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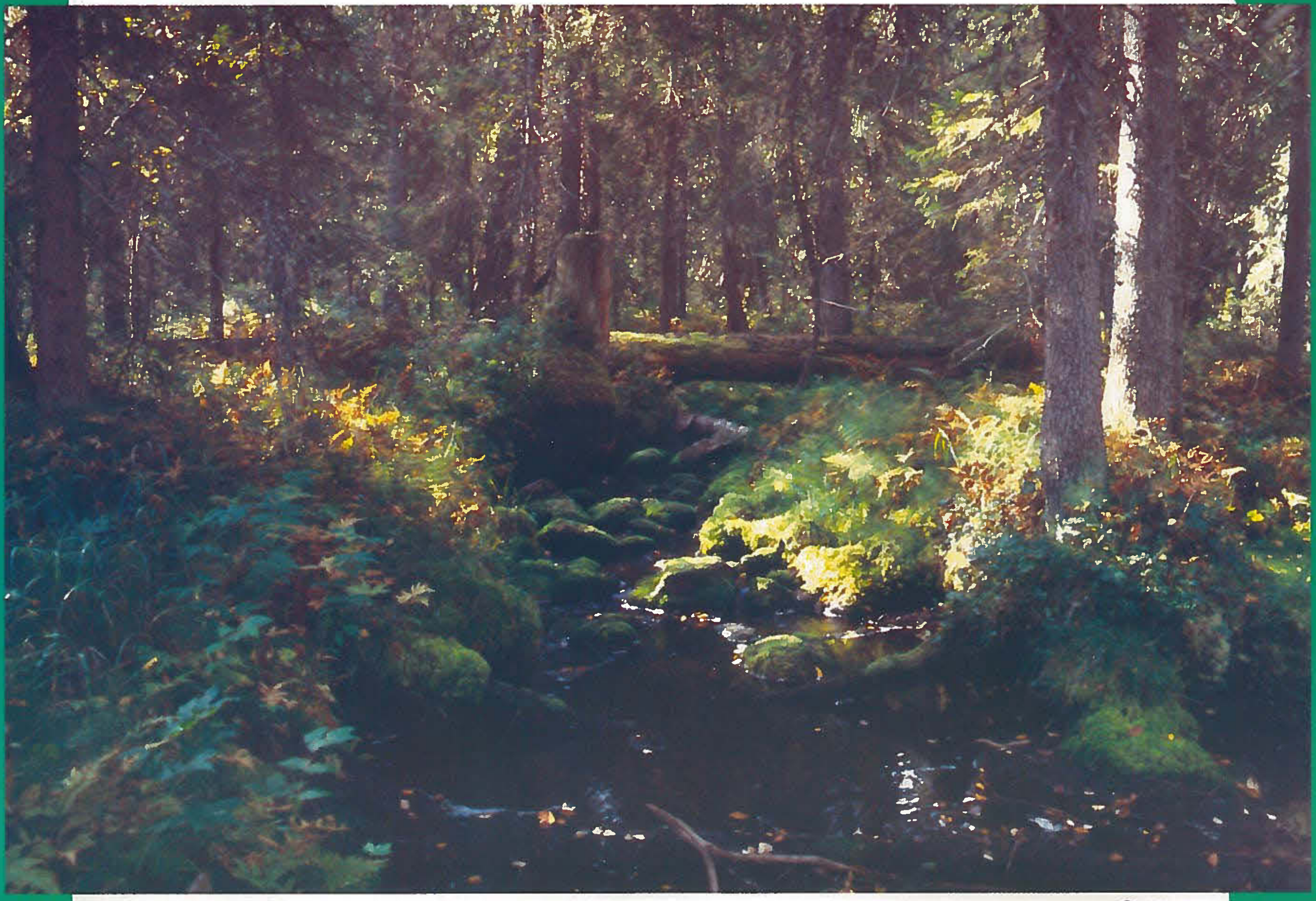
NATURE AND NATURAL RESOURCES

Raimo Heikkilä & Tapio Lindholm (eds.)

Biodiversity and conservation of boreal nature

Proceedings of the 10 years anniversary symposium of the Nature Reserve Friendship



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Cover picture: Old-growth forest in Ulvinsalo Photo: Raimo Heikkilä
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Contents

The Nature Reserve Friendship as a part of the Fennoscandian Green Belt

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The Nature Reserve Friendship

The Nature Reserve Friendship was established in 1990 on the basis of an agreement signed by the presidents of Finland and the Soviet Union, Mauno Koivisto and Mihail Gorbachew in 1989. The aim of the agreement was to promote Finnish-Russian cooperation in nature conservation, and especially nature conservation research. The nature reserve consists of six different parts in Russia and in Finland (Fig. 1). The area belongs to the Fennoscandian Archaean bedrock area with gently undulating terrain formed of several glaciations during tha latest two million years.

Kostamus State Nature Reserve (zapovednik) on the Russian side is strictly protected and reserved for ecological research. It was established in 1984, and it covers 47 500 hectares including the large Lake Kiitehenjärvi, numerous smaller lakes, pristine forests and small aapamires. The reserve was opened for guided tourist excursions along 8 routes in 1995, and recently also ecological education is one task of the reserve in addition to scientific research.

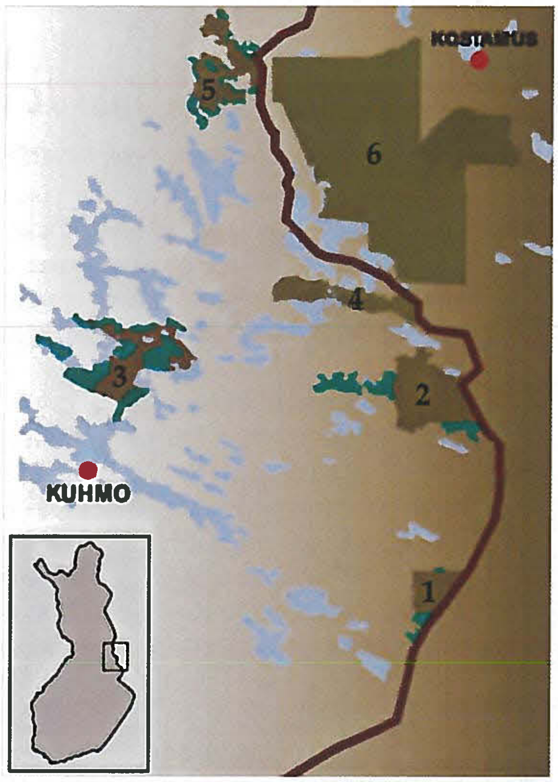

Fig. 1. Nature Reserve Friendship. 1. Ulvinsalo, 2. Elimyssalo, 3. Lentua, 4. Iso Palonen-Maariansärkät, 5. Juortanansalo-Lapinsuo, 6. Kostamus state nature reserve, extensions of reserves in green

On the Finnish territory there are five nature reserves, which together form Friendship Park. Ulvinsalo strict nature reserve was established in 1956 covering 2500 hectares. In the 1990s it was extended up to 3000 hectares in connection with the old forest conservation programme. In Ulvinsalo there is a mosaic of pristine forests, small aapamires and small watercourses. It is reserved for ecological research and closed for the public. Elimyssalo Nature Reserve (established in 1990) is the largest protected area in Kainuu province, covering after recent extensions about 8000 hectares. There are old-growth forests, a large diversity of small mires, numerous small lakes and natural streams. Iso Palonen – Maariansärkät Nature Reserve (4000 ha) was also established in 1990. It consists of pine forests on eskers and oligotrophic lakes with very clear water. Lentua Nature Reserve (5100 ha) contains a part of the largest unregulated lake in Kainuu province, and some islands with pine forests. Juortanansalo mire reserve (established in 1988) covers about 3000 hectares of relatively large aapamires and pristine forests on mineral soil islands. Thus Friendship Park covers altogether 23 000 hectares in Kuhmo and Suomussalmi towns.

