and *S. magellanicum* are dominant in low hummocks, which cover about 10% of the sites. Various sedge species, typical for riverside mires, grow there: *Carex elata* subsp. *omskiana* and *C. acuta* (Table 3). *Betula nana* and *Salix* species are abundant at the sites. In the Finnish classification (Ruuhijärvi 1983), the site type corresponds to herb-rich sedge fen (RhSN) which often has a sparse tree cover (RhNR).

Meso-eutrophic *Cariceta* (C) mire sites are found in the northern part of the mire. It is a very wet *Carex–Menyanthes* swamp where small *Sphagnum* carpets formed by the mesotrophic *Sphagnum flexuosum* occur. *Carex limosa, C. chordorrhiza, C. lasiocarpa* and *Menyanthes trifoliata* are indicator species of these sites. Synusia of the eutrophic *Sphagnum teres* and *S. subsecundum* are found in the swamp habitats. Unlike the eutrophic *Herbeta* mire sites, spread in Karelian fens, the species composition of *Bryales* is poor there. We found the most eastern habitats of *Juncus stygius* in Karelia in meso-eutrophic *Cariceta* mire sites. The site type corresponds to herb-rich sedge fen (RhSN) and herb-rich flark fen (RhRiN) in the Finnish classification.

Mesotrophic *Spagneta fallaxi* (SFa) mire sites are widespread in the Lishkmokh mire margins. The site surface is flat with *Sphagnum* hummocks and sometimes with flarks. The moss cover of the sites is continuous. Together with *Sphagnum fallax, S. papillosum, S. majus* and *S. riparium* grow in the site type. *Sphagnum angustifolium* and *S. magellanicum* are common in the hummocks. Dwarf shrubs are abundant in the hummocks and carpets as well, but the most visible plant species of these mire sites is *Carex rostrata*. In the Finnish classification, this site type corresponds to sedge fen (SN).

Mesotrophic *Menyantheto–Sphagneta maji* (MSM) mire sites are found in the central part of the Lishkmokh mire. They occur in *Sphagnum* water tracks which have a nearly black tone on black-and-white aerial photographs. In addition to *Menyanthes trifoliata* and *Sphagnum majus*, synusia of *S. papillosum, S. annulatum* var. *porosum* and *S. fallax* are also found in the site type. *Sphagnum magellanicum, S. fallax* and *S. angustifolium* are usual on the low hummocks. This site type corresponds to *Sphagnum* flark fen (RiN) and small sedge *Sphagnum papillosum* fen (LkKaN) in the Finnish mire classification.

Meso-oligotrophic *Sphagneta maji* (SM) mire sites are patterned water tracks (*sensu* Glaser et al. 1981) of the Lishkmokh mire with the entire moss cover formed by *Sphagnum majus*. *Menyanthes trifoliata* is rare or does not grow here. Hummocks with *Eriophorum vaginatum* and *Sphagnum angustifolium* are usual in the patterned water tracks. *Carex limosa* and *Eriophorum vaginatum* are the site indicators. This site type corresponds to *Sphagnum* flark fen (RiN) in the Finnish mire classification.

### *Flark fens*

This group includes mesotrophic and meso-eutrophic mire sites of complex structure with

Fig. 3 (Opposite). Distribution of mire sites in the Lishkmokh mire: 1) M *Herbeto–Sphagneta*, 2) ME *Cariceta*, 3) M *Sphagneta fallaxi*, 4) M *Menyantheto–Sphagneta maji*, 5) MO *Sphagneta maji*, 6) M + ME *Sphagneta + Cariceta*, 7) MO *Sphagneta fallax + Sphagneta maji*, 8) ME *Pineto–Mixtosphagneta*, 9) M *Pineto–Sphagneta angustifolii*, 10) O *Pineto–Sphagneta angustifolii*, 11) O *Pineto–Sphagneta fusci*, 12) O *Pineto–Sphagneta fusci + Sphagneta baltici*, 13) O *Sphagneta maji + Sphagneta angustifolii*, 14) *Sphagneta angustifolii*; 15) lakes, 16) mineral islands, 17) coring sites (see Fig. 6). M = mesotrophic, ME = meso-eutrophic, MO = meso-oligotrophic, O = oligotrophic.

*Kuva 3 (Vasemmalla). Lishkansuon suotyypit karjalaisen koulukunnan mukaan: 1)–14) ks. yllä, 15) järvet, 16) kivennäismaasaaret, 17) kairauspisteet (ks. Kuva 6).*

