

BRYOPHYTES OF FRAGMENTED OLD-GROWTH SPRUCE FOREST STANDS OF THE NORTH KARELIAN BIOSPHERE RESERVE AND ADJACENT AREAS OF FINLAND

МОХООБРАЗНЫЕ ФРАГМЕНТИРОВАННЫХ СТРОВОЗРАСТНЫХ ЕЛОВЫХ ЛЕСОВ БИОСФЕРНОГО ЗАПОВЕДНИКА СЕВЕРНАЯ КАРЕЛИЯ И ПРИЛЕГАЮЩИХ ТЕРРИТОРИЙ ФИНЛЯНДИИ

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Abstract

North Karelian Biosphere Reserve and adjacent areas of Finland were studied in 1996 – 2001 for bryophytes in 21 fragmented old-growth spruce forest stands. In total 194 bryophyte species (119 mosses and 75 liverworts) were recorded, including nine of Red List of Finland (*Anastrophyllum hellerianum*, *Calypogeia suecica*, *Cephalozia macounii*, *Harpanthus scutatus*, *Herzogiella turfacea*, *Lophozia ascendens*, *Polytrichastrum pallidisetum*, *Riccardia multifida*, *R. palmata*). The bryophyte flora is analysed with respect to species composition and distribution within the area, ecological groups and frequency of species. The groups of mosses and liverworts common for the North Karelian Biosphere Reserve and adjacent areas and conservation issues are considered. The main characteristics of the floras of studied spruce stands are connected with the amount of rotting wood, shaded rocky outcrops and presence of constant moisture and admixture of deciduous trees. Distinctive features of the flora are defined in comparison with the Central Norway spruce stands.

Резюме

В результате выполненных в 1996-2001 гг. исследований 21 участка фрагментированных старовозрастных лесов Биосферного заповедника Северная Карелия и прилегающих территорий Финляндии выявлено 194 видов мохообразных (119 мхов и 75 печеночников). Девять из выявленных видов (*Anastrophyllum hellerianum*, *Calypogeia suecica*, *Cephalozia macounii*, *Harpanthus scutatus*, *Herzogiella turfacea*, *Lophozia ascendens*, *Polytrichastrum pallidisetum*, *Riccardia multifida*, *R. palmata*) являются краснокнижными в Финляндии. В статье анализируются таксономический состав флоры, распространение мохообразных по территории исследования, экологические группы и встречаемость видов. Определены и обсуждены группы обычных и редких для территории исследования видов мхов и печеночников. Особенности флор мохообразных изученных ельников связаны главным образом с количеством гниющей древесины, затененных скальных выходов, постоянной влажностью и наличием примеси лиственных пород. Отличительные черты флоры выявлены при ее сравнении с флорой мохообразных ельников Центральной Норвегии.

INTRODUCTION

The bryophytes are an integral component of old-growth spruce forests. They form forest floor, cover logs, stumps, tree bases and trunks as well as rocky outcrops, abundantly grow near water courses and in wet depressions. Studies

of bryophytes of spruce forests in Sweden and Norway (Gustafsson & Hallingbäck, 1988; Söderström, 1988; Hallingbäck, 1991; Frisvoll, 1997; Frisvoll & Prestö, 1997) show that bryophyte diversity is higher in old-growth than in young forests.

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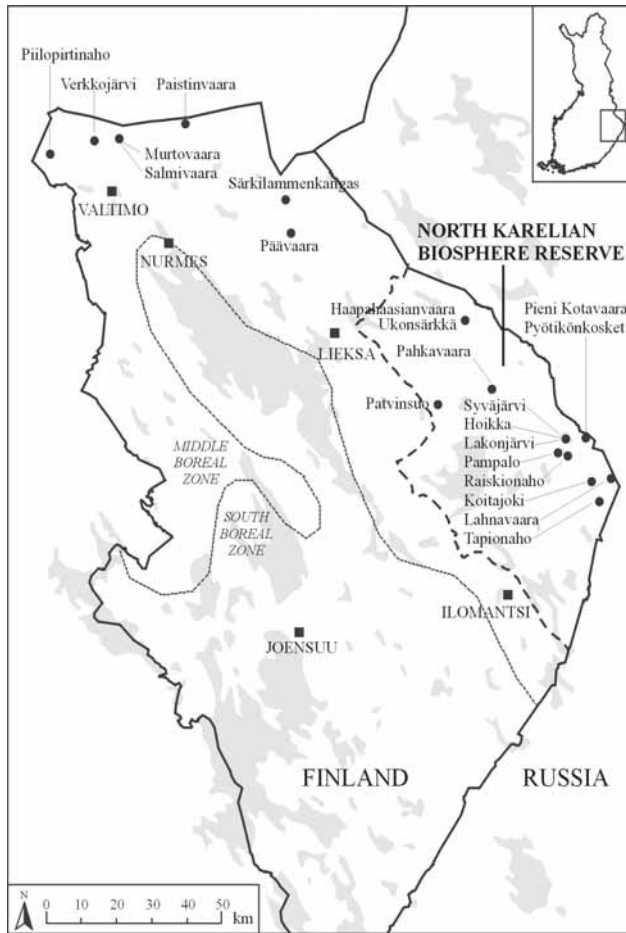


Fig. 1. The study area.

Table 1. List of fragmented mature spruce forest stands of the North Karelian Biosphere Reserve and adjacent territories of Finland

Stand	Municipality	Longitude	Latitude
Tapionaho	Iloimantsi	62°52'15"	31°27'60"
Lahnavaara	Iloimantsi	62°55'22"	31°32'47"
Koitajoki	Iloimantsi	62°55'23"	31°25'51"
Raiskionaho	Iloimantsi	62°59'24"	31°18'25"
Pampalo	Iloimantsi	62°59'55"	31°15'07"
Pampalo slope	Iloimantsi	62°59'55"	31°15'07"
Hoikka	Iloimantsi	63°01'29"	31°21'14"
Lakonjärvi	Iloimantsi	63°01'35"	31°17'51"
Pyötikönkosket	Iloimantsi	63°01'41"	31°26'33"
Syväjärvi	Iloimantsi	63°01'48"	31°18'16"
Pieni Kotavaara	Iloimantsi	63°01'48"	31°22'40"
Pahkavaara	Lieksa	63°09'48"	30°55'16"
Suolaminvaara	Lieksa	63°19'18"	30°46'49"
Ukonsärkkä	Lieksa	63°19'18"	30°46'49"
Haapahaasianvaara	Lieksa	63°20'03"	30°44'02"
Päävaara	Lieksa	63°33'51"	29°48'30"
Piilopirtinaho	Valtimo	63°46'31"	28°26'03"
Salmivaara	Valtimo	63°47'41"	28°50'16"
Verkkojärvi	Valtimo	63°47'51"	28°42'57"
Murtovaara	Valtimo	63°48'28"	28°54'11"
Paistinvaara	Nurmes	63°49'18"	29°14'51"