Nature conservation research in the Nature Reserve Friendship

Since the previous symposium on the Finnish-Russian research cooperation in the framework of the Nature Reserve Friendship (Heikkilä & Lindholm 1997, Lindholm et al. 1997) a lot has happened. The research both in Finland and in Russia has turned more and more from basic inventories to analytical research on the functioning of ecosystems from regional to local scale. An important task has been compiling data to promote the ideas about forming a green belt along the Finnish-Russian border. Large projects have been conducted with funding from the ministries of the environment and natural resources as well as from EuropeanUnion TACIS and LIFE foundations. At the moment there is a large project going on to study the influence of the large wilderness areas on the Russian side on the animal populations in the fragmented network of small reserves on the Finnish side. The studies nowadays also aim at showing alternative economical possibilities to compensate the losses in forestry caused by the establishment of new large nature reserves.

The international 10 years anniversary symposium of the Nature Reserve Friendship

The symposium was organised in Kuhmo, Finland 16th to 19th October, 2000. There were altogether 140 participants from eight countries. They gave 81 oral presentations in 13 sessions with Dr. Andrei Gromtsev, Prof. Ilkka Hanski, Mr. Kalevi Heikura, Prof. Evgeni Ieshko, Dr. Oleg Kuznetsov, Dr. Tapio Lindholm, Mr. Matti Määttä, Dr. Mikko Mönkkönen, Prof. Jaanus Paal, Prof. Leonid Rybalov, Prof. Heikki Toivonen, Dr. Harri Vasander and Prof. Yrjö Vasari as chairmen. In addition, 35 posters were presented. The language of the symposium was English. After the symposium there was a two-day excursion to Kostamus and Vuokkiniemi in Russia with 35 participants.

A special topic of the symposium was the 70 years birthday celebration of professor Rauno Ruuhijärvi, the grand old man of Finnish nature conservation and Finnish-Russian cooperation. This volume is dedicated to the magnificent work, which professor Ruuhijärvi is still continuing very actively.

Dr. Oleg Kuznetsov, Dr. Boris Kashevarov and Dr. Olga Galanina helped with contacts with the Russian authors during the editing process. Dr. Hanna Kondelin helped with the editing of half of the articles. Mr. Martti Salo and Ms. Paula Piirainen prepared the layout of the volume. The Finnish ministry of the environment financed the symposium and the printing of this volume. We express our warmest gratitude to all those who helped us to finish the editing of the proceedings.

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Co-operation between Russia and Finland in the field of nature conservation

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Initial phase of co-operation

The nature conservation co-operation between Finland and the Soviet Union was started in the 1970's in the framework of Scientific-technical co-operation agreement. In the beginning the parties in nature protection were the ministries of agriculture. Already at this stage the parties observed the planning of the Kostomuksha strict nature reserve, which had been initiated by Finland (1971) in the aim of protecting the wild forest reindeer. In the initial phase of co-operation the parties got acquainted with each others' protected area systems, threatened species, animals, migration across the border and the principles of protecting common ecosystems, especially forests and mires.

The co-operation became more official in 1985, when both countries signed an inter-governmental agreement on co-operation in the field of environmental conservation. The main parties at that time were the Finnish Ministry of the Environment and Goskomgidromet.

Nature conservation co-operation with the neighbouring regions of Finland

In the end of the 1980's in compliance with the wishes of the Finnish side the co-operation was focused on the neighbouring regions. The planning of the Park of Friendship began in 1987 and the discussions about the Karelian protected area network started at the same time. The first objective being the lake Paanajärvi region (1989), which was threatened by the hydro-electric power station project.

A new agreement was signed in 1992 with the new Russia, and since then the activities have been carried out in the neighbouring regions of Finland first in Karelia. The projects of establishing the national parks of Vodlozero (1991) and Paanajärvi (1992) lead to quick decisions. The decisions of protecting these areas also enabled research co-operation, as well as collaboration between the park personnel. The Park of Friendship, Oulanka Biological Station and the National Parks of Oulanka and Paanajärvi and the biosphere area of North Karelia on the Finnish side and Karelian Research Center on the Russian side have been the most active in this respect.

The Green Belt of Eastern Fennoscandia is being outlined

The decrease in closed frontier zones and threats of large-scale wood cutting lead into launching a frontier zone forest research project in co-operation with the Karelian Research Centre in 1992. Biodiversity inventories were started in the frontier zone of more than 600 km in length, and they were supported by Finland. At the same time it was possible to enhance the protected area projects in the near-frontier territories. The planning of the national park of Lake Ladoga Archipelago had been started earlier, and it was completed by projecting the parks of Tolvajärvi-Koitajoki and Tuulos in the south and the Kalevala park in the north.

The idea of forming a chain of protected areas, starting from the Barents Sea and ending in the Gulf of Finland was initiated in the final phase of the frontier forest project. The Russian-Finnish nature conservation working group started to promote this idea and was soon joined by Russian and Finnish nongovernmental nature conservation organisations. The plans of the green belt started to take shape. In the Murmansk oblast there had been established the Pasvik strict nature reserve in 1992 and the Kutsa protected area in 1994. Planning of the strict nature reserve in the Archipelago of the Gulf of Finland was started by Leningrad oblast.

However, after the optimistic beginning no new decisions on nature protection have been made in the close-border regions. On the contrary, the dispute between forestry and nature protection has rather become more aggravated. The development of the Paanajärvi National Park and planning of the protected areas near the border is being continued now by the EU Tacis project "Karelia Parks Development".

In Finland the conservation of the green belt has been promoted in the frame of old-growth forests protection programme, as well as through establishing the "Natura 2000" network. It is being continued through the forest protection programme for the Southern Finland.

Finnish-Russian Development Programme on Sustainable Forest Management and Conservation of Biological Diversity in Northwest Russia

In 1997 forest management and biodiversity issues of the projects in the neighbouring regions between Finland and Russia were linked together under one management group, which is controlled by the three Finnish ministries. The management group has its own secretariat, who takes care of the agreements, their administration and the financial issues between the partners in different regions. The Russian-Finnish nature conservation working group was transformed into an expert group on scientific planning, monitoring, evaluation and publishing, but it still carries out some smaller projects, excursions, seminars and meetings in co-operation with the Finnish Environment Institute, the nature protection department of the Finnish Forest Service, regional environmental centres and universities.

The co-ordination of forest management with nature conservation projects and biodiversity issues is a difficult task, which so far has not been successful. It remains to be seen, whether these circumstances will be affected by the administrative fusion of the forest service and environmental protection authorities of Russia or the more and more international projects in the frame of the Barents region and EU.

As far as project planning is concerned, the Northwest regions of Russia have prioritised planning of new nature conservation areas. Large parks are being designed especially in Murmansk and Archangelsk districts. In Karelia also other inventories of biodiversity have been carried out for many years already. Russian Academy of Sciences in Karelia and Murmansk is our most important partner.

The essential goal is to protect the pristine old-growth forests and the younger succession phases naturally developed forests. Large areas of any of these cannot any more be found outside Russia, and even in Russia their amount is diminishing and the areas are quickly becoming more and more fragmented.

However, there are still valuable green zones, for example, across the Kola Peninsula in east-west direction, around the White Sea and around the Vodlozero park, as well as in the border regions of Archangelsk and Komi districts.

The Russian-Finnish nature conservation working group has lately been discussing the so-called GAP-analysis of the representativeness and the deficiencies of the protected area network in Northwest Russia. This would include estimating the network also as a part of the networks of Western Europe. Financing the project fits well together with our programme and we believe that it is also possible to get international support. The planning process has been slowed up this year because of the reorganisation of the Russian environmental authorities.

Publications in different languages

From the very beginning scientific publications and environmental education have been considered as an important component of nature conservation co-operation. Several seminar reports have been published in different journals. Publication of the Red Data Book of Eastern Fennoscandia (1998) is the result of many years' co-operation. The Red Data Book of Leningrad district consists of three parts; Hot spots of nature, protected and planned, Plants and fungi and Animals. The Karelian Research Centre has published several research reports on the planned protected areas and biodiversity in Karelia. Along with the reports of Murmansk and Archangelsk they will be published in the future also for international use.