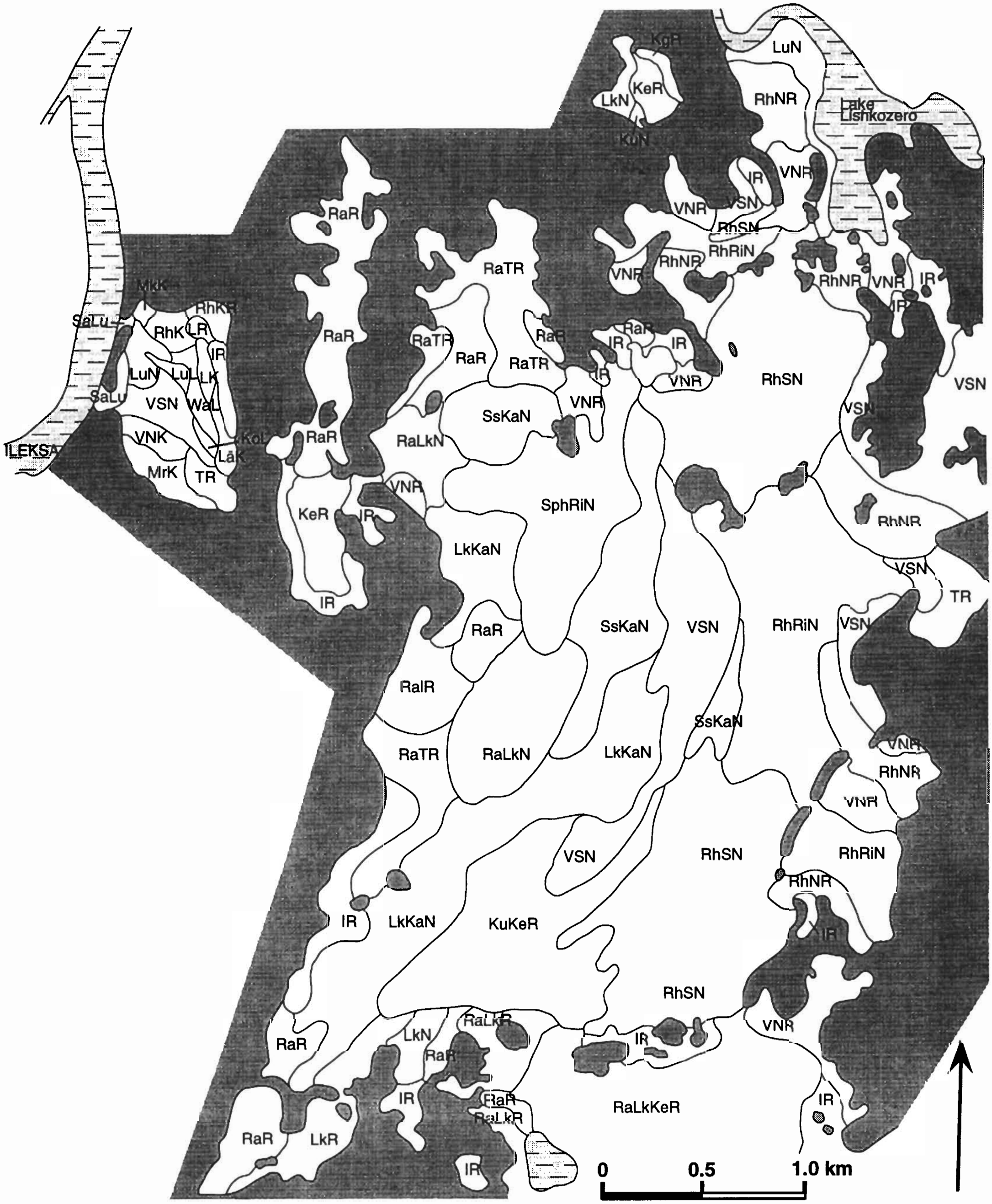



Fig. 4. Vegetation of the northern half of the Lishkmokh mire according to the Finnish school (Ruuhijärvi 1983). For the abbreviations see text.

*Kuva 4. Lishkansuon pohjoispuoliskon kasvillisuus suomalaisen suotyyppijärjestelmän mukaan (Ruuhijärvi 1983). Lyhenteet ks. teksti.*

distinct flarks ("rimpi"). In the black-and-white aerial photographs their structure is as follows: light narrow continuous or interrupted strips (*Sphagnum* strings, hummocks and carpets) against the dark background of flarks, pools and water tracks.

*Sphagneta* + *Cariceta* (S + C) mire sites are situated in the central area of the Lishkmokh mire. They are very wet mesotrophic herb flarks with individual *Sphagnum* hummocks and carpets. *Carex limosa, Menyanthes trifoliata* and *Equisetum fluviatile* dominate in the depressions. *Sphagnum teres, S. subsecundum, S. annulatum* var. *porosum* and *S. obtusum* are found in the ground layer. The latter two species usually form *Sphagnum* carpets. Communities with *S. magellanicum* and *S. angustifolium* prevail on the low hummocks. In the Finnish classification (Ruuhijärvi 1983), the site type corresponds to herb-rich flark fen (RhRiN) and herb-rich sedge fen (RhSN).

Meso-oligotrophic *Sphagneta fallaxi* + *Sphagneta maji* (SF + SM) mire sites are located in the centre of the Lishkmokh mire. The site surface is formed by *Sphagnum* strings, carpets and flarks. Communities with *Carex rostrata* and *Sphagnum fallax* are dominant on the wide and flat strings. The plant cover of the flarks is very sparse because of the wetness. The central areas of the flarks are formed as pools. *Sphagnum* carpets with *S. majus, S. papillosum* and *Carex limosa* lie between the strings and flarks. This site type corresponds to *Sphagnum* flark fen (RiN) in the Finnish classification

### *Swamps*

Mesotrophic herb–*Sphagnum* and meso-eutrophic herb–moss mire sites with a sparse tree cover are included in this group. On the black-and-white aerial phototographs they are separated from forests by a lighter tone and fine-grained structure (tree crown pattern).

Meso-eutrophic *Pineto–Mixtosphagneta* (PMS) mire sites are generally situated in the eastern marginal area of the Lishkmokh mire (Fig. 3). The site surface is formed by hummocks, *Sphagnum* carpets and flarks. *Sphagnum magellanicum, S. centrale* and *S. warnstorfii* are found in the moss layer of the hummocks. *Betula nana* and *Carex lasiocarpa* predominate in the field layer. The *Sphagnum* carpets are usually formed by *S. obtusum* and *S. fallax*. *Sphagnum aongstroemii* is found occasionally. It grows commonly in Northern Karelia, but is rare in the southern part (Maksimov 1988). *Menyanthes trifoliata* and *Carex lasiocarpa* contribute to the plant cover of the hollows. *Sphagnum subsecundum, S. fallax* and species of *Bryales* are also found there. The plant indicators of *Pineto–Mixtosphagneta* mire sites are *Pinus sylvestris, Carex lasiocarpa, Menyanthes trifoliata, Sphagnum warnstorfii* and *S. obtusum*. In the Finnish classification, this site type corresponds to herb-rich sedge fens with sparse tree cover (RhNR), and it is not included in swamps.

Mesotrophic *Pineto–Sphagneta angustifolii* (MPSA) mire sites are found in the Lishkmokh mire margins (Fig. 3). *Pinus sylvestris, Carex lasiocarpa* and *Sphagnum angustifolium* are indicator species there. The site surface is slightly wavy. Dwarf shrubs and *Eriophorum vaginatum* are abundant on the hummocks and *Carex lasiocarpa* on the *Sphagnum* carpets. *Menyanthes trifoliata* occurs here sporadically. In the Finnish classification, this site type corresponds to sedge fens with sparse tree cover (NR), and it is not included in swamps.

### *Bogs*

This group includes oligotrophic mire sites of simple and complex structure. The mire sites of simple structure have fine-grained homogeneous pattern of grey or light grey tone on black-and-white aerial photographs. The sites of complex structure have a characteristic eccentric-striped pattern. Dark strips with grained pattern (forested hummocks and ridges) alternate with lighter "cells" (*Sphagnum* hollows). Where the hollows are very wet, the "cells" are dark or even black on the aerial photographs. The ridges are lighter in this case.