Area of old-growth spruce forests is diminishing in Finland. However, until present there were no available for international scientific community special studies on bryophytes of old-growth spruce forests of Finland. North Karelian Biosphere Reserve in eastern Finland, adjacent to the Russian border, is a part of UNESCO's research, monitoring and development network (UNESCO 2002), and the information from these areas is especially important from the international point of view. These facts stimulated our research project, which was initiated by T.J. Hokkanen in 1996 by selecting the sites from North Karelian old-growth spruce forests. In 1996-1997 all the studied sites were sampled for mosses and liverworts by A. I. Maksimov. T. A. Maksimova was involved in the project in 1998 to study mosses together with A.I. Maksimov. A. D. Potemkin joined the project to study liverworts in 1999. He identified all previous gatherings of liverworts, made his own collections in selected sites (*Pieni Kotavaara*, *Syväjärvi*, *Pampalo*, *Pampalo* slope) in summer 2001, 2003 as well as suggested and developed basic approaches to analysis of the bryophyte flora of the studied area in the course of preparation of this paper.

The goals of this paper are (i) to make an overview of bryophyte species composition in fragmented old-growth spruce forests of the North Karelian Biosphere Reserve and adjacent areas of Finland, (ii) to provide some features of distribution and ecological behaviour of bryophytes in the area, and (iii) to define some peculiarities of bryophyte flora of the studied Finnish fragmented old-growth spruce forests.

STUDY AREA, MATERIAL AND METHODS

The forested areas of Finnish North Karelia as well as the rest of Finland consist of extensive cuttings, young forests and drained bogs. Old-growth forests are ± rare. North Karelian Biosphere Reserve and adjacent areas of Finland belong to the middle taiga zone, a little to the north of boundary between middle and southern taiga zones (Ahti *et al.*, 1968) (Fig. 1). The climate of the area is moderately continental. The average annual precipitation in period since 1961 till 1990 was 648 mm and temperature +2.1°C. The warmest month of the year, July, has average temperature + 15.8°C, the coldest, January, – 11.9°C (Helminen, 1997).

Collections of bryophytes in the studied area were made in 21 old-growth spruce stands situated in the North Karelian Biosphere Reserve and adjacent territories in Finland (Fig. 1, Table 1). The southernmost stand (*Tapionaho*) is situated in about 200 kilometres from the northernmost (*Verkköjärvi*). The area of studied stands varies from 8 to 61 hectares. The stands are 120-160 years old and should be attributed according to classification of A. K. Cajander (1926) to the spruce forests of *Myrtillus* type. Spruce (*Picea abies*) associates usually with pine (*Pinus sylvestris*) and birch (*Betula pendula*, *B. pubescens*), sporadically with willow (*Salix caprea*), aspen (*Populus tremula*) and rowan (*Sorbus aucuparia*).

The stands, considered most interesting from bryofloristic viewpoint (*Pieni Kotavaara*, *Hoikka*, *Lakonjärvi*, *Syväjärvi*, *Ukonsärkkä*), were investigated repeatedly. Some stands (*Pahkavaara*, *Tapionaho*, *Pampalo* slope) were investigated only partly because of unfavourable weather and/or short time for collecting. Moreover, stands *Piilopirtinaho*, *Murtovaara*, *Koitajoki*, *Tapionaho*, *Pyötikönkosket* were insufficiently studied with respect to hepatics. Taking into account uneven investigation of separate stands we pay attention to investigation of their common characteristics mainly and avoid their detailed analysis and comparison.

In every stand all recognized bryophyte habitats (Table 4) were repeatedly studied with respect to bryophyte species composition. Frequency, abundance and ecological preferences of the bryophytes were determined in the field wherever possible. The identification of every species was verified in the laboratory. Totally about 2000 bryophyte specimens were collected. Frequency of the species in separate stands was estimated using a five-grade scale: 1 – found 1-2 times in studied stand; 2 – found 3-6 times; 3 – 7-15 times; 4 – 16-22 times; and 5 – over 22 times (Table 3). For evaluation of species frequency in the studied area their frequency grades for separate stands were summarized. To define how regularly every species occurs in different stands the percentage of stands in which species was found was estimated. Ecological preferences of every species were defined as percentage of their frequency in recognized habitats (Table 4). To clarify which taxonomic groups play more

Table 2. Largest families and genera in the studied area and number of their species in the studied sites. Pa - Pahkavaara, Uk - Ukonsärkkä, Pä - Päävaara, Pv - Paistinvaara, Pi - Piilopirtinaho, Mu - Murtovaara, Ve - Verkkojärvi, Ho - Hoikka, Sy - Syväjärvi, Pk - Pieni Kotavaara, Py - Pyötikönkosket, La - Lakonjärvi, Ta - Tapionaho, Ko - Koitajoki, Pm - Pampalo, Ps - Pampalo slope, Ha - Haapahaasianvaara, Sa - Salmivaara, Ra - Raiskionaho, Lv - Lahnavaaara, Su - Suolaminvaara.