Acknowledgements

The nature conservation co-operation has been successful and it has given good experience to the parties. We wish to continue the same way, so that the projects will be carried out mainly by Russian scientists and financed by Finland either partially or completely. We believe that this ensures better possibilities for carrying out these projects in practice. We appreciate the competence and the highly experienced work of the Russian scientific community and are willing to support it.

On behalf of the Russian-Finnish nature conservation working group I want to thank all our partners in Russia and Finland. The work you have done for the nature is of very high value. We believe that before long the commenced projects will lead to better protected area network in Northwest Russia.

Conservation of biological diversity in Northwest Russia as a part of the Finnish-Russian Development Programme, 1997-2000

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Introduction

There is a long tradition of cooperation between Finland and Russia in the sphere of nature conservation. The geographical proximity and similarity of natural conditions found in Finland and Northwest Russia have created a natural basis for such cooperation. Thus, since the signing of an agreement on environmental cooperation in 1985 by the governments of Finland and the Soviet Union, nature protection has occupied a central position in cooperation between the two countries at both official and unofficial levels.

Cooperative traditions in nature conservation have been created largely by the activities of the Finnish-Russian working group on nature protection, led on the Finnish side by Professor Rauno Ruuhijärvi. This group has performed a great deal of the valuable work over many years, striving towards the establishment of new protected areas in NW Russia. At the beginning of the nineties, with the focus of attention turning increasingly towards cross-border cooperation, the efforts of the working group began to bear fruit with the establishment of new nature reserves in the regions situated along the Finnish-Russian border.

This long tradition of nature protection has also seen the birth of the Finnish-Russian Development Programme on Sustainable Forest Management and Conservation of Biological Diversity in NW Russia. During the three years of its existence (1997-2000) the programme has, among other things, served as a link between numerous other programmes as well as aiming at developing broader international cooperation for the promotion of nature conservation in NW Russia. The programme has links with many other international programmes such as the Northern Dimension Forest Programme of the European Union, the Barents Euro-Arctic Council and the Habitat Contact Forum.

Background to the programme

The background to this programme is one of the numerous international and bilateral agreements which have helped to raise the international profile of nature conservation and biodiversity issues. Among the best known of these agreements include the UN Environment and Development Conference on Biodiversity held in Rio de Janeiro in 1992 and certain bilateral agreements between Finland and Russia.

As the Finnish-Russian Development Programme covers both forestry and biodiversity issues, its general aim is to promote a balanced development of the forest sector in NW Russia. The main aim of its biodiversity projects is to achieve visible results in the development of a network of protected areas and the conservation of biodiversity in NW Russia.

A further aim of these biodiversity projects is to promote scientific cooperation and to carry out studies into the biodiversity and conservation value of areas in NW Russia. The programme also aims to promote a wider international dialogue on the importance of and opportunities for conserving forest and mire ecosystems in NW Russia. Furthermore, it aims at promoting better mutual understanding of the basic concepts and objectives of nature protection, as well as encouraging international cooperation in this field.

Biodiversity conservation projects during 1997-2000

The programme's biodiversity projects have been based on agreements between the Ministry of the Environment of Finland, the State Committee of the Russian Federation on Environmental Protection, and regional state committees on environmental protection in NW Russia. Though agreements have been made at the ministerial level, the important practical work has been performed by the Russian regional scientific institutes which have implemented the projects.

Over the course of these three years there have been almost twenty projects of various sizes in the regions of Leningrad, Arkhangelsk, Murmansk and the Republic of Karelia. They have included, among other things, scientific expeditions to potential new protection areas such as the proposed Onezhkoe Pomore National Park and to Lake Kozhozero in the Arkhangelsk region. The projects have also included inventories of biodiversity as well as studies into nature and landscape value. Projects of this type have been implemented in all four of the regions covered by the programme. Projects have also included support for new scientific and popular publications including literature about the Leningrad region and the Republic of Karelia. In general, preference has been shown towards projects aiming at conservation of old-growth forests. However, projects assisting nature protection in more general terms have also been supported.

The following list details the biodiversity conservation projects implemented during 1997-2000 as part of the programme:

	Project	Region	Completed
1.	Research on the biodiversity of territories close to the Finnish-Russian border-zone	Republic of Karelia	1997
2.	Bioinventories in the proposed national parks Kalevala, Tuulijärvi and Koitajoki-Tolvajärvi	Republic of Karelia	1998
3.	Research on the biodiversity of the coast and lowlands of the White Sea	Republic of Karelia	1998
4.	Research on biodiversity in Zaonezhye and on the northern shores of Lake Ladoga (Lahdenpohja and Pitkäranta areas)	Republic of Karelia	1999
5.	An expedition of Russian-Finnish-Swedish-Norwegian scientists to Onega peninsula (Onezhkoye Pomorye) in the White Sea to promote the establishment of a national park	Archangelsk region	1997
6.	A Russian-Finnish-Swedish-Norwegian scientific expedition to Belomor-Kuloyskoe Plateau to promote the establishment of a national park	Archangelsk region	1998

7.	A Russian-Finnish-Swedish-Norwegian scientific expedition to Kozhozero to promote the establishment of a national or nature park	Archangelsk region	1999
8.	Nature inventories and planning for the establishment of the proposed Onezhkoye Pomorye national park	Archangelsk region	1999
9.	Nature inventories and planning for the establishment of the proposed national parks at Kutsa, Khibiny (Hiipinä in Finnish) and Terskij bereg (Turjanranta in Finnish)	Murmansk region	2000
10.	Forest and nature inventories in Laplandskij les forest area (Itäsaariselkä in Finnish)	Murmansk region	2000
11.	Studies of the protection value of Rakovye ozera (Äyräpäänjärvet in Finnish) and of threats to the natural environment; a project for the planning of a permanent nature exhibition at Äyräpäänjärvi	Leningrad region	1999
12.	Nature value inventories in Lesogorsk (Jääski in Finnish) and Dymovo (Kirvu in Finnish)	Leningrad region	1999
13.	Nature value inventories and planning for the establishment of nature reserves in the Karelian forest, Anisimovskie ozera (Kemppilänjärvet in Finnish), Kuznechnoye (Kaarlahti in Finnish) and Nizovskoye boloto (Suursuo in Finnish)	Leningrad region	1999
14.	Support for the writing, editing and publication of the Red Data Book of Leningrad Area, volume I (existing, projected and proposed protected areas)	Leningrad region	1999
15.	Nature value inventories, studies into biodiversity and planning the establishment of nature reserves: initially Rjabovo, replaced in summer 2000 by Reka Velichka (Kuolemajärvi in Finnish), Myullisaari (Myllysaari in Finnish); initially Belitshja Protoka, replaced in the summer 2000 by Ozero Vuoksa (Vuoksi in Finnish), Termolovo (Termola in Finnish).	Leningrad region	2001
16.	Support for the writing, editing and publication of the Red Data Book of Leningrad Area, volumes II (fungi and plants) and III (fauna)	Leningrad region	2000,2002
17.	Initiation of cooperation in biodiversity projects; nature value inventories in the Vologda region and support for the writing, editing and publication of the Red Data Book of Vologda region.	Vologda region	In progress
18.	Support for the writing, editing and publication of literature in English about nature inventories performed in the Karelian Republic.	Republic of Karelia.	In progress

In all, the projects have enjoyed a broad-based cooperation and have involved very large numbers of people. In both countries the projects have made use of numerous experts, authorities and researchers from various ministries, committees, scientific centres, institutes, universities and other organisations. However, as responsibility for project implementation has lain with the Russian partners and as all projects have been proposed, prepared and performed in Russia, so the amount of work has been considerably greater and regional cooperation more extensive on the Russian side. Numerous organisations have taken part in projects in each of the four regions and projects have often brought together experts from many different fields, including biologists, geologists, geographers, hydrologists and ethnographers, as well as specialists with other academic backgrounds.

Results of the programme

One of the results of the programme has been a broadened discussion concerning nature protection and cooperation between authorities, researchers, and both public and NGOs both in Finland and Russia. Cooperative scientific research efforts have been significantly promoted.