Oligotrophic *Pineto–Sphagneta angustifolii* (OPSA) mire sites are distributed in the margins of the southern part of the Lishkmokh mire. *Pinus sylvestris*, dwarf shrubs, *Eriophorum vaginatum* and *Sphagnum angustifolium* are indicators of those sites. The microrelief there is wavy or hummocky. More rarely it is even hummock surface. Dwarf shrubs *Chamaedaphne calyculata, Andromeda polifolia* and *Empetrum nigrum* dominate in the field layer. In the ground layer, besides the edificator *Sphagnum angustifolium, S. fuscum* and

Table 3. Plant species composition and their cover percentage at various mire sites in the Lishkmokh mire. f = flark, hl = hollow, c = carpet, w = wavy surface, h = hummock, s = string, r = ridge. For site type abbreviations, see text.

*Taulukko 3. Suotyyppien lajisto ja %-peittävyys Lishkansuolla karjalaisen koulukunnan mukaan. f = rimpi, hl = kulju, c = välipinta, w = vaihteleva pinta, h = mätäs, s = jänne, r = kermi.*

| Species composition | HS | | C | | SFa | | MSM | | SM | | S + C | | | SF + SM | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h | c | c | f | c | f | c | f | h | f | h | c | f | s | c | hl |
| *Pinus sylvestris* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Picea abies* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Betula pubescens* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Alnus incana* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Salix cinerea* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *S. myrtilloides* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *S. pentandra* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *S. rosmarinifolia* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Andromeda polifolia* | + | + | 10 | 5 | 10 | + | 10 | + | 10 | + | 15 | + | + | 5 | + | – |
| *Betula nana* | 10 | – | + | + | + | – | + | – | + | – | 5 | + | + | + | + | – |
| *Chamaedaphne calyculata* | 10 | – | + | – | 5 | + | + | + | 5 | 5 | + | + | – | + | + | – |
| *Empetrum nigrum* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Ledum palustre* | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – |
| *Vaccinium microcarpum* | – | – | – | – | – | – | – | – | 5 | – | – | – | – | – | – | – |
| *V. myrtillus* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *V. oxycoccos* | + | 10 | 5 | + | 5 | + | 5 | + | 5 | – | + | + | – | 10 | + | – |
| *V. uliginosum* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Calamagrostis canescens* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *C. stricta* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Carex chordorrhiza* | 10 | + | + | 10 | – | – | – | – | – | – | 5 | + | + | – | – | – |
| *C. dioica* | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *C. elata* subsp. *omskiana* | + | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *C. magellanica* | + | + | – | – | – | – | – | – | – | – | – | + | – | – | – | – |
| *C. lasiocarpa* | 10 | 5 | 20 | + | + | – | – | – | – | – | + | + | – | – | – | – |
| *C. limosa* | + | 5 | 5 | 10 | 5 | 5 | 5 | 15 | + | 5 | 5 | 10 | 20 | + | 10 | 5 |
| *C. magellanica* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *C. pauciflora* | – | – | – | – | + | – | – | – | + | – | – | – | – | + | – | – |
| *C. rostrata* | 5 | 5 | + | – | 20 | 5 | + | + | + | + | – | – | – | 30 | + | + |
| *Drosera anglica* | – | – | + | + | – | – | + | – | + | – | – | + | + | + | 5 | – |
| *D. rotundifolia* | + | – | + | + | + | + | 5 | + | – | + | 5 | + | – | + | – | – |
| *Dactylorhiza maculata* | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *D. traunsteineri* | – | – | + | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *Equisetum fluviatile* | + | + | 5 | 10 | – | – | – | – | – | – | – | + | + | – | – | – |
| *Eriophorum angustifolium* | + | – | 5 | + | + | + | – | – | – | – | + | + | – | + | + | – |
| *E. gracile* | + | – | + | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *E. latifolium* | + | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *E. vaginatum* | – | – | – | – | 5 | + | 10 | + | 10 | 5 | + | – | – | 15 | + | – |
| *Galium album* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *G. palustre* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Juncus stygius* | – | + | – | + | – | – | – | – | – | – | – | – | + | – | – | – |
| *Lysimachia thyrsiflora* | – | + | – | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *Melampyrum sylvaticum* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Menyanthes trifoliata* | 5 | 5 | 15 | 15 | 5 | 20 | 10 | 15 | + | + | 15 | 20 | 20 | + | + | + |
| *Pedicularis palustris* | + | – | + | + | – | – | – | – | – | – | – | + | + | – | – | – |
| *Peucedanum palustre* | + | + | + | + | – | – | – | – | – | – | – | + | + | – | – | – |
| *Phragmites australis* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Potentilla palustris* | 10 | + | – | – | + | – | – | – | – | – | – | – | – | – | – | – |
| *Rubus chamaemorus* | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – |

| PMS | | | mPSA | oPSA | PSF | PSF + SB | | SM + SA | | SA |
|---|---|---|---|---|---|---|---|---|---|---|
| h | c | f | w | w | w | r | hl | r | hl | w |
| 20 | – | – | 20 | 10 | 10 | + | – | + | – | + |
| + | – | – | + | – | – | – | – | – | – | – |
| 5 | – | – | + | + | + | – | – | – | – | – |
| + | – | – | + | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| + | – | – | + | – | – | – | – | – | – | – |
| + | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| 10 | 5 | + | 10 | 10 | 15 | 15 | 5 | 20 | + | 15 |
| 10 | 5 | + | 15 | + | 10 | + | + | + | + | 5 |
| 5 | + | + | 5 | 15 | 20 | 30 | 10 | 5 | + | 10 |
| – | – | – | + | 5 | 10 | 20 | + | + | – | 5 |
| – | – | – | – | + | 10 | 5 | – | + | – | + |
| – | – | – | – | + | 5 | 10 | – | + | – | + |
| – | – | – | – | + | – | – | – | – | – | – |
| 10 | 20 | + | 10 | 10 | 5 | 10 | + | + | + | 10 |
| + | – | – | + | + | 10 | 10 | – | – | – | – |
| – | + | + | + | – | – | – | – | – | – | – |
| + | + | + | + | – | – | – | – | – | – | – |
| + | + | + | + | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| 10 | 10 | 5 | 15 | – | – | – | – | – | – | + |
| + | + | + | + | – | – | – | – | – | 10 | + |
| – | – | – | – | – | – | – | – | – | + | – |
| – | – | – | – | – | – | – | – | – | – | – |
| + | + | + | – | – | – | – | – | – | – | + |
| – | – | – | + | – | – | – | – | – | – | – |
| 5 | – | – | + | + | + | + | – | + | + | + |
| – | – | – | + | – | – | – | – | – | – | – |
| + | – | – | + | – | – | – | – | – | – | – |
| + | + | + | + | – | – | – | – | – | – | – |
| + | + | + | + | – | – | – | – | – | – | – |
| – | + | + | – | – | – | – | – | – | – | – |
| + | + | + | + | – | – | – | – | – | – | – |
| – | – | – | + | 15 | 10 | 10 | 5 | + | + | 20 |
| – | + | + | – | – | – | – | – | – | – | – |
| – | + | + | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | + | – | – | + | – | – | – | – |
| 15 | 25 | 25 | 15 | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | + | – | – | – | – | – | – | – | – |
| – | + | – | – | – | – | – | – | – | – | – |
| + | + | + | + | – | – | – | – | – | – | – |
| – | – | – | + | 10 | 25 | 30 | + | 20 | + | 10 |