Families and genera	Stands and number of species																				
	Pa	Uk	Pä	Pv	Pi	Mu	Ve	Ho	Sy	Pk	Py	La	Ta	Ko	Pm	Ps	Ha	Sa	Ra	Lv	Su
HEPATICAE																					
Lophoziaceae (19)	4	7	6	7	3	1	7	5	7	9	3	6	4	3	14	7	11	10	7	5	7
Jungermanniaceae (9)									1	8					7				2		
Cephaloziaceae (8)		2	1				2	2	2	6		1	1		5		3	3	4	1	2
Scapaniaceae (6)							2			3	1				4						
Calypogeiaceae (5)	1	1	2	1	1	1	3	1	3	5	1	1	1	1	4	1	1	2	1	2	2
Geocalycaceae (5)		1						2	1	1		1			4		1	1	2		
<i>Lophozia</i> (7)	1	3	3	3	2		3	2	3	4	2	3	1	2	6	3	6	5	4	2	3
<i>Barbilophozia</i> (6)	2	1	1	3	1	1	4	2	3	3	1	2	1	1	4	2	3	3	2	2	3
<i>Cephalozia</i> (6)		2	1				2	2	2	4		1	1		4		3	3	4	1	2
<i>Scapania</i> (6)							2			3	1				4						
<i>Jungermannia</i> (5)										5					3						
<i>Calypogeia</i> (5)	1	1	2	1	1	1	3	1	3	5	1	1	1	1	4	1	1	2	1	2	2
<i>Riccardia</i> (4)								1		1					3	1					
<i>Anastrophyllum</i> (3)	1	2	2	1					1	2		1	2		2	2	2	2	1	1	1
<i>Nardia</i> (3)										3					2				1		
<i>Cephaloziella</i> (3)								1	1	2		1			2						
MUSCI																					
Dicranaceae (19)	6	11	9	9	5	8	7	8	11	7	9	7	6	8	13	5	7	7	8	5	5
Sphagnaceae (14)	7	9	6	7	5	6	7	8	7	10	6	5	7	4	9	3	5	9	10	9	4
Brachytheciaceae (10)	1	7	9	2	3	4	4	5	5	6	3	7	6	5	9	4	6	6	6	5	6
Polytrichaceae (9)	4	7	1	3	2	4	2	2	5	6	3	2	6	1	6	3	2	2	4	3	3
Amblystegiaceae (8)	1	3	3	1	1	3	3	2	3	4	4	3	3	5	7	1	2	2	4	4	3
Hypnaceae (8)	1	1	2	2	1	3	2	1	2	2	1	1	2	4	4	3	3	2	2	2	1
Mniaceae (7)		2	1		2	2	1	2	2			1	1	1	7		3	2	2	1	1
Bryaceae (6)	2	1	1	1	2	2	1	2	2	2	1	1	1	1	4	1	3	2	1	1	1
Hylacomiaceae (5)	2	3	3	2	4	3	2	3	2	3	3	3	3	3	5	2	3	3	3	3	3
<i>Sphagnum</i> (14)	7	9	6	7	5	6	7	8	7	10	6	5	7	4	9	3	5	9	10	9	4
<i>Dicranum</i> (9)	5	7	6	6	4	6	5	7	7	6	5	6	5	7	7	5	5	6	6	5	5
<i>Brachythecium</i> (6)	1	5	6	1	3	4	4	5	5	5	3	6	6	5	5	4	6	6	6	5	5
<i>Dicranella</i> (4)	1	3	1		1	1		1	1	1	2		1		2		1		2		
<i>Plagiothecium</i> (4)	1	2	2	2	1	1	2	3	1	1	1	1	1	1	3	1	3	2	2	1	1
<i>Pohlia</i> (3)	2	1	1	1	2	2	1	1	2	2	1	1	1	1	2	1	2	1	1	1	1
<i>Polytrichum</i> (3)	2	2	1	1	1	1	2	1	2	3	2	1	1	1	2	2	2	2	2	1	2
<i>Plagiommium</i> (3)		1	1					1	1			1	1	1	3		1	1	1	1	1
N of bryophyte species	37	66	57	46	35	45	53	56	68	91	40	49	51	41	140	41	63	62	66	47	44
N of moss species	29	50	44	36	29	39	36	40	44	47	33	35	43	35	85	27	41	41	47	36	29
N of liverwort species	8	16	13	10	6	6	17	16	24	44	7	14	8	6	55	14	22	21	19	11	15
Moss/liverwort species	3.6	3.1	3.4	3.6	4.8	6.5	2.1	2.5	1.8	1.1	4.7	2.5	5.4	5.8	1.5	1.9	1.9	2.0	2.5	3.3	1.9

significant role in old-growth spruce forests the taxonomic sorting and analysis of species list were carried out (Table 2). These approaches provide the basis to analyse species composition with respect to their frequency in separate stands, in all stands together and in regularity of species occurrence in the studied area.

Our data are roughly comparable with Frisvoll's (1997) study on bryophytes of spruce forest stands of Central Norway. The author studied bryophytes from 110 spruce stands of different age with particular emphasis on old-growth forest. Unfortunately the list of bryophytes of Central Norway spruce stands was

not segregated with respect to age of spruce stands. This made impossible to reveal the species composition of the old-growth spruce stands *per se*, which is important for a proper comparison. The species lists of Finnish and Central Norway spruce stands were analysed with respect to their taxonomic composition, differential species composition, ecological and geographical distribution of differential species, and species frequency.

Circumscription of families and genera of mosses is accepted after Ignatov & Afonina (1992), of hepatics – after Grolle & Long (2000), except families Scapaniaceae and Diplophylaceae treated after Potemkin (1999) and genus *Chiloscyphus* after Engel & Schuster (1984). Nomenclature of mosses follows to Söderström (1996, 1998), liverworts to Grolle and Long (2000), mainly. Representative collections are allocated in Herbarium of Botanical Museum, University of Helsinki (H), Herbarium of the Institute of Biology, Petrozavodsk, Russia, and liverworts partly in Herbarium of V.L. Komarov Botanical Institute, St. Petersburg, Russia (LE).

RESULTS AND DISCUSSION

TAXONOMIC COMPOSITION

Totally 119 moss and 75 liverwort species were recorded in fragmented old-growth spruce forests of the North Karelian Biosphere Reserve and adjacent territories of Finland. The liverwort species of this flora belong to 29 genera and 19 families. The families Lophoziaaceae, Jungermanniaceae, Cephaloziaaceae, Scapaniaceae, Geocalycaceae and Calypogeiaceae include 19, 9, 8, 6, 5 and 5 species respectively. Other liverwort families are represented by 1-4 species. The largest genera in the flora are *Lophozia* (7 species), *Barbilophozia*, *Cephalozia*, *Scapania* (6 species), *Jungermannia*, *Calypogeia* (5 species). The other genera are represented by 1-3 species. Comparison of the species numbers of families and genera of different stands shows common and distinctive features of their species composition. The species of the families Lophoziaaceae (especially of the genera *Lophozia* and *Barbilophozia*), Calypogeiaceae (*Calypogeia*), Ptilidiaceae (*Ptilidium*), and in less extent of Trichocoleaceae (*Blepharostoma*) appear to be most constant components of different fragmented old-growth spruce forest stands of the middle taiga zone of NE Finland.

The moss species of the studied old-growth spruce forests belong to 64 genera and 26 families. The families Dicranaceae, Sphagnaceae, Brachytheciaceae, Polytrichaceae, Hypnaceae, Amblystegiaceae, Mniaceae, Bryaceae are richest in the flora (Table 2). They include 19, 14, 10, 9, 8, 8, 7, and 6 species respectively. The family Hylocomiaceae includes 5 species. Species of families Dicranaceae, Sphagnaceae and Hylocomiaceae are common dominants in the forest floor. The genera *Sphagnum*, *Dicranum*, *Brachythecium*, *Plagiothecium*, *Dicranella* comprise largest number of species in the flora, i.e., 14, 9, 6 and 4 respectively. The other genera are represented by 1-3 species.