During the course of the programme numerous publications related to nature protection in NW Russia have been produced. These include analysis in Finnish of debates concerning the forest and of the need for nature protection (Haapala 1999, Kemppainen 2000) as well as various nature inventory reports in English. For example, a publication detailing the three proposed national parks in the Karelian Green Belt, i.e. Kalevala, Tulos and Koitajoki, will soon be published. There are also plans to publish (in summer 2001) a wide-ranging book concerning nature inventories carried out in the Karelian Republic during the period 1997-2000.

There have also been many other publications. For example, the bulletin "Forest and Nature in Northwest Russia" ("Лес и природа на Северо-Западе России») has been published regularly on six occasions during the three years both in Russian and English (http://www.vyh.fi/kvasiat/lahialue/venmetsa/venmetsa.htm.). The Red Book of Leningrad Region has been prepared. The first part of this series was published at the end of 1999 and deals with protected areas in the Leningrad region (Noskov & Botch 1999). The second (plants and fungi) and third (fauna) parts appeared in 2000 and 2002, respectively (Tzvelev 2000, Noskov 2002). The Red Data Book of East Fennoscandia was published as early as 1998 (Kotiranta et al. 1998). There are also plans to start preparations for a Red Data Book of the Vologda Region.

The above mentioned projects and publications have each in their own way contributed towards the final aim of the programme, the establishment of new nature protection areas in NW Russia. Unfortunately, during these three years there has not been much in the way of positive decisions taken to establish new protected areas in NW Russia. However, there has been some good news. The announcements of the foundation of a nature conservation area (landshaftnyj zakaznik) at Vepsä (Vepskij les) in 1999 and the establishment of an important watershed conservation area at Atleka (landshaftnyj zakaznik) in the region of Northern Vologda at the end of summer 2000 were both warmly received. There has also been news concerning the Eastern Islands of the Finnish Gulf, where plans to establish a strict nature reserve area (zapovednik) at Ingermanlandsky have progressed thanks to a positive decision from the regional defence forces.

The future

By the year 2000 the first phase of the programme was nearing its end. The second phase started in 2001. We now seek to develop and increase international cooperation with both existing and new contacts. One of the most challenging new projects will be the Gap-analysis. The Gap-analysis aims to develop and complete the conservation of nature in NW Russia through the establishment of new protected areas and the optimising of the functions of those nature protected areas already in existence.

Another challenge for the future will be the new reformed administration for environment protection and forest management in Russia. In dealing with questions of nature conservation and sustainable forest management in Russia we can be certain that challenges will not be in short supply. However, as long as there are people interested in working in this field who determined to build a more sustainable future, so these problems may yet be overcome. Cooperation will continue and, it is hoped, will become even more constructive and fruitful during the forthcoming years.

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The study and assessment of biodiversity in the Republic of Karelia (1997-2000)

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Introduction

A series of biodiversity assessment studies was carried out on cenotic and species levels in 1997-1999 under a Russian-Finnish project with the same name. Specialists of four institutes of the Karelian Research Centre, Russian Academy of the Sciences, were involved in the project. Joint research and analysis of available materials provided extensive data on the characteristics of the study region.

Methodological approach

The study was conducted in accordance with the following programme:

1. Physical - geographical conditions with assessment of biotic life

1.1. Geological characteristics of the territory
1.2. Geomorphologic characteristics of the territory
1.3. Characteristics of Quaternary deposits and history of geological development in the Quaternary period (with evidence for species dynamics pattern)
1.4. Hydrographic characteristics of the territory
1.5. Characteristics of the soil cover

2. Diversity and present state of ecotopes, forest, mire and meadow communities

2.1. Taiga landscapes
2.2. Forest cover (present situation)
2.3. Mires
2.4. Meadows

3. Flora and fauna of terrestrial ecosystems: characteristics and assessment of the pattern of changes caused by human activities

3.1. Vascular plants
3.2. Mosses
3.3. Aphyllophorous fungi (Aphyllophorales s. lato)
3.4. Lichens
3.5. Mammals
3.6. Birds
3.6.1.General description of ornithofauna
3.6.2. Characteristics of local bird fauna
3.7. Insects

4. Flora and fauna of aquatic ecosystems: characteristics and assessment of the pattern of anthropogenic changes

4.1. Higher aquatic vegetation
4.2. Phytoplankton
4.3. Periphyton
4.4. Zooplankton
4.5. Macrozoobenthos
4.6. Fish

5. Unique species: characteristics of populations (Ladoga seal, Margaritifera margaritifera etc.) and their variation pattern

Study areas

In the first two years, our research work was focused on the Finnish-Russian border areas and the White Sea coast, with special attention to the territories proposed for national parks (Fig 1.). The assessment study has shown that the forest, mire and water ecosystems in the vast study territory are either in natural state or are slightly disturbed, and that rare, vulnerable and Red Data Book species are widespread there. In 1999, the study continued on the Zaonezhye Peninsula and in the northern Lake Ladoga region known to display the highest biota diversity. In 2000, Central Karelia was studied. The protection of these natural floristic and faunistic complexes was shown to be highly important.

Two belts of proposed and existing protected areas are now being formed in Karelia. They are represented by natural forest and mire communities evolving along the Russian-Finnish border and on the White Sea coast. These, together with other protected areas, form probably the largest and most representative regional system of protected areas in the West European boreal zone, which is second to none in West Europe. It will help maintain biotic diversity more efficiently.

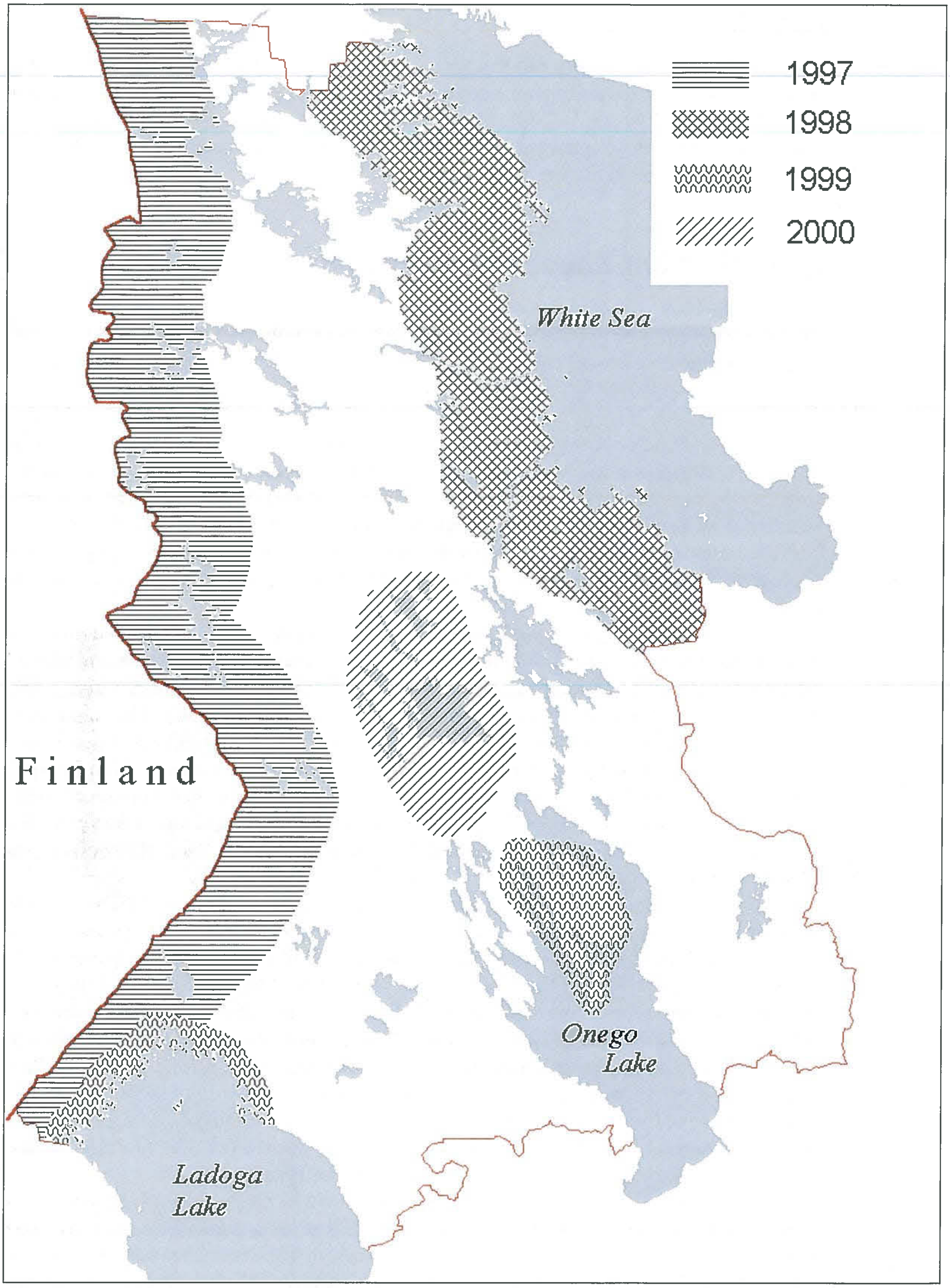

Fig. 1. Biodiversity inventory areas in 1997 –2000.