*Continued …*

*S. magellanicum* are common. In the Finnish mire site classification, this type corresponds to dwarf shrub pine bog (IR) and *Eriophorum vaginatum* pine bog (TR).

Oligotrophic *Pineto–Sphagneta fusci* + *Sphagneta baltici* (PSF + SB) are situated mainly in the centre of the southern part of the Lishkmokh mire. They are of a complex structure: ridges alternate with *Sphagnum* hollows. *Sphagnum fuscum* is the edificator of the plant communities of the ridges and *S. balticum* of the hollows. *Pinus sylvestris, Chamaedaphne calyculata* and *Eriophorum vaginatum* are abundant on the ridges and hummocks. *Eriophorum vaginatum* is common in the hollows. *Carex limosa* and *Scheuchzeria palustris* are not abundant there, and they mainly occur in the wettest central areas of the hollows. We found also *Sphagnum rubellum*, which is rare on Karelian mires. In the Finnish mire site classification, this type corresponds to hummock–hollow pine bog (KeR).

The oligotrophic *Sphagneta maji* + *Sphagneta angustifolii* (SM + SA) mire site is situated in the centre of the Lishkmokh mire. It has a complex structure: narrow ridges alternate with wide and flat sphagnum hollows. *Sphagnum angustifolium* is the edificator of the ridge plant communities. Small pines occur sparsely on the ridges. The field layer is predominantly formed by *Andromeda polifolia* and *Rubus chamaemorus*. *Sphagnum majus* is the hollow edificator. *Carex limosa* and *Scheuchzeria palustris* are dominants in the field layer of hollows. In the Finnish mire site classification, this type corresponds to hummock–hollow pine bog (KeR).

Oligotrophic *Sphagneta angustifolii* (SA) mire sites are formed mainly in the southwestern part of the Lishkmokh mire, near Lake Gauzhozero. The surface is wavy, flat or even hummock with some *Sphagnum* hollows. *Sphagnum angustifolium* is the plant cover edificator. *S. fuscum* and *S. magellanicum* are common and abundant in the moss layer. *Chamaedaphne calyculata, Andromeda polifolia* and *Eriophorum vaginatum* are dominant in the field layer. Pines grow very sparsely. In the Finnish mire site classification, this type corresponds to small-sedge pine bog (LkR) and *Eriophorum vaginatum* pine bog (TR).

Table 3. Continues.

*Taulukko 3. Jatkuu.*

| Species composition | HS | | C | | SFa | | MSM | | SM | | S + C | | | SF + SM | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h | c | c | f | c | f | c | f | h | f | h | c | f | s | c | hl |
| *Scheuchzeria palustris* | + | 5 | + | + | 5 | 5 | 5 | 10 | + | 10 | + | + | + | + | + | + |
| *Trichophorum cespitosum* | – | – | – | – | – | – | – | – | – | – | + | – | + | – | – | – |
| *Utricularia intermedia* | – | – | – | 5 | – | – | – | – | – | – | – | – | + | – | – | – |
| *Sphagnum angustifolium* | 5 | – | + | – | + | – | + | – | 80 | – | 10 | – | – | + | + | – |
| *S. annulatum* var. *porosum* | – | + | – | – | – | + | + | + | + | + | – | 10 | + | – | – | – |
| *S. aongstroemii* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *S. balticum* | – | – | – | – | – | – | + | + | + | + | – | – | – | – | – | – |
| *S. centrale* | 10 | – | – | – | – | – | – | – | – | – | 10 | – | – | – | – | – |
| *S. fallax* | 10 | – | – | – | 90 | 90 | 80 | 5 | + | + | 15 | 10 | + | 90 | 10 | + |
| *S. flexuosum* | – | – | 90 | – | + | + | – | – | + | + | – | 5 | + | – | – | – |
| *S. fuscum* | – | – | – | – | – | – | – | – | + | – | – | – | – | – | – | – |
| *S. majus* | – | + | – | – | + | 10 | + | 80 | + | 90 | – | – | + | – | 60 | 40 |
| *S. magellanicum* | 50 | – | – | – | + | – | 20 | – | 20 | – | 65 | – | – | 5 | – | – |
| *S. nemoreum* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *S. obtusum* | – | 80 | – | – | – | – | – | – | – | – | – | 85 | 5 | – | – | – |
| *S. papillosum* | – | 20 | – | – | 10 | + | 10 | 15 | + | 10 | – | – | – | 5 | 20 | + |
| *S. rubellum* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *S. russowii* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *S. subsecundum* | – | – | – | 15 | – | – | – | – | – | – | – | – | 5 | – | – | – |
| *S. teres* | – | – | – | 10 | – | – | – | – | – | – | – | – | 10 | – | – | – |
| *S. pulchrum* | – | – | – | – | – | + | – | – | – | – | – | – | – | – | – | – |
| *S. warnstorfii* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Aulacomnium palustre* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Bryum pseudotriquetrum* | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *Calliergon giganteum* | – | – | – | + | – | – | – | – | – | – | – | – | + | – | – | – |
| *C. stramineum* | – | – | – | + | – | – | – | – | – | – | – | – | + | – | – | – |
| *Dicranum scoparium* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Drepanocladus exannulatus* | + | + | – | + | – | – | – | – | – | – | – | – | 5 | – | – | – |
| *Hylocomium splendens* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Meesia triquetra* | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *Mylia anomala* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Pleurozium schreberi* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Polytrichum commune* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *P. alpestre* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *Pseudobryum cinclidoides* | – | – | – | + | – | – | – | – | – | – | – | – | – | – | – | – |
| *Cladina rangiferina* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *C. stellaris* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *C. arbuscula* | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Microrelief forms (%) | 10 | 90 | 10 | 90 | 10 | 90 | 15 | 85 | 20 | 80 | 10 | 10 | 80 | 40 | 20 | 40 |

## Comparison of mire site classification of Finnish and Karelian schools of mire research

The DCA analysis of the vegetation data shows connections between the site types in the Finnish classification and facies according to the Karelian school of mire vegetation science (Fig. 5). The ombrotrophic sites are located down and left while eutrophic sites are located up right. Wetness seems to increase down and right.