NUMBER OF SPECIES IN STANDS

Number of bryophyte species of the studied stands varies considerably from 35 (*Piilo-pirtinaho*) to usually 40-68(-91) and up to 140 species recorded for *Pampalo* (Table 2). Such a considerable difference in species number results from the habitat diversity of stands and a difference in degree of their investigation. The stands, which have only small admixture of aspen (e.g., *Pieni Kotavaara*) have fewer moss species due to absence of substrate for species associated with aspen. The influence of aspen abundance is, however, indistinct in liverwort species number because there are no hepatics obligatory associated with this tree in the studied territory. The other important factor of bryophyte diversity is an abundance of wetland habitats. It leads to dominance of several species of *Sphagnum*, prevents distribution of the other species of mosses and creates habitats for some hepatics associated with *Sphagnum*. In drier stands the number of the liverwort species is considerably lower than that of the moss species. Occurrence of rocky outcrops affects much on bryophyte species diversity due to inclusion in the flora of numerous species associated with rocky habitats. Estimations of species numbers in separate stands show that in cases of their rather detailed investigation they have usually from 44 (*Suolamminvaara*) – 47 (*Lahnavaara*) to 68 bryophyte species (*Syväjärvi*) (Table 2). Moss/liverwort species ratio in them varies from 1.8 to 3.3 and is predetermined primarily by their moisture and the proportion of microhabitats of mosses and liverworts rather than by degree of investigation of both groups.

Table 3. Bryophyte species of mature spruce stands of the North Karelian Biosphere Reserve and adjacent areas of Finland and species frequency grades. Abbreviations of names of studied spruce stand localities: Pa - Pahkavaara, Uk - Ukonsärkkä, Pä - Päävaara, Pv - Paistinvaara, Pi - Piilopirtinaho, Mu - Murtovaara, Ve - Verkköjärvi, Ho - Hoikka, Sy - Syväjärvi, Pk - Pieni Kotavaara, Py - Pyötikönkosket, La - Lakonjärvi, Ta - Tapionaho, Ko - Koitajoki, Pm - Pampalo, Ps - Pampalo slope, Ha - Haapahaasianvaara, Sa - Salmivaara, Ra - Raiskionaho, Lv - Lahnavaara, Su - Suolaminvaara. For every species the frequency grades for stands of collecting are listed (1 – found 1-2 times in studied stand; 2 – found 3-6 times; 3 – 7-15 times; 4 – 16-22 times; and 5 – over 22 times).

Species	Stands and species frequency grades																				
	Pa	Uk	Pä	Pv	Pi	Mu	Ve	Ho	Sy	Pk	Py	La	Ta	Ko	Pm	Ps	Ha	Sa	Ra	Lv	Su
<i>Anastrophyllum hellerianum</i>		1						2	2		1	1		2	1	1	2			1	1
<i>Anastrophyllum minutum</i>	2	2	2	2						1			1		2	1	1	1	1		
<i>Anastrophyllum saxicola</i>			1												1						
<i>Anthelia juratzkana</i>															1						
<i>Barbilophozia attenuata</i>	3	3	3	3		2	1	3	2	2	1	2	2	2	1	2	2	3	2	2	
<i>Barbilophozia barbata</i>				1				1						2	1	1	1				1
<i>Barbilophozia floerkei</i>									1												
<i>Barbilophozia lycopodioides</i>	2			2	2	2	1	2	2			1			1		2	2	1	2	2
<i>Barbilophozia hatcheri</i>						1									1						
<i>Barbilophozia kunzeana</i>						2		1													
<i>Blasia pusilla</i>									1						2						
<i>Blepharostoma trichophyllum</i>	2	2	2	2	2	2	2	2	1	2				2	3	2	2	2	1	1	1
<i>Calypogeia integrispula</i>	2	3	3	1	3	2	1	2	2	3	1	1	3	2	3	2	1	3	3	2	1
<i>Calypogeia muelleriana</i>						1		1	2						2						1
<i>Calypogeia neesiana</i>									2	2							1			1	
<i>Calypogeia sphagnicola</i>			1				2			1											
<i>Calypogeia suecica</i>										1						1					
<i>Cephalozia bicuspidata</i>		1					1	1	2				1	3		1	1	1			
<i>Cephalozia connivens</i>														2					1		
<i>Cephalozia leucantha</i>										1					1	1	1				1
<i>Cephalozia lunulifolia</i> s.l.		1	2			2	1	1	1		1	1		2		1	1			2	1
<i>Cephalozia macounii</i>																				1	
<i>Cephalozia pleniceps</i>						1			1											1	
<i>Cephaloziella elachista</i>										1											
<i>Cephaloziella elegans</i>							1	1cf.								2					
<i>Cephaloziella rubella</i>									1			1			2						
<i>Chiloscyphus polyanthos</i>							1								2					1	
<i>Chiloscyphus profundus</i>		1					1	1	1						1		1	1	1		
<i>Cladopodiella fluitans</i>																					
<i>Cladopodiella francisci</i>										1					1						
<i>Diplophyllum obtusifolium</i>									1	2					1						
<i>Diplophyllum taxifolium</i>						1	2														
<i>Geocalyx graveolens</i>															1						
<i>Gymnocolea inflata</i>		1																			
<i>Harpanthus flotoxianus</i>												1									
<i>Harpanthus scutatus</i>																1					
<i>Jungermannia caespiticia</i>										2					2						
<i>Jungermannia confertissima</i>										1											
<i>Jungermannia gracillima</i>										1					1						
<i>Jungermannia hyalina</i>										1					2						
<i>Jungermannia sphaerocarpa</i>										1											
<i>Leiocolea heterocolpos</i>															1						
<i>Lepidozia reptans</i>	2	2	2				2	1	2						2	1	1	2	1	2	1
<i>Lophozia ascendens</i>															3		1				
<i>Lophozia bicrenata</i>										2					1		1				
<i>Lophozia incisa</i>															1			1			
<i>Lophozia longidens</i>	2	2	1	1	2		2		1	1		1		1	2	1	1	1	1		1
<i>Lophozia longiflora</i> s.l.		1	1	1		1	1	2	2	1	1	1	1	4	2	1	1	1	1	1	1
<i>Lophozia obtusa</i>								1	1						1		1	1	1		
<i>Lophozia ventricosa</i> s.l.		2	2	1	2		1		2	3	1	1		1	2	1	2	3	1	2	2
<i>Marsupella emarginata</i>											1										
<i>Marsupella sprucei</i>										1											
<i>Metzgeria furcata</i>			1												1						
<i>Mylia anomala</i>										2										1	
<i>Nardia insecta</i>								1	3						3					1	
<i>Nardia japonica</i>									1						1						
<i>Nardia scalaris</i>									1												
<i>Pellia</i> cf. <i>neesiana</i>															1						