Results

The main part of the region, most valuable with respect to biodiversity, has been studied for 3 years. The results of research are summarised in three volumes that have a total of about 650 pages. In 2001, the results of the assessment study, carried out in Central Karelia, will be reported in volume 4. The data presented have no analogues, at least in other boreal regions of Russia.

Example from Zaonezhye Peninsula

Because the data collected are voluminous, only the main results of our biodiversity assessment studies on the Zaonezhye Peninsula are briefly reviewed.

The biotic diversity of this area is higher than that of East Fennoscandia. In comparison with the White Sea region and some border areas, the higher diversity of the local biota results largely from the transformation of natural complexes by human activities, let alone environmental conditions. Until now, the present biotic diversity and its variation pattern have not been thoroughly assessed. Besides, in the study territory we face a lot of environmental, economic and social problems in the comprehensive development of forest, recreational, mineral, agricultural and other resources. One major problem is to prevent the loss of biotic diversity and to optimize the ecological, social and economic parameters of wildlife management with due regard for the public opinion.

The *geological and geomorphological settings* of the biota are described in detail and a set of maps was presented. Twenty-one highly valuable geological sites were identified on the Zaonezhye Peninsula. The most significant geomorphological sites formed during the Quaternary Period are listed and briefly described. The geological history of the region over the past 130 000 years and the main geological processes, responsible for the formation of the Earth's surface and the evolution of landscapes, are discussed in detail. The formation of biota is traced, using pollen-and-spore diagrams. The hydrographic pattern of the peninsula is discussed and major water bodies and watercourses are analysed quantitatively. A soil map was made and various types of soils were described.

Two types of geographic landscape are identified on the peninsula. The present state and diversity of ecotopes and forest and mire communities are characterized quantitatively and qualitatively for each landscape. Available forest management data on the present structure of the forest cover are presented in detail, stands being split into age groups, types and quality classes. Forest communities older than 100 years make up about 20%.Various types of mires, unique mires and their plant diversity are described. It is noted, for example, that 83% of Karelia's mire flora, including 8 Red Data Book species, occur on the Zaonezhye Peninsula. The study of meadows on the eastern shore of the peninsula has shown that meadows with highly diverse vegetation are numerous there. The region's meadow flora consists of 159 vascular plants, which is over ½ of Karelia's meadow flora (in all, 304 species).

A list of protected plants is presented. Occurring in Zaonezhye are 77 plant species listed in various Red Data Books, such as: the Red Data Book of Russia 6, the Red Data Book of Karelia 53, and the Red Data Book of East Fennoscandia 62 species. Protected species were reported from over 400 localities. Most of them (53%) were found in the skerries, 33% on the plains and only 14% in the upland part of the peninsula. Areas and localities, most valuable from the point of view of protection of rare and the most vulnerable vascular plant species, were specified. Valuable localities are understood as localities known to host at least 5 protected plant species. They are characterized briefly, other regionally rare but not protected species being listed, too. A list of leading families and genera of cormophyte mosses is presented. The mire bryoflora of Zaonezhy is represented taxonomically by 90 cormophyte moss species (Sphagnum and Bryaceae), of 38 genera and 18 families. The aphyllophorous fungi occurring on islands in Zaonezhye are listed and characterized taxonomically. The list of aphyllophorous fungi collected so far on the Kizhi islands consists of 64 species from 41 genera and 17 families A list of lichen species occurring in the insular part of the peninsula is given. The preliminary studied lichen flora consists of 53 species and subspecies. Most of them are synantropic species living in nitrotic environments.

A full list of mammals and a set of maps showing the abundances of some species in the different parts of the peninsula are presented. Special estimations made in 1999, analysis of the archives and the study of the relevant literature have shown that Zaonezhye hosts 44 mammal species, 12 species being listed in the Red Data Book of Karelia (1995). The bird fauna is generally characterized, and a full list of birds is given and their migration patterns and abundances are specified. Areas and sites of high ornithological value are described. The full list of birds consists of 223 species, including 136 nesting species, 42 presumably nesting species, 2 species that nested in the past, 28 species that stop there during migration, and 15 alien species. The pattern of stay of most of them is supported by encounters of birds, findings of nests and broods. The local bird faunas of the peninsula and adjacent areas are thoroughly analysed. For example, the list of rare and vulnerable species, which occur only in the Zaonezhye Park to be established and need strict protection, consists of 39 species, of which 24 species are listed in the Red Data Books of Russia and Karelia. A list of insect species is presented and their protection status is specified. Some species, not reported earlier from other parts of Karelia, are identified.

Higher aquatic vegetation is described, with examples from the largest lakes. Six plant species need protection. The taxonomic and species composition of phytoplankton in major water bodies is discussed. The communities identified are found to be diverse. For instance, in the Kizhi skerries phytoplankton is represented by 124 species and varieties. Seventy-four algal taxa, lower in rank than a genus, were identified in periphyton. The species composition and relative abundance of algae in the periphyton of the water bodies located on the peninsula are described. The planktonic lake fauna consists of 90 taxa (a list is given).The invertebrate fauna is represented 70 unequally ranking taxa (a list is given). The benthic cenoses were found to be highly diverse. The water bodies are inhabited by 32 fish and fish-like species and one crayfish species. Nine fish species and fish varieties, listed in the Red Data Book of Karelia (1995) and in the Red Data Book of East Fennoscandia (1998), are known there.

To sum up, the natural-areal complexes of the study region are shown to be highly significant from the point of view of conservation of cenotic and species diversity in East Fennoscandia. Arguments in favour of the establishment of a protected area in the central (selkä) part of the Zaonezhye Peninsula, including the skerries, are provided.

Perspectives

Assessment of biodiversity is, in fact, a never-ending process, and this work will continue. However, the main fundamental and practical problem is as follows. Scientists must answer two simple but principal questions: 1) What and how much are we losing or may lose from the point of view of biodiversity? 2) What should we do to minimize the adverse anthropogenic transformation of natural communities and species diversity?

Establishment and development of the network of protected areas in the Republic of Karelia

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The republic of Karelia lies in the north- and mid-taiga subzones of the boreal zone. Forests cover over 50% of the republic's area, mires over 20% and meadows only 1%. Lakes take up 8,800 km², or 11.4% of the total.

Protected areas (PA) occupy 1 229 192 ha (7.0% of the total area) and are found in practically every district of Karelia, though a great proportion of PA is located in the southern, best studied and most economically active part of the republic (Государственный доклад 2002). Development of the PA network has for a long time been a largely chaotic process, especially before 1990, when the Decree of the Supreme Council of the Karelian Autonomous Republic "On the Establishment of a PA Network" was passed. The lack of a unified integrated approach to its organization resulted among other things in uneven distribution of the nature reserves over the republic's territory, as well as over-representation of some PA categories and insufficient use of others. Therefore, the existing PA network is not yet a holistic system which would efficiently and comprehensively fulfill conservation tasks.

The present paper offers data on the existing PA network, specific characteristics of Karelian biodiversity, and a review of some aspects of the PA network development in Republic of Karelia for the nearest future.