On the left, *Sphagnum fuscum* pine bogs (RaR) are closely connected with *Pineto–Sphagneta fusci* (PSF) as well as oligotrophic *Sphagneto angustifolii* (SA). Also *Carex globularis* pine mire (PsR) and *Eriophorum vaginatum* pine bogs (TR, RaTR) are rather close to *Sphagneta angustifolii*. *Sphag-*

| PMS | | | mPSA | oPSA | PSF | PSF + SB | | SM + SA | | SA |
|---|---|---|---|---|---|---|---|---|---|---|
| h | c | f | w | w | w | r | hl | r | hl | w |
| – | + | + | + | – | – | – | + | – | 5 | + |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | + | – | – | – | – | – | – | – | – |
| + | + | – | 80 | 70 | 20 | 10 | 20 | 80 | + | 80 |
| – | – | – | – | – | – | – | – | – | – | – |
| – | + | + | + | – | – | – | – | – | – | – |
| – | – | – | – | + | + | – | 70 | – | + | 5 |
| 20 | – | – | – | – | – | – | – | – | – | – |
| + | 50 | + | + | – | – | – | – | – | – | + |
| – | + | + | – | – | – | – | – | – | – | – |
| – | – | – | – | 10 | 80 | 70 | 5 | 20 | – | 10 |
| – | – | – | – | – | + | – | 5 | – | 95 | + |
| 50 | – | – | 5 | 20 | + | 5 | – | – | + | 10 |
| – | – | – | – | + | + | + | – | + | – | + |
| – | 50 | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | + | – | – | – |
| + | – | – | 10 | – | – | – | – | – | – | – |
| – | – | + | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| 5 | – | – | – | – | – | – | – | – | – | – |
| + | – | – | + | + | + | + | – | + | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | + | + | – | – | – | – | – | – | – |
| – | – | + | – | – | – | – | – | – | – | – |
| + | – | – | + | + | + | + | – | – | – | – |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | – | + | + | – | + | – | – |
| + | – | – | + | + | 5 | + | – | + | – | – |
| + | – | – | + | + | – | – | – | – | – | – |
| – | – | – | – | + | 5 | + | – | + | – | + |
| – | – | – | – | – | – | – | – | – | – | – |
| – | – | – | – | + | + | + | – | – | – | – |
| – | – | – | – | + | + | + | – | – | – | – |
| – | – | – | – | + | + | + | – | – | – | – |
| 50 | 40 | 10 | 100 | 100 | 100 | 60 | 40 | 20 | 80 | 100 |

*neta baltici* and ombrotrophic hollow bog (KuN) are rather close to each other, quite clearly separated from minerotrophic *Sphagneta maji* (SM), *Menyantheto–Sphagneta maji* (MSM) and *Sphagnum* flark fen (SphRiN). Lawn-level minerotrophic sites *Sphagneta fallaxi* + *Sphagneta maji* (SF+SM), *Sphagneta fallaxi* (SFa), *Pineto–mixtosphagneta* (PMS), Mesotrophic *Pineto–Sphagneta angustifolii* (MPSA), *Herbeto–Sphagneta* (HS), *Cariceta* (C), *Sphagneta* + *Cariceta* (S + C), sedge fen (VSN) and small-sedge fen (LkN) are agglomerated in the middle of the scatterplot diagram. On the right there are mesotrophic and eutrophic rather wet sites, *Cariceta* (C), *Sphagneta* + *Cariceta* (S + C), herb-rich flark fen (RhRiN), rich spring fen (LäL) and swampy rich fen (LuL). Uppermost in the figure there are lawn–hummock level eutrophic sites, *Sphagnum warnstorfii* rich fen (WaL), rich spruce mire (LK) and herb-rich spruce-hardwood mire (RhK).

A problem in the comparison of the Finnish and the Karelian classifications of mire vegetation is that the gradient of mire vegetation is cut at different points in Finnish and Karelian classification. In general, Finnish mire sites seem to be ecologically slightly more narrow, but because the boundaries between the classes are at different points, one site type in Finnish classification can correspond to two types in the Karelian system and *vice versa*. In this material, ombrotrophic bogs seem to form a rather uniform group, but minerotrophic fens and flark fens seem to be in need of consideration of the classification. On the basis of the DCA analysis and comparison of concepts in different sites in the Lishkmokh mire, a mutual understanding of the correspondence of the site types studied by both Finnish and Karelian authors was obtained (Table 4).

## Development of the vegetation

The peat deposit of the studied *Sphagneta* + *Cariceta* mire site was 2.5 m thick. The macrofossil analysis of peat revealed the main stages of this mire site genesis (Fig. 6). *Equisetum–Carex*, *Carex*, *Scheuchzeria–Carex* and *Menyanthes–Carex* communities were pioneers at the first stage of this mire site formation. They resemble the present communities of meso-eutrophic *Cariceta* mire sites. Approximately since the second half of the Subatlantic period of the Holocene, *Sphagna* started to spread there. They formed *Sphagnum* carpets and hummocks, thus giving the present structure of the *Sphagneta* + *Cariceta* mire site.