	Pa	Uk	Pä	Pv	Pi	Mu	Ve	Ho	Sy	Pk	Py	La	Ta	Ko	Pm	Ps	Ha	Sa	Ra	Lv	Su
<i>Hypnum pallescens</i>														1	1						
<i>Isopterygiopsis pulchella</i>									1					1		1					
<i>Isothecium alopecuroides</i>		1	2												2						
<i>Isothecium myosuroides</i>		2	3	2											1						
<i>Kiaeria blyttii</i>										1											
<i>Mnium stellare</i>															1						
<i>Neckera oligocarpa</i>			1												1						
<i>Oligotrichum hercynicum</i>															1						
<i>Oncophorus wahlenbergii</i>														1							
<i>Orthotrichum obtusifolium</i>				1	1	1	1		1			1	1	1	1						
<i>Orthotrichum speciosum</i>			1			2	1		1			2	2	3		1		1			
<i>Paraleucobryum longifolium</i>		1	2	2		1	1		1		2	1			1		1	1			
<i>Plagiomnium cuspidatum</i>		1	2						1			1	1	2	2		2	1	1	1	2
<i>Plagiomnium ellipticum</i>								1							2						
<i>Plagiomnium medium</i>															1						
<i>Plagiothecium curvifolium</i>			1					1									1				
<i>Plagiothecium denticulatum</i>		3	4	3	3	3	3	2	3	1	3	3	3	3	3	3	3	3	3	2	3
<i>Plagiothecium laetum</i>															1						
<i>Plagiothecium piliferum</i>															1						
<i>Pleurozium schreberi</i>	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5
<i>Pogonatum dentatum</i>	1	1			1					1	1		1	1	1	1			1		1
<i>Pogonatum urnigerum</i>	2	2		1	2	2			2	2			2		2						
<i>Pohlia andalusica</i>										1											
<i>Pohlia cruda</i>	2				2	2			1						1		1				
<i>Pohlia nutans</i>	2	3	3	2	2	2	2	1	2	3	3	1	1	2	2	1	2	3	3	3	3
<i>Polytrichastrum longisetum</i>		1						1	1	1			2		1					1	
<i>Polytrichastrum pallidisetum</i>		1				1			1				1								
<i>Polytrichum commune</i>	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	3	4	3	3
<i>Polytrichum juniperinum</i>	1	1							1	3	3				1	3	2	1	1		1
<i>Polytrichum strictum</i>							1			1											
<i>Pseudobryum cinclidioides</i>					2				3						3						
<i>Pterigynandrum filiforme</i>															1						
<i>Ptilium crista-castrensis</i>	4	4	3	3	4	4	3	1		3	2	4	3	3	4		3	2	3	2	3
<i>Pylaisia polyantha</i>			1	1		1	1		2	1			2	1	1	1	2	1	1	1	
<i>Racomitrium fasciculare</i>				1																	
<i>Racomitrium microcarpon</i>			2	2				1			1				2	1					
<i>Rhizomnium pseudopunctatum</i>		1			2	1	1	2							1		1		1		
<i>Rhizomnium punctatum</i>					1										2		1	1			
<i>Rhodobryum roseum</i>								1									1	1			
<i>Rhytidiadelphus subpinnatus</i>																					
<i>Rhytidiadelphus triquetrus</i>		3	3		3	2		3		2	3	1	2	2	3		2	2	2	1	1
<i>Saelania glaucescens</i>															1						
<i>Sanionia uncinata</i>	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	1	2
<i>Schistidium papillosum</i>															1						
<i>Schistostega pennata</i>	1	1		1		2				1	1	1	2		2				1		
<i>Sphagnum angustifolium</i>	2	3	1	2	2	2	2	2	1	3	1	2	3	2	1	1	1	1	2	2	1
<i>Sphagnum capillifolium</i>	2	2	2	2	3	2	3		1	3			3					1	2	2	1
<i>Sphagnum centrale</i>		2			1		3	2	1	1	2				1			1		1	
<i>Sphagnum compactum</i>																			1	1	
<i>Sphagnum fallax</i>		1	1					1					2								
<i>Sphagnum fuscum</i>							1														
<i>Sphagnum girgensohnii</i>	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	1	2	3	3	3	2
<i>Sphagnum magellanicum</i>		2			1	3			1	1	2		2		1		1	1	2	1	
<i>Sphagnum quinquefarium</i>	1	1	1	1		2			1	2	2		1		1		1		1	1	1
<i>Sphagnum riparium</i>										1					2	3			1		
<i>Sphagnum russowii</i>	2	3	2	3	3	2	3	3	3	3	3	3	2		1	1	1	2	3	1	
<i>Sphagnum squarrosum</i>				1			2					2			2						
<i>Sphagnum warnstorffii</i>	1	1			2			1							3			1			
<i>Sphagnum wulfianum</i>	1			1				2		2					1			1	1	1	
<i>Splachnum luteum</i>													1								
<i>Splachnum rubrum</i>													1								
<i>Straminergon stramineum</i>			2												1				1		
<i>Taxiphyllum wissoygrillii</i>															1						
<i>Tetraphis pellucida</i>	1	2	2	3	3		1	3	2	1			3	3	2	2	2	3	2	2	2
<i>Tetraplodon angustatus</i>			1																		
<i>Tetraplodon mnioides</i>										1											
<i>Timmia austriaca</i>															1						
<i>Tortella totrouosa</i>															1						
<i>Warnstorfia fluitans</i>							1								1				2		

Two of the studied stands are much richer in species number than the others. They are *Pieni Kotavaara* (91 species) and *Pampalo* (140 species). Moss/liverwort species ratio in them is 1.1 and 1.5 respectively. This, however, results from more detailed studies of liverworts than mosses on bare and disturbed soil in these stands and from only small admixture of aspen in *Pieni Kotavaara*. Extreme richness of these stands in bryophyte species results from abundance of moist habitats and microhabitat diversity. So, the high rocks, which are constantly shaded by spruce forest in *Pampalo*, provide such a diversity of bryophyte habitats that number of species in this locality is 1.5-3 times higher than in the other stands.

Thus, among 21 studied old-growth spruce forest stands, the highest number of species have *Haapahaasianvaara* (63 species), *Raiskionaho* (66), *Salmivaara* (62), *Syväjärvi* (68), *Ukonvärkkä* (66), and particularly *Pieni Kotavaara* (91) and *Pampalo* (140). The species diversity of the studied stands is predetermined by degree of their microhabitat diversity, which correlates closely first of all with their moisture, presence of aspen, constantly shaded rocks and of rotten wood. It is noteworthy that number of species in the studied stands is not correlated with their area. *Haapahaasianvaara*, being the stand with the largest area – 61 ha, has 63 species, whereas the stands *Pieni Kotavaara* and *Pampalo*, having 91 and 140 species, have the area around 15 ha.