Protected areas and objects in Republic of Karelia

The system of existing and planned PA covers much of the most representative and unique natural complexes in the republic (Table 1.). In the 1990s decisions were made which resulted in the designation of a number of national (Vodlozersky and Paanajärvi) and natural parks, as well as several partial reserves. The area of PA and 1st group forests (with no forestry activities in forested zones) is expected to reach 2,689,000 ha or 14.9% of the Karelian territory by the year 2005. The plans are to establish such national parks as Ladoga skerries, Kalevalsky, Koitajoki and Tulos. An interesting fact is that practically all large PA to a certain extent focus on conservation of Karelian forests. The situation is quite justifiable, since old-growth (primary) forests occupy an impressive area (some 0.5 million ha) in existing and planned PA in Republic of Karelia. These forest areas are an exceptionally valuable part of the natural heritage of the land, and their preservation is one of the priorities for conservation activities.

Current PA network comprises a relatively small share of strictly protected areas, including only strict nature reserves, national and natural parks (see table), whereas most (about two thirds) of the republic's nature conservation fund is partial reserves (zakazniks) (represented chiefly by game and landscape reserves) (Хохлова et al. 2000), e.g., the network of game reserves embraces almost all districts of the republic. Most of the reserves have operated since the 1970's, the oldest one (Kolatselksky) since 1965. The period of designation for many of them has already expired, and updated evaluation of their compliance with the status is necessary. The greatest areas in the category are occupied by landscape (integrated) reserves, the designation of which started in 1981, mainly to restrict intensive economic activities deteriorating valuable natural communities and complexes in scenic sites popular among tourists and local people (exposed to recreational overload). As regards their aims and conservation regime some landscape reserves (e.g., Zaozerskii and Vazhozerskii) proved to be very close to natural parks – a new PA form introduced to national environmental legislation only in 1995.

Table 1. Protected areas of Republic of Karelia (Государственный доклад, 2002)

PA category	Area, ha	Percent	
		of total area	of PA area
State strict nature reserves	60047	0.3	37658
National and natural parks	259654	37712	37859
Partial reserves	587715	37683	60.6
Natural monuments	40527	0.2	37656
Other	22251	0.12	37682

In accordance with the legislation valuable small-sized nature objects are protected as state natural monuments (NM). An example are protected individual rare trees in the Olonets district, Petrozavodsk and Tri Ivana spring in the Medvezhjegorsk district. Designation as NM withdrew some mires (valuable high-productivity berry-rich sites), rare and medicinal plant habitats, unique water objects (small lakes, springs), etc. from reclamation plans.

Some specific characteristics of biodiversity in Republic of Karelia

Karelia's specific geographical position, namely its considerable latitudinal extent, is one of the key factors affecting plant distribution patterns. Thus, floristic composition is noted for high concentration of species found both in the northern and southern margins of their distribution range. Known vascular plant species richness in Karelia amounts to 1631 species distributed among 10 biogeographical provinces (Кравченко & Кузнецов 2001). Regrettably, however, complete species checklists have not yet been compiled for a whole number of plant groups (lichens, algae). Over 200 higher vascular plant species (some 20% of the flora) are in need of protection, and are likely to be included in the second edition of the "Red Data Book of Karelia".

Noteworthily, aboriginal flora contributes a little over a half (57%) of the number of species found, which testifies to an important role of introduced (*adventitious*) species, and may serve as an indicator of the youth of floristic complexes in Karelia (Малышев 1981). Describing biogeographical aspects of vascular plant distribution, Кравченко & Кузнецов (2001) revealed clear distinctions between the compositions of local floras in the north- and mid-taiga subzones. The authors stressed a distinct upwards tendency in the species richness towards the south. They also found a significant positive relationship to exist between the species richness of local floras and the proportion of aboriginal species in them (Fig. 1).

It should be stressed that the present level of knowledge does not provide convincing evidence that there are serious risks and factors aggravating the situation with plant biological diversity in Karelia. In some cases, changes in the species composition

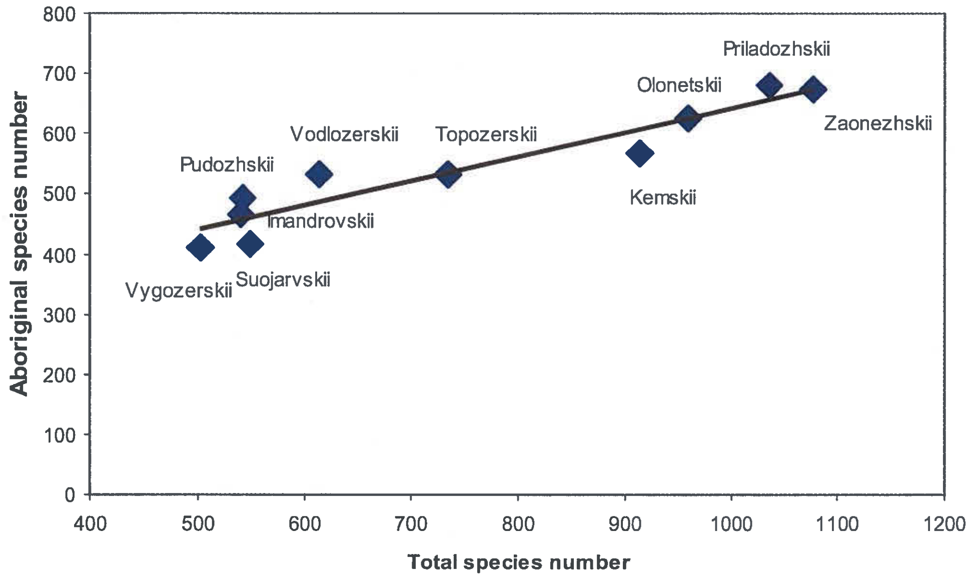

Fig. 1. Common/indigenous species ratio in floristic districts of Karelia (data from Кравченко & Кузнецов 2001)

are distinctly local. Thus, a new survey of local floras carried out after a more than 40-year pause demonstrated that some boreal species disappeared from areas subjected to intensive logging, but a number of new, previously unrecorded species were found (Кравченко et al. 1999). The same authors pointed out that in the Zaonezhje peninsula 10 plant species have not been re-encountered for a 100 years, but 12 new Red Book species were found only recently.

Terrestrial fauna in Karelia is typical of forested regions. Current figures (Государственный доклад, 2002) for the number of species in the main animal groups are: insects ca. 20000 (at present their species composition is not fully known; researchers report of 8208 species), amphibians 5, reptiles 5, birds 285 and mammals 63.

Karelia is either the northern or the southern margin of the distribution range for a little less than a half (40%) of its bird and mammal species (Данилов et al. 2001). The cited authors have identified some patterns in the distribution of animals belonging to different faunal complexes. Thus, a tendency towards expansion northwards has been demonstrated mainly by species pertaining to broad-leaved forests, whereas representatives of the north-taiga fauna are observed to shift the southern limits of the distribution range to the north; and those of Siberian fauna to the west. In just the last several years local bird and mammal faunas received 25 and 7 new species, respectively (Данилов et al. 2001).

The main factors responsible for the above tendencies in the animal population dynamics are related primarily to human activities. Thus, profound transformations were caused in natural complexes by large-scale clear-cuttings, as well as mire and water-logged forest drainage. The nuisance factor has grown dramatically owing to increased visitation by hunters, and berry and mushroom pickers. This forced wolverine, forest reindeer, capercaillie, whooper swan and bean goose to retreat to the north (Данилов et al. 2001). Another direct effect of economic activities is introduction of new species (Canadian beaver, American mink) which spread to replace their indigenous relatives.

Karelian territory is of special importance for migrating birds. The republic lies on the White Sea-Baltic flyway, with many bird species flocking in large migration and pre-migration aggregations, of which many are still not known. Landscapes in the republic are highly diverse, with varying degrees of economic utilization. Many areas have preserved quite satisfactory conditions for a lot of rare and endangered species. Some of particularly important bird areas are the White Sea islands, Olonets fields and Zaonezhje peninsula.