The genesis of *Sphagneta fallaxi* + *Sphagneta maji* has some peculiarities (Fig. 6). The strings' plant cover has evolved from *Carex* and *Eriopho-*

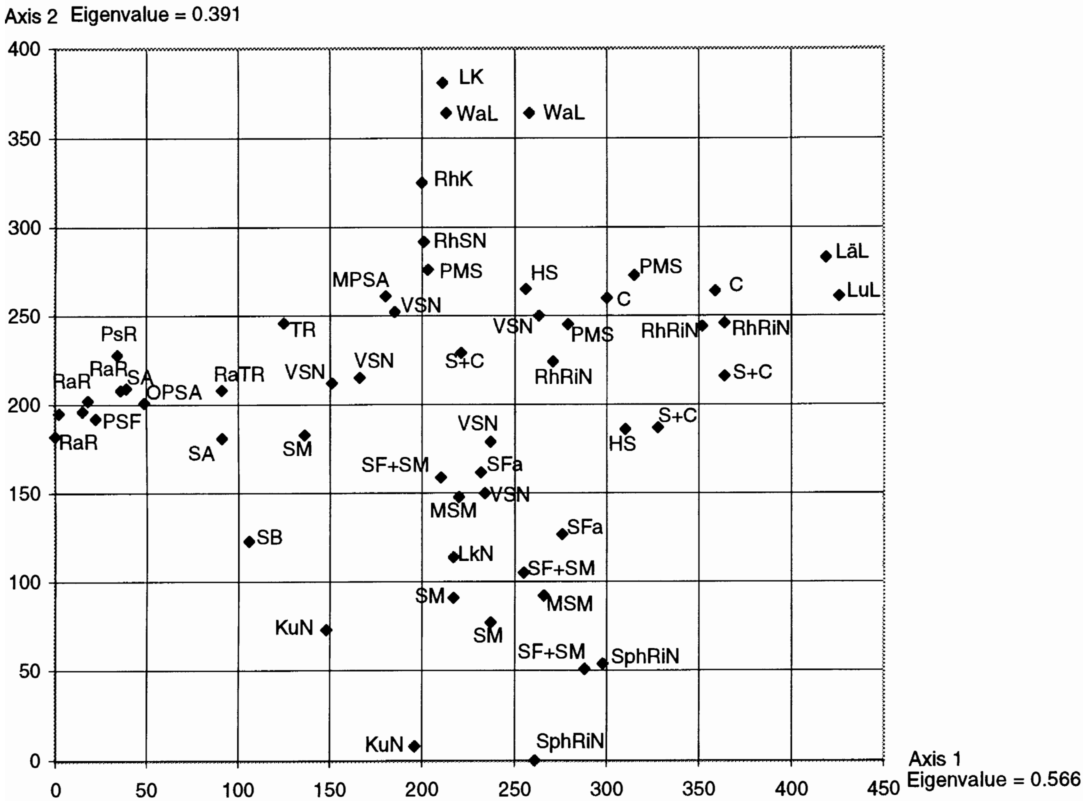



Fig. 5. DCA ordination of the vegetation of Lishkmokh Mire on the basis of the materials of the Finnish and Karelian participants in this study. The abbreviations show the site types.

*Kuva 5. Lishkansuon kasvillisuudesta suomalaisen ja karjalaisen koulukunnan mukaan tehtyjen kuvauksien DCA-ordinaatio. Kasvillisuustyypit on esitetty lyhentein.*

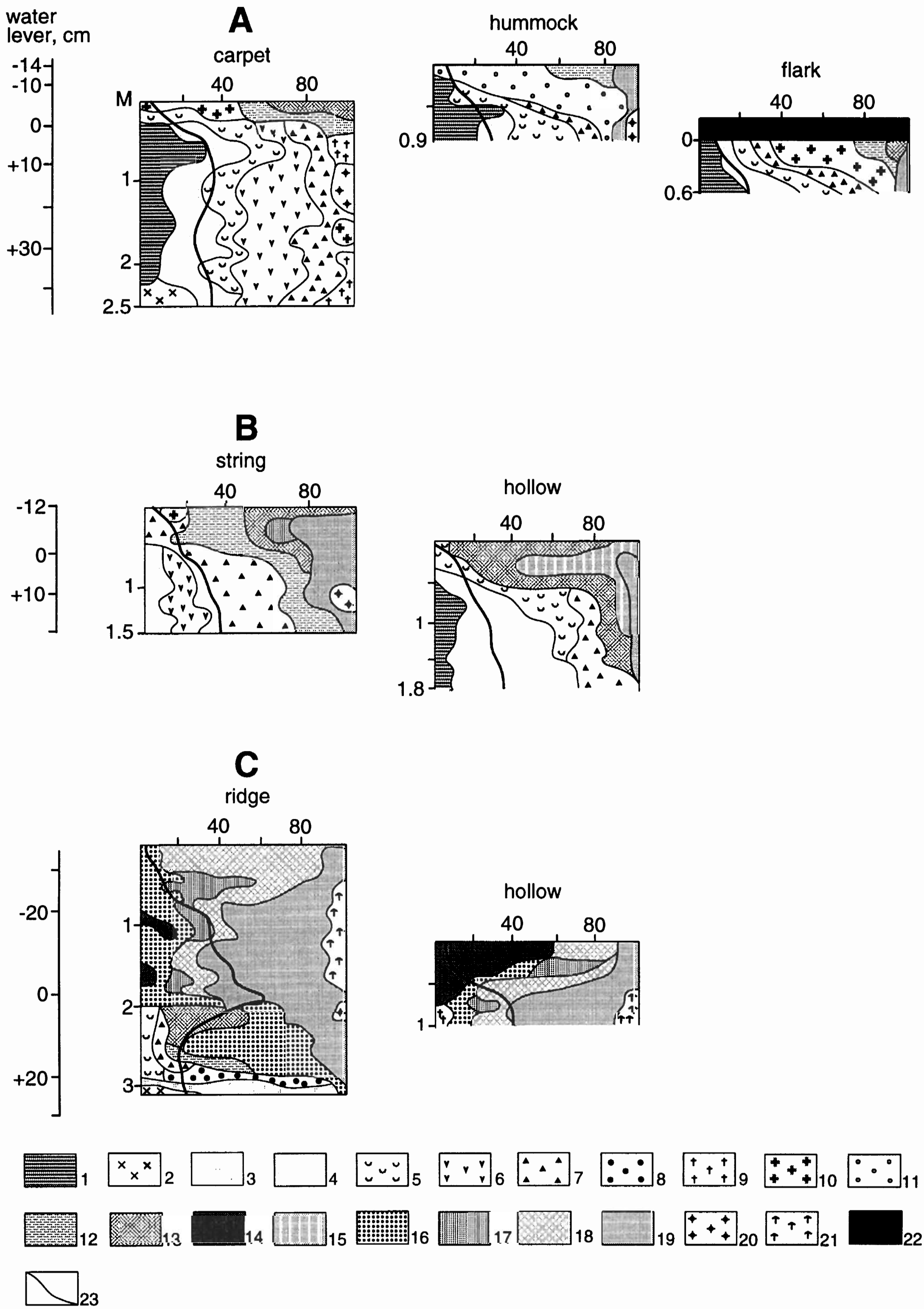
Table 4. Comparison of mire site types in Karelian and Finnish schools of mire science. See text for the abbreviations.