FREQUENT SPECIES, SUBSTRATE AND RARITY

Comparison of the species lists of separate stands (Table 3) provides the basis to establish the “core species”, which normally occur in the studied fragmented old-growth spruce forest stands. The most common liverwort species are *Ptilidium pulcherrimum*, *Calypogeia integristipula*, *Barbilophozia attenuata*, *Blepharostoma trichophyllum*, *Lophozia ventricosa s.l.*, *L. longiflora*, *L. longidens*, *Barbilophozia lycopodioides*, *Cephalozia lunulifolia*, *Lepidozia reptans*. They were collected in most studied stands and have higher total frequency in comparison with the other species of the flora. Constant occurrence of these species in old-growth spruce forests appears to be connected with their wide distribution in taiga and predetermined by

correlation of their distribution with occurrence of habitats, which are characteristic of old-growth spruce forests (rotten wood, humid shady niches). 11 moss species occur in all 21 stands, whereas 5 species in 19-20 stands. Among them *Pleurozium schreberi*, *Hylocomium splendens*, *Dicranum scoparium*, *D. majus*, *D. polysetum*, *Sphagnum angustifolium*, *S. girgensohnii*, *S. russowii*, *Polytrichum commune* have a dominant role in the forest floor formation. The other species are insignificant in the forest floor formation and occur in the other habitats.

Analysis of ecological distribution (Table 4) shows that most liverwort species occur primarily on rotten wood (19 species) or on bare soil (17 species). Fewer species were found mainly in forest floor (14 species) or on boulders and rocky outcrops (7 species). Five species occur mostly at tree bases and among *Sphagnum*. Ecological distribution of mosses is different. 32 species were collected mainly on ground layer, 31 species on boulders and rocky outcrops, 14 on bared soil, 12 at aspen base and only five species were found mostly on rotten wood. Fewer moss species were collected on the other substrates (Table 4). A comparison of the revealed habitat distribution shows that the number of predominantly epixylic liverworts (19 species) is much higher than mosses (5); the number of saxicolous mosses (31 species) is considerably higher than liverworts (7); and the number of species growing at bases and bark of deciduous trees is significantly higher in mosses (17 species) than in liverworts (2). This appears to be resulted from different ecological preferences and strategy of liverworts and mosses, namely from stronger ability of liverworts than mosses to inhabit wet old logs characteristic of old-growth spruce forests and from weak ability of liverworts to grow on drier rocks, boulders, bases and bark of deciduous trees.

Nine species, which were included in Red Data Book of Finland (Rassi *et al.*, 2001), are recorded in the study area. Most of them occur on rotten wood and bare soil. They are *Calypogeia suecica*, *Harpanthus scutatus*, *Herzogiella turfacea* (all vulnerable – VU), *Cephalozia macounii* (endangered – EN), *Anastrophyllum hellerianum*, *Lophozia ascendens*, *Riccardia*

Table 4. Continued

Species	Species frequency in habitats (approx.%)													
	FF	BS	AB	BB	SB	PB	RB	WB	AS	BR	RW	SP	ED	
	MUSCI													
<i>Bryum pseudotriquetrum</i>	100													
<i>Calliergon cordifolium</i>	100													
<i>Dicranum drummondii</i>	100													
<i>Dicranum polysetum</i>	100													
<i>Hylocomiastrum umbratum</i>	100													
<i>Plagiomnium ellipticum</i>	100													
<i>Plagiomnium medium</i>	100													
<i>Polytrichum strictum</i>	100													
<i>Pseudobryum cinclidioides</i>	100													
<i>Ptilium crista-castrensis</i>	100													
<i>Rhizomnium pseudopunctatum</i>	100													
<i>Rhodobryum roseum</i>	100													
<i>Rhytidiadelphus subpinnatus</i>	100													
<i>Sphagnum</i> (14 species)	100													
<i>Dicranum majus</i>	90	5										5		
<i>Hylocomium splendens</i>	90	5										5		
<i>Straminergon stramineum</i>	90									10				
<i>Warnstorfia fluitans</i>	90							10						
<i>Aulacomnium palustre</i>	85	10			5									
<i>Pleurozium schreberi</i>	85							5				10		
<i>Polytrichum commune</i>	65	35												
<i>Cirriphyllum piliferum</i>	50		50											
<i>Rhizomnium punctatum</i>	50		20								20			
<i>Dicranum scoparium</i>	30	10	15	10							10	25		
<i>Atrichum undulatum</i>		100												
<i>Dicranella cerviculata</i>		100												
<i>Dicranella crispa</i>		100												
<i>Dicranella heteromalla</i>		100												
<i>Ditrichum heteromallum</i>		100												
<i>Ditrichum pusillum</i>		100												
<i>Pogonatum dentatum</i>		100												
<i>Pogonatum urnigerum</i>		100												
<i>Polytrichastrum longisetum</i>		100												
<i>Polytrichastrum pallidisetum</i>		100												
<i>Schistostega pennata</i>		100												
<i>Oligotrichum hercynicum</i>		100												
<i>Pohlia andalusica</i>		100												
<i>Polytrichum juniperinum</i>	10	90												
<i>Ceratodon purpureus</i>		80									10	10		
<i>Pohlia nutans</i>		80										20		
<i>Amlystegium subtile</i>			100											
<i>Campylium chrysophyllum</i>			100											
<i>Fissidens adianthoides</i>			100											
<i>Isopterygiopsis pulchella</i>			100											
<i>Plagiomnium cuspidatum</i>			100											
<i>Brachythecium erythrorrhizon</i>	5	80	5					5				5		
<i>Campylium sommerfeltii</i>		70										30		
<i>Eurhynchium pulchellum</i>		70									30			
<i>Rhytidiadelphus triquetrus</i>	30	70												
<i>Brachythecium salebrosum</i>	10	55				5		5	5			20		
<i>Amblystegium serpens</i>		5	50	20								25		
<i>Brachythecium velutinum</i>		5	50	5				5				35		
<i>Callicladium haldanianum</i>				100										
<i>Hypnum pallescens</i>							100							
<i>Pylaisia polyantha</i>									90			10		
<i>Orthotrichum speciosum</i>									85					
<i>Orthotrichum obtusifolium</i>			12	25				12	51					

Table 4. Continued.