Numerous rivers and lakes of Karelia are also quite diverse and unique as regards both the drainage system and biodiversity of plant and animal species in them. Fish fauna includes 70 both freshwater and marine species. Major ecological problems of water communities are caused by anthropogenic impact. Ecosystems of the largest rivers such as Kem and Vyg were much modified by water engineering (building hydropower plant dams, canal laying); quite a few lakes are exposed to local-scale industrial pollution. Most vulnerable fish species are salmonids, first of all Atlantic salmon. Therefore, protection is required for rivers flowing to lakes Ladoga and Onego.

On the strategy and prospects of protected area network development in the Republic of Karelia

An important ecological and conservation role is played by the 1st group forests, the area of which in Karelia is 3.3 mill. ha, or about 22% of the republic's forest area (Fig. 2). This group includes territories with a protection status: resort and green zones, shelter-belt forests along spawning rivers and roads, and water protection forest belts. However, for these territories to actually become a component of the republic's protected area network an inventory of the 1st group forests should be carried out, scientific argumentation for their designation developed, the boundaries of the most valuable areas (zoological and botanical reserves, natural monuments) delimited, and the legal status of the designated areas officially defined. PA organized in the 1st group forests will be able to provide for conservation of old-growth forests in about 600,000 ha. The network formed in this manner in combination with large PA's (strict nature reserves, national and natural parks) will expand the opportunities for biodiversity conservation, and ensure a more stable ecological situation in the region.

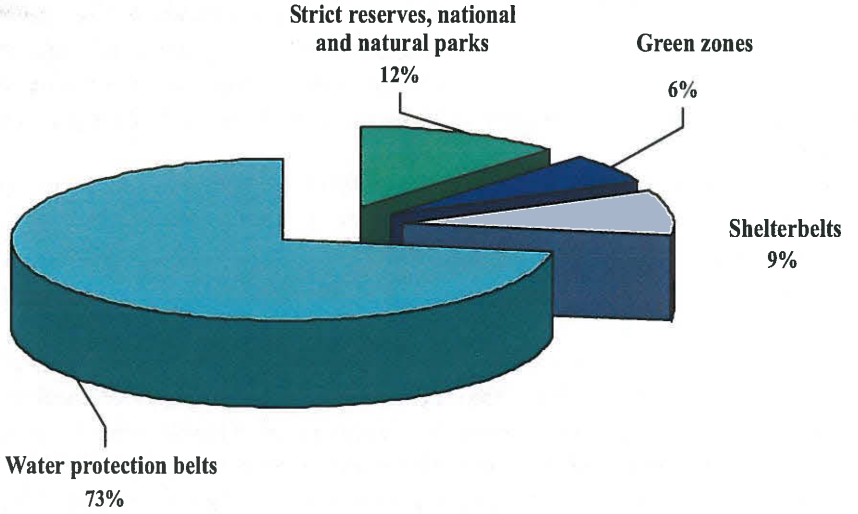

Fig. 2. First group forests in Karelia (3.3 million ha or 22% of the forest area)

Specific landscapes affected by the presence of two largest European freshwater lakes (lakes Ladoga and Onego), vicinity of the White Sea proper, and high paludification degree, should be adequately represented in the PA network. The Republic of Karelia differs from its neighbour regions in that it has a unique, well-developed drainage network and abundant mires. Total run of the republic's 27 000 rivers is over 80 000 km,

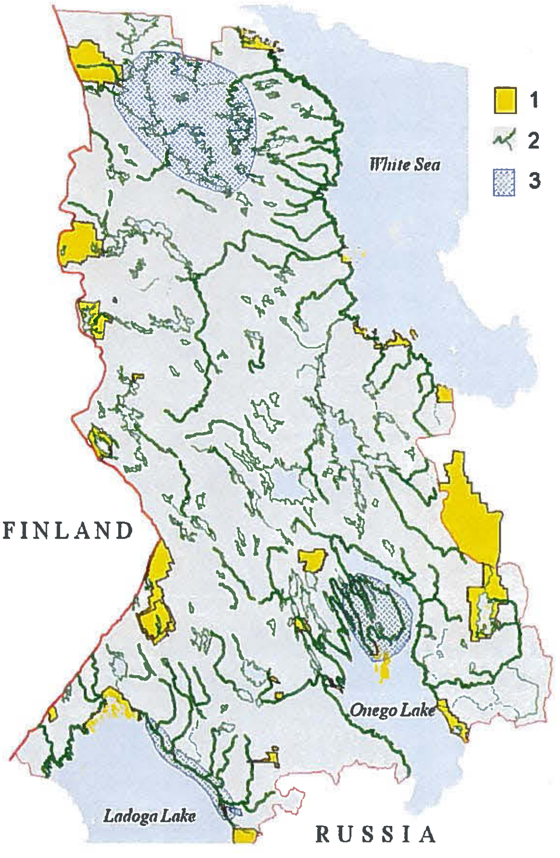

Fig. 3. Developing PA network in Karelia. 1 – Existing and planned PA (partial reserves and natural monuments not included), 2 – Water protection 1st group forest belts (a model of developing the network of "ecological corridors"), 3 – Perspective Ramsar territories. Map made by staff of the Forest Research Institute of Karelian Research Centre RAS.

and the total surface area of its 61 100 lakes is 17 800 km^2 (Литинская 1986). All the above creates optimum habitats for numerous plants, as well as aquatic, coastal and riparian wildlife.

One has to admit however, that despite the generally satisfactory situation with PA network in the republic, most PA hardly contribute to the conservation of migratory waterfowl, being located away from their major concentration areas.

Wetlands are particularly important for preservation of the White Sea – Baltic flyway, used for mass seasonal migrations by birds nesting both on the White Sea, and further east in the tundra, on the coast and islands of Russian Northern seas. Many of the birds living in Karelian wetlands are included in international and national Red Data Books, and Karelian populations of some of these species are in a far better condition than those in West European countries. Therefore, wetlands of Karelia are of international importance, being crucial for maintaining bird populations of northern Europe and north-western Asia (Fig. 3).

In view of the above we believe that further development of the PA network in the republic should envisage expansion of the number of PA within large wetlands. Their designation will not only ensure biogeographical representativeness and implementation of the watershed approach to PA network establishment, but also promote conservation of unique natural objects. These activities will be an essential biocenotic augmentation in designating PA in the 1st group forests, and in water protection belts.

Fulfillment of the above tasks will facilitate establishment of an integrated, multi-level PA system. Water protection forest belts and wetlands in numerous lake-river systems of Karelia, in combination with strict nature reserves, partial reserves, natural and national parks will ensure sustainable conservation of biological diversity.

Establishment of the PA network alone cannot, however, solve the problem of nature conservation. It takes also a clear strategy, which can only be developed within long-term planning based on thorough inventory of natural objects, and creating economic, organizational and legal mechanisms for preserving natural diversity. One of the planning instruments used in many western countries is Protected Area Management Plans. They are based on subdivision of the land and water area into zones (functional zoning), with a special management regime defined for each zone. The main aim of involving PA in economic activities is to achieve sound, balanced combination of socio-economic development and maximum possible preservation of natural complexes. As the "green" image of the territory is used there appear more and more new job opportunities for local people, related e.g. to development and maintenance of the tourism infrastructure, utilization and processing of non-timber forest resources.

Finally, it should be emphasized that the implementation of PA management plans and specific nature conservation activities depends both on the attitudes of local and republican authorities, and, maybe even more importantly, on the recognition of the need to conserve natural and cultural heritage by people living or spending their vacations in the republic.

Our idea is that the strategy of PA network development in Karelia should comprise the following mandatory actions:

- Enhancing not only the total number, but also representativeness of the PA network, which will further promote biodiversity conservation in forested as well as other landscapes (aquatic, wetland, mire and agricultural areas), and ultimately result in a better balance in the PA network in general;
- Expanding the list of protected areas meeting the Ramsar Convention criteria;
- Developing the laws and standards to stimulate the application of economic mechanisms in promoting sustainable nature use, preservation of natural habitats for most valuable and rare plant and animal species;
- Integrating conservation tasks and major activities (including those related to PA function) in local socio-economic development programmes;
- Strengthening the general "nature conservation effect" and amending the overall ecological situation in the course of PA network development in Republic of Karelia through implementing the complementary principle as regards individual elements of the network, as well as PA in neighbour regions (of Russia and Finland).

Summing up, the following conclusions can be made. Current overall situation in PA network organization and biodiversity in Karelia can be evaluated as satisfactory. However, continuously growing anthropogenic pressure urges one to strive for reinforcement of "nature protection". One of the ways to achieve this end is to further develop and optimize the existing PA network.

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Outlines for a GIS-based assessment of nature reserve network in NW Russia

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Introduction

The importance of nature reserves in preserving biodiversity on community and species level as well as the selection of areas for protection has been under intensive discussion and research during latest decades. In northwestern Russia nature reserves are typically large strict nature reserves (zapovedniks) or national parks. Due to different land ownership and land use history, in Finland there are numerous small reserves.

The situation is interesting for comparison, especially on the basis of needs for protection taken in discussion during the preparation of red data books about threatened species in various regions (e.g. Kotiranta et al. 1998, Rassi et al. 2001). A comprehensive analysis and assessment of the nature reserve network in NW Russia as a whole and also on region level is needed to form a basis for protection of nature and international comparisons in whole Europe with regions with very different population density, history and land use intensity. The analysis gives basis for planning of an effective network of nature reserves as well as their sustainable use in environmental education and nature tourism. Also the evaluation of the impacts of forestry and forest industry is important in the boreal forest zone (see Ahti et al. 1968, Tuhkanen 1984, Aksenov et al. 1999, Yaroshenko et al. 2001). It will help to develop forestry on a sustainable and internationally acceptable basis.

An important tool for the evaluation is the creation of a GIS system about the main features of nature, land use pattern and nature reserves (see e.g. Gurnell et al. 2002). The GIS analysis must start from the whole area and its biogeographical zones and sections. In the evaluation of the whole area main emphasis must be put in the main characters of nature and large nature reserves (larger than 100 square km). When going to regional level also smaller nature reserves with different conservation status (e.g. landscape reserves and natural monuments) must be taken into account. Special attention should also be paid to temporal dynamics of nature as well as questions of extinction debt, caused by the fragmentation of habitats (Syrjänen et al. 1994, Hanski 2000, Gu et al. 2003).

Nature conservation activities in Russia have rapidly become an international issue. There is a strong interest in the nature of NW Russia e.g. in the northern dimension of the EU, in the Nordic cooperation framework as well as in Barents region and Arctic region frameworks. Therefore it makes sense to start an international project for the assessment of nature reserve network in NW Russia, i.e. in the city of St. Petersburg, the regions of Leningrad, Murmansk, Arkhangelsk and Vologda and the Karelian Republic.

Goals of the assessment

1) To survey the representativity of the nature reserve network (ecosystems, biotopes, species diversity) taking into account also recreational, socio-economical, historical and cultural aspects

- NW Russian level
- Different regions (Arkhangelsk, Vologda, Leningrad, Murmansk oblasts (provinces), the city of St. Petersburg and the Republic of Karelia)
- Existing, planned and proposed nature reserves

2) To analyse the gaps of the existing nature reserve network

- Biogeographical features
- Local special characteristics

3) To give recommendations to fill in the possible gaps of the nature reserve network

Preparing the assessment

Biodiversity of NW Russia, its conservation status and needs for nature reserves should be conducted by preparing a GIS covering all the area and taking into account the following parameters, of which adequate knowledge is available:

- Climatic vegetation zones and sections
- Hydrological units
- Main features of bedrock
- Main features of geomorphology
- Typical habitats
- Rare and unique habitats
- Red list species
- Indicator species
- Undisturbed areas, e.g. old-growth forests
- Existing nature reserves in different categories
- Biotopes included in the nature reserves
- Red list species observed in the nature reserves

Combining the above mentioned characteristics, answers to the following questions should be found:

- What has been adequately protected?
- Where are the gaps?
- What should possibly be added to the nature reserve network?
- Are there any other ways to protect biodiversity?

Criteria and methods of the evaluation

Priorities in choosing areas to be protected should be organised in the following order:

I. Protection of landscapes
II. Protection of ecosystems
III. Protection of rare and threatened species
IV. Using of the recreation potential
V. Scientific studies
VI. Ecological education
VII. Economical benefits

The evaluation of threat degree for species and habitats, and methods for the protection of rare and threatened species must take into account the following characteristics:

1. local distribution
2. low density of population and its sharp inter-year fluctuations
3. narrow ecological requirements
4. existing on the border of distribution area

To select the objects in need of special protection, criteria of the evaluation of these objects and their priority must be chosen as well as methods to perform this analysis. The criteria can be divided in the diversity of main habitat types and their classification, and criteria connected with the degree of human disturbance on the ecosystems (e.g. Ieshko & Titov 2003). The main habitat types in NW Russian conditions should include at least:

1. old-growth forests (Aksenov et al. 1999, Yaroshenko et al. 2001)
2. forest and other ecosystems on the continuums of natural zones (Heikkilä et al. 2000)
3. mire ecosystems (Antipin et al. 1997, Galanina 2003, Heikkilä et al. 2001, Kallio & Aapala 2001, Kuznetsov 2003, Yurkovskaya 2003)
4. upper reaches of rivers
5. deltas and the lower reaches of rivers
6. ecosystems on the edges of different forms of relief (Systra 2003)
7. coastal sea and lake ecosystems
8. island ecosystems
9. tundra and polar deserts ecosystems

The selection of new nature reserves should start from existing data in literature, maps and collections of plant and animal specimens. A recent study has shown that it is possible to use also uneven herbarium data for quantitative analysis of temporal frequency changes of species (Hedenäs et al. 2002). This is necessary in many regions of NW Russia. The existing knowledge can be complemented by using remote sensing methods especially to assess human impact on nature (e.g. Sigurdsson 1999, Luoto et al. 2002, Gromtsev et al. 2003, Kalliola et al. 2003). On the basis of the data obtained from existing knowledge and remote sensing material it is necessary to plan complementary field inventories in key areas. Parallel to compiling the data it is possible to create a GIS for the spatial analysing of the material. After these steps have been taken it is possible to make a gap-analysis of the nature reserve network. At that stage modern mathematical optimisation methods (see e.g. Angelstam 1997, Bailey et al. 2002, Heikkinen 2002, Luoto et al. 2002, Rodrigues & Gaston 2002) support the reaching of objective results. However, the use of these methods must be based on solid knowledge and understanding of nature to avoid nonsense results (see Virolainen 1999).

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Inventories for nature protection in Estonia; problems and results

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After re-establishing political independence, Estonia has joined a number of international conventions, whereby Estonia has made commitments to protect areas, objects or functions of biodiversity and the quality of environment. The existence of a detailed overview of biodiversity on a species, community/habitat and landscape level is a prerequisite for the implementation of these conventions and for effective planning of nature protection. "It is not possible to protect something, if it is not known, where, how much, what, and in which conditions it exists (has been preserved) and what the factors threatening it are..." (Leibak & Lutsar 1996: 5). At the same time, drastic changes have been taking place in land-use practice in connection with the collapse of the collective farm system and the re-privatisation of land. The area and structure of agricultural land has been crucially changed mainly due to the abandonment of numerous cultivated grasslands, as well as arable land. Therefore, to create an effective nature management planning and protection system, several large-scale nature inventory projects have been carried out between 1993 and 2000 with the support of Finland, Denmark, Sweden and the Netherlands. The aim of the current paper is to give an overview of these studies.

Old Forest Stands in Estonia, 1993-1996

The problems of preserving and protecting primeval forests as representatives of different site types have come sharply into focus after the 1992 Rio convention and other similar documents underlining the importance of biodiversity. Almost all Estonian forests have been managed to some extent. However, ineffective forest management during the Soviet occupation allowed the formation of non-managed forests also outside the officially protected areas. Until the commencement of this project a comprehensive survey of Estonian old and primeval forests, from the point of view of biodiversity and nature conservation, was lacking.

The project was carried out with financial and methodological help from the Finnish Union for Nature