*Taulukko 4. Karjalaisen ja suomalaisen suontutkimuskoulukunnan mukaisten suotyyppien vertailu. Lyhenteet ks. teksti.*

| Karelian – *Karjalainen* | Finnish – *Suomalainen* |
|---|---|
| HS | RhNR, RhSN, RhRiN |
| C | RhSN, RhRiN, LuN |
| SFa | VSN |
| MSM | RiN, LkN, LkKaN |
| SM | SphRiN |
| S + C | RhSN, RhN |
| SF + SM | SphRiN |
| PMS | RhNR, RhSN, RhRiN |
| MPSA | NR, VSN |
| OPSA | TR, IR |
| PSF | RaR, RaIR |
| PSF + SB | KeR |
| SM + SA | KeR |
| SA | TR, RaTR, LkR |

Fig. 6 (Opposite). Stratigraphical columns of the peat deposit of Lishkmokh mire. For the coring sites see Fig. 3. Plant remains in peat: 1) *Menyanthes trifoliata*, 2) *Equisetum*, 3) *Drepanocladus*, 4) *Scheuchzeria*, 5) *Carex limosa*, 6) *C. lasiocarpa*, 7) *C. rostrata*, 8) *Sphagnum teres*, 9) *S. subsecundum* 10) *S. obtusum*, 11) *S. centrale*, 12) *S. fallax*, 13) *S. majus*, 14) *S. balticum*, 15) *S. papillosum*, 16) *S. angustifolium*, 17) *S. magellanicum*, 18) *S. fuscum*, 19) *Eriophorum*, 20) *Betula*, 21) *Pinus sylvestris*; 22) water layer, 23) degree of decomposition (%). Site types of the coring sites: A) M + ME *Sphagneta + Cariceta*, B) mire site MO *Sphagneta fallaxi + Sphagneta maji*, C) O *Pineto–Sphagneta fusci + Sphagneta baltici.*

*Kuva 6 (Oikealla). Lishkansuon turvekerrosten stratigrafia. Kairauspisteet Kuvassa 3. Kasvinjäänteet turpeessa: 1)–21) ks. yllä, 22) vesikerros, 23) maatuneisuusaste (%). Kairauspisteiden suotyypit: A) M + ME* Sphagneta + Cariceta, *B) MO* Sphagneta fallaxi + Sphagneta maji, *C) O* Pineto–Sphagneta fusci + Sphagneta baltici.


water lever, cm
A
carpet
hummock
flark
B
string
hollow
C
ridge
hollow
40
80
M
0.9
0.6
1.5
1.8
2.5
-14
-10
0
+10
+30
-12
-20
+20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

*rum–Carex* communities to *Eriophorum–Sphagnum* and existing *Sphagnum* communities with *S. fallax*. Wetness was initially characteristic of flarks, which is evidenced by the *Scheuchzeria* remains in their peat deposit. *Scheuchzeria* and *Scheuchzeria–Sphagnum* were the pioneer communities there (Fig. 6).

The plant cover dynamics of *Pineto–Sphagneta fusci* + *Sphagneta baltici* has also some peculiar features (Fig. 6). Eutrophic *Hypnum–Carex* communities were pioneers there, but not for a long time. Later mesotrophic and meso-oligotrophic *Sphagnum* communities and then oligotrophic *Eriophorum–Sphagnum* communities were formed. The latter communities existed there for a long time, probably during the whole Sub-Atlantic period. At the end of the Sub-Atlantic period oligotrophic *Sphagnum* communities replaced them.

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Appendix 1. Mire sites of Lishkmokh Mire. – *Liite 1. Lishkansuon suotyypit karjalaisen koulukunnan mukaan.*

| Name of mire sites<br>*Suotyyppi* | Index<br>*Koodi* | Trophic status<br>*Ravinnetaso* | Location on the mire<br>*Sijainti* |
|---|---|---|---|
| Fens | | | |
| *Herbeto–Sphagneta* | HS | ME | North part, near Novguda river |
| *Cariceta* | C | ME | North part |
| *Sphagneta fallaxi* | SFa | M | Marginal part |
| *Menyantheto–Sphagneta maji* | MSM | M | Centre |
| *Sphagneta maji* | SM | MO | Centre |
| *Sphagneta + Cariceta* | S + C | M + ME | Centre |
| *Sphagneta fallaxi + Sphagneta maji* | SF + SM | MO | Centre |
| Swamps | | | |
| *Pineto–Mixto–Sphagneta* | PMS | ME | East marginal part |
| Mesotrophic *Pineto–Sphagneta angustifolii* | mPSA | M | Marginal parts |
| Bogs | | | |
| *Pineto–Sphagneta angustifolii* | oPSA | O | Marginal parts |
| *Pineto–Sphagneta fusci* | PSF | O | Marginal parts |
| *Pineto–Sphagneta fusci + Sphagneta baltici* | PSF | O | South part |
| *S. baltici* | | | |
| *Sphagneta maji + Sphagneta angustifolii* | SM + SA | MO + O | Centre |
| *Sphagneta angustifolii* | SA | O | West marginal part |