Species	Species frequency in habitats (approx.%)												
	FF	BS	AB	BB	SB	PB	RB	WB	AS	BR	RW	SP	ED
<i>Amphidium lapponicum</i>													100
<i>Andraea rupestris</i>													100
<i>Bartramia ithyphylla</i>													100
<i>Bartramia pomiformis</i>													100
<i>Bryum flaccidum</i>													100
<i>Cnestrum schistii</i>													100
<i>Cynodontium strumiferum</i>													100
<i>Cynodontium tenellum</i>													100
<i>Dicranella grevilleana</i>													100
<i>Dicranum bergeri</i>													100
<i>Grimmia muehlenbeckii</i>													100
<i>Hedwigia ciliata</i>													100
<i>Heterocladium dimorphum</i>													100
<i>Homalia trichomanoides</i>													100
<i>Hypnum cupressiforme</i>													100
<i>Isothecium alopecuroides</i>													100
<i>Isothecium myosuroides</i>													100
<i>Kiaeria blyttii</i>													100
<i>Mnium stellare</i>													100
<i>Neckera oligocarpa</i>													100
<i>Paraleucobryum longifolium</i>													100
<i>Plagiothecium piliferum</i>													100
<i>Pohlia cruda</i>													100
<i>Pterigynandrum filiforme</i>													100
<i>Racomitrium fasciculare</i>													100
<i>Racomitrium microcarpon</i>													100
<i>Saelania glaucescens</i>													100
<i>Schistidium papillosum</i>													100
<i>Taxiphyllum wissgrillii</i>													100
<i>Timmia austriaca</i>													100
<i>Tortella tortuosa</i>													100
<i>Dicranum montanum</i>				15	15					55	15		
<i>Plagiothecium denticulatum</i>					30			30		40			
<i>Herzogiella turfacea</i>												100	
<i>Oncophorus wahlenbergii</i>												100	
<i>Tetraphis pellucida</i>			10			10						80	
<i>Dicranum fuscescens</i>	10	5		20	5	5				5	50		
<i>Sanionia uncinata</i>		10	20					10			50		
<i>Brachythecium reflexum</i>	15	5	20	5	10						40		
<i>Brachythecium starkei</i>	10	5	30	5	5						40		
<i>Dicranum flagellare</i>						30		30			40		
<i>Plagiothecium curvifolium</i>						30		30			40		
<i>Dicranum flexicaule</i>	16		3	20	3	3				16	39		
<i>Brachythecium oedipodium</i>	20	5	30	5							30		
<i>Plagiothecium laetum</i>		20		10	20			5		20	25		
<i>Splachnum luteum</i>													100
<i>Splachnum rubrum</i>													100
<i>Tetraplodon</i> (2 species)													100

palmata, *R. multifida* (all near threatened – NT). Moreover, *Polytrichastrum pallidisetum*, considered as regionally extinct in Finland (RE), have been collected four times in the study area on disturbed soil over roots of fallen trees. This species sporadically occurs in

Russian Karelia (Volkova & Maksimov, 1993) and in Leningrad Province (Kurbatova *et al.*, 1999). *Nardia japonica*, recently found as new for Finland (Potemkin, in press), is the other rare species probably of conservation concern.

COMPARISON WITH THE CENTRAL NORWAY
SPRUCE STANDS

Comparison of the studied bryophyte flora with the bryophyte flora of Central Norway spruce stands (Frisvoll, 1997) shows that despite different species number (19 and 28 species respectively), they have rather common composition of most frequent species. All 22 liverwort species of the studied area found in highest number of studied stands (from 96 to 22% of studied stands) occur in the Central Norway spruce stands. However, studied stands differ from the Central Norway spruce stands in presence of 18 species (positive differential species), which occur less frequently and were found mostly on bared soil and in rocky habitats (*Anastrophyllum saxicola*, *Anthelia juratzkana*, *Blasia pusilla*, *Cephaloziella elegans*, *Cladopodiella francisci*, *Jungermannia confertissima*, *J. hyalina*, *Marsupella sprucei*, *Nardia insecta*, *N. japonica*, *Scapania lingulata*) or in swampy conditions (*Cephaloziella elachista*, *Cladopodiella fluitans*, *Mylia anomala*). Moreover, 39 species (negative differential species) were recorded for the Central Norway spruce stands but not found in the North Karelian stands. These species are mainly characteristic for eutrophic and calcareous soils and for regions with \pm oceanic climate (e.g., *Bazzania tricrenata*, *B. trilobata*, *Calypogeia azurea*, *Chiloscyphus coadunatus*, *Diplophyllum albicans*, *Frullania tamarisci*, *Jungermannia exsertifolia*, *Scapania paludosa*). Furthermore, in the studied flora there were not found such species of \pm arcto-montane distribution as *Barbilophozia quadriloba*, *Lophozia opacifolia*, *L. sudetica*, *Odontoschisma elongatum*, *Tetralophozia setiformis*, which are characteristic of the Central Norway spruce stands.

18 moss species of the North Karelian flora found in highest number of studied stands (from 100 to 78 % of studied stands) occur in the Central Norway spruce stands. Among species with lower stand frequency there are 36 species which are known from the study area and absent in the Central Norway spruce stands, i.e. positive differential species. They include 6 species growing at base and on bark of aspen (*Amblystegium serpens*, *A. subtile*, *Brachythecium erythrorrhizon*, *Campylium chrysophyllum*, *C. sommerfeltii*, *Pylaisia polyantha*) and 7 species

of the genus *Sphagnum*, having apparently more continental distribution (*Sphagnum compactum*, *S. fallax*, *S. fuscum*, *S. lindbergii*, *S. magellanicum*, *S. riparium*, *S. wulfianum*). Moreover, there is a considerable group of species, which occurrence appears to be possible in the Central Norway spruce stands, but they were not found there (*Amphidium lapponicum*, *Callicladium haldanianum*, *Calliergon cordifolium*, *Cnestrum schisti*, *Dicranum bergeri*, *D. drummondii*, *D. flagellare*, *Ditrichum pusillum*, *Grimmia muehlenbeckii*, *Herzogiella turfacea*, *Heterocladium dimorphum*, *Hypnum pallescens*, *Neckera oligocarpa*, *Plagiothecium curvifolium*, *Pogonatum dentatum*, *Polytrichastrum pallidisetum*, *Saelania glaucescens*, *Splachnum luteum*, *Taxiphyllum wissgrillii*). The studied moss flora is characterized by absence of 106 species (negative differential species), which were recorded in the flora of the Central Norway spruce stands. They include some \pm arcto-mountain species (e.g., *Blindia acuta*, *Plagiobryum zieri*), many calciphilous and eutrophic species (*Amphidium mougeotii*, *Brachythecium glareosum*, *Distichium capillaceum*, *Gymnostomum aeruginosum*, *Neckera complanata*, etc.), some species of suboceanic (e.g., *Racomitrium affine*, *Rhytidiadelphus loreus*, *Sphagnum rubiginosum*) as well as of nemoral distribution (*Mnium hornum*, *Plagiommium affine*, *Plagiothecium undulatum*, etc.).