| Microrelief<br>*Pienmuodot* | Vegetation<br>*Kasvillisuus* | Water level<br>*Vedenkorkeus* | Area %<br>*Osuus %* |
|---|---|---|---|
| Hummock | *Sphagnum centrale, S. magellanicum, Betula nana, Carex lasiocarpa, C. chordorrhiza* | – 16– – 20 | 10 |
| Carpet | *Sphagnum obtusum, Calamagrostis neglecta, Scheuchzeria palustris* | – 2– – 8 | 90 |
| | | | |
| Flark | *Carex limosa, Menyanthes trifoliata, Sphagnum teres, S. subsecundum, Juncus stygius, Drepanocladus exannulatus, Utricularia intermedia* | + 2– + 10 | 90 |
| Carpet | *Carex lasiocarpa, Menyanthes trifoliata, Sphagnum flexuosum* | – 4– – 8 | 10 |
| | | | |
| Carpet | *Menyanthes trifoliata, Carex rostrata, Sphagnum fallax* | – 6– – 14 | 90 |
| Flark | *Carex limosa, Sphagnum majus* | 0– –4 | 10 |
| | | | |
| Carpet | *Chamaedaphne calyculata, Sphagnum angustifolium, S. magellanicum* | – 20– – 30 | 15 |
| Flark | *Menyanthes trifoliata, Carex limosa, Sphagnum majus, S. papillosum, S. fallax* | – 3– – 5 | 85 |
| | | | |
| Hummock | *Eriophorum vaginatum, Sphagnum angustifolium* | – 10– – 15 | 20 |
| Flark | *Carex limosa, C. rostrata, Scheuchzeria palustris, Sphagnum majus, S. papillosum, S. fallax* | – 4– – 8 | 80 |
| | | | |
| Hummock | *Andromeda polifolia, Betula nana, Menyanthes trifoliata, Sphagnum fallax, S. magellanicum* | – 10– – 18 | 10 |
| Carpet | *Menyanthes trifoliata, Juncus stygius, Sphagnum obtusum, S. jensenii* | – 1– – 10 | 10 |
| Flark | *Carex limosa, Menyanthes trifoliata, Sphagnum teres, S. subsecundum, Drepanocladus exannulatus* | + 2– + 15 | 80 |
| | | | |
| String | *Carex rostrata, Eriophorum vaginatum, Sphagnum fallax, S. papillosum* | – 10– – 15 | 40 |
| Carpet | *Carex limosa, C. rostrata, Sphagnum fallax, S. papillosum,* | – 1– – 3 | 20 |
| Hollow | *Carex limosa, Sphagnum majus* | + 3– – 3 | 40 |
| | | | |
| Hummock | *Pinus sylvestris, Betula nana, Carex lasiocarpa, Menyanthes trifoliata, Sphagnum centrale, S. warnstorfii, S. magellanicum* | – 20– – 40 | 50 |
| Carpet | *Betula nana, Menyanthes trifoliata, Sphagnum obtusum* | – 5– – 20 | 40 |
| Flark | *Carex lasiocarpa, Menyanthes trifoliata, Sphagnum obtusum, S. subsecundum, Drepanocladus exannulatus* | 0– – 2 | 10 |
| | | | |
| Wavy surface | *Pinus sylvestris, Andromeda polifolia, Carex lasiocarpa, Sphagnum angustifolium, S. magellanicum* | – 20– – 30 | 100 |
| | | | |
| Wavy surface | *Pinus sylvestris, Eriophorum vaginatum, Sphagnum angustifolium, S. magellanicum* | – 20– – 30 | 100 |
| | | | |
| Wavy surface | *Pinus sylvestris, Rubus chamaemorus, Ledum palustre, Chamaedaphne calyculata, Sphagnum fuscum, S. angustifolium* | – 30– – 40 | 100 |
| | | | |
| Ridge | *Pinus sylvestris, Empetrum nigrum, Rubus chamaemorus, Sphagnum fuscum, S. angustifolium* | – 30– – 40 | 60 |
| | | | |
| Hollow | *Eriophorum vaginatum, Scheuchzeria palustris* | – 8– – 14 | 40 |
| | | | |
| Ridge | *Eriophorum vaginatum, Sphagnum angustifolium* | – 10– – 20 | 20 |
| Hollow | *Scheuchzeria palustris, Carex limosa, Sphagnum majus* | – 4– – 6 | 80 |
| | | | |
| Wavy surface | *Eriophorum vaginatum, Sphagnum angustifolium* | – 12– – 18 | 100 |

TIIVISTELMÄ:

## Karjalan tasavallan Vodlajärven kansallispuistossa sijaitsevan Lishkansuon kasvillisuus

Karjalais–suomalainen retkikunta teki tutkimusmatkan Karjalan tasavallan itäisimpään kolkkaan Vodlajärven kansallispuistoon kesällä 1992 osana suomalais–karjalaista suontutkimusyhteistyötä. Lishkansuolla tehtyjen yhteistutkimusten tavoitteena oli tutkimusmenetelmien ja kasvillisuusluokittelujen vertailu siten, että Suomessa ja Karjalassa tehtävien tutkimusten tulokset olisivat vertailukelpoisia. Yhteistyössä on tavoitteena tuottaa tietoa Suomen ja Karjalan suoluonnosta kokonaisuutena soidensuojelun arvioimiseksi. Lishkansuon tutkimuksella tuotetaan tietoa myös Vodlajärven kansallispuiston käytön suunnittelua varten.

Karjalaisessa suotutkimuskoulukunnassa suokasvillisuutta on käsitelty monella toiminnallisella tasolla: mikrokenoosi (esim. yksittäinen tupasvillamätäs), fytokenoosi (yksittäinen esim. neliömetrin kasvillisuuslaikku), suotyyppi eli fasies (vastaa mittakaavaltaan suunnilleen suomalaista käsitettä), suomassiivi (vastaa suomalaista suoyhdistymäkäsitettä) ja suosysteemi (usean massiivin muodostama kokonaisuus, joka voi sisältää keidas- ja aapasoita). Sen sijaan Suomessa on suotutkimuksessa yleensä tarkasteltu vain suotyyppi- ja yhdistymätasoa.

Lishkansuon kasvillisuutta tutkittiin ilmakuvilta ja maastotutkimuksin. Kasvillisuustyypit rajattiin erikseen karjalaisen ja suomalaisen koulukunnan mukaan, ja kultakin havaitulta suotyypiltä tehtiin kasvillisuuskuvauksia karjalaisia ja suomalaisia menetelmiä käyttäen. 2 050 ha:n laajuisella alueella on useita keidassoita ja aapasoita, jotka ovat täysin luonnontilaisia. Suomalaisen suotyypityksen mukaan alueelta löytyi 32 suotyyppiä, joka on suuri määrä yhden suosysteemin alueella. Monimuotoisen kasvillisuutensa sekä eräitten harvinaisten ja itäisten kasvilajien perusteella Lishkansuo on luonnonsuojelun kannalta erittäin arvokas kokonaisuus.

Kasvillisuustutkimusten ja maastossa yhdessä käytyjen keskustelujen pohjalta tehtiin suomalaisen ja karjalaisen koulukunnan tyypittelyjen vertailu (Taulukko 4). Eri koulukunnissa suotyyppien rajat on määritelty hiukan eri kohtiin, mistä johtuen yksi suomalainen suotyyppi voi sisältyä useampaan karjalaiseen suotyyppiin ja päinvastoin.

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