Aforementioned distinctions in the species composition of liverworts and mosses result in difference of both floras in taxonomic structure. Species numbers in the leading families and genera in floras of spruce stands of the North Karelian Biosphere Reserve and adjacent territories of Finland and of Central Norway may be represented as follows: Lophoziaceae (19 vs. 25), Jungermanniaceae (9 vs. 9), Cephaloziaceae (8 vs. 4), Scapaniaceae s.str. (6 vs. 11), Geocalycaceae (5 vs. 7), Calypogeiaceae (5 vs. 6); Dicranaceae (19 vs. 24), Sphagnaceae (14 vs. 11), Brachytheciaceae (10 vs. 13), Polytrichaceae (9 vs. 9), Hypnaceae (8 vs. 11), Amblystegiaceae (8 vs. 8), Mniaceae (7 vs. 17), Bryaceae (6 vs. 16); *Lophozia* (8 vs. 13), *Scapania* (6 vs. 11), *Barbilophozia* (6 vs. 7), *Cephalozia* (6 vs. 4), *Calypogeia* (5 vs. 6), *Jungermannia* (4 vs. 7), *Sphagnum* (14 vs. 11), *Dicranum* (9 vs. 6), *Brachythecium* (6 vs. 9), *Plagiothecium* (4 vs. 8), and *Polytrichum* (3 vs. 5).

Together with distinctions in taxonomic composition of the studied and the Central Norway spruce stands their difference in species frequency and composition of dominant moss species of forest floor is obvious. Some liverwort species (*Calypogeia integristipula*, *Barbilophozia attenuata*, *Blepharostoma trichophyllum*, *Lepidozia reptans*, *Anastrophyllum minutum*, etc.) are more frequent in the studied area than in the Central Norway stands whereas the other (*Cephalozia lunulifolia*, *Barbilophozia lycopodioides*, *Lophozia obtusa*, *Barbilophozia barbata*, *Tritomaria quinquedentata*, *Barbilophozia floerkei*, etc.) are more rare in the studied area, i.e. more frequent in the Central Norway stands. This distinction may result from differences in climate (moderately continental vs. suboceanic), edaphic conditions (soils rather poor vs. rather rich), and landscape (plain vs. mountain). The compared areas have partly similar composition of dominant moss species of the forest floor. However, in the flora of old-growth spruce forests of North Karelia the species of the genus *Sphagnum* take larger part in forest floor formation whereas suboceanic species of some other genera are absent (*Rhytidiadelphus loreus*, *Plagiothecium undulatum*, *Polytrichastrum formosum*) or very rare (*Hylocomiastrum umbratum*, *Rhytidiadelphus subpinnatus*).

CONCLUSIONS

1. 119 moss species of 64 genera and 26 families and 75 liverwort species of 29 genera and 19 families were found in 21 fragmented old-growth spruce forest stands of the North Karelian Biosphere Reserve and adjacent territories of Finland. The families of mosses, leading in number of species in the flora, are Dicranaceae (19 species), Sphagnaceae (14), Brachytheciaceae (10), Polytrichaceae (9), Amblystegiaceae (8), Hypnaceae (8), Mniaceae (7), Bryaceae (6), Hylocomiaceae (5) and Plagiotheciaceae (4 species). The families of liverworts, leading in number of species in the flora, are Lophoziaceae (19 species), Jungermanniaceae (9), Cephaloziaceae (8), Scapaniaceae (6), Geocalycaceae (5) and Calypogeiaceae (5 species).

2. Among 21 studied old-growth spruce forest stands, the highest number of species have *Haapahaasianvaara* (63 species), *Raiskionaho* (66), *Salmivaara* (62), *Syväjärvi* (68), *Ukon-särkkä* (66), and particularly *Pieni Kotavaara*

(91) and *Pampalo* (140). The species diversity of the studied stands is predetermined by degree of their microhabitat diversity, which closely correlates first of all with their moisture, presence of aspen, constantly shaded rocks and amount of rotten wood. The number of species in the studied stands is not correlated with their area.

3. Most common moss species in old-growth spruce stands of the North Karelian Biosphere Reserve and adjacent territories of Finland, which have mainly a dominant role in the forest floor formation, are *Pleurozium schreberi*, *Hylocomium splendens*, *Dicranum scoparium*, *D. majus*, *D. polysetum*, *Sphagnum angustifolium*, *S. girgensohnii*, *S. russowii*, *Polytrichum commune*. The most common liverwort species are *Ptilidium pulcherrimum*, *Calypogeia integristipula*, *Barbilophozia attenuata*, *Blepharostoma trichophyllum*, *Lophozia ventricosa* s.l., *Lophozia longiflora*, *Lophozia longidens*, *Barbilophozia lycopodioides*, *Cephalozia lunulifolia*, *Lepidozia reptans*. They were collected in most studied stands and have higher total frequency in comparison with the other species of the flora.

4. Liverworts and mosses have different ecological distribution in the studied area. Species diversity of liverworts is considerably higher on rotten wood and bare soil whereas the species diversity of mosses is higher on rocks and at bases and bark of deciduous trees. This appears to be resulted from stronger ability of liverworts than mosses to inhabit wet old logs characteristic of old-growth spruce forests and from weak ability of liverworts to grow on drier rocks, boulders, bases and bark of deciduous trees.

5. Nine bryophyte species (*Anastrophyllum hellerianum*, *Calypogeia suecica*, *Cephalozia macounii*, *Harpanthus scutatus*, *Herzogiella turfacea*, *Lophozia ascendens*, *Polytrichum pallidisetum*, *Riccardia multifida*, *R. palmata*) included in Red Data Book of Finland (Rassi & al., 2001) have been revealed in the North Karelian Biosphere Reserve and adjacent territories of Finland. They occur on rotten wood and bared soil in the area under research.

6. The bryophyte flora of fragmented old-growth spruce forest stands of the North Karelian Biosphere Reserve and adjacent areas of Finland is characterized in comparison with the flora of the Central Norway spruce stands by 54 positive differential species (36 mosses and 18 hepatics)

and 145 negative differential species (39 hepatics and 106 mosses). It has more poor representation of the most families and genera leading in number of species, except family Sphagnaceae and genus *Sphagnum*. Specificity of the taxonomic composition of the flora is predetermined by moderately continental climate, absence of eutrophic and calcareous soils, presence of spruce forest of *Myrtillus* type with often admixture of aspen, plain relief of the territory, and restricted occurrence of rocky outcrops.

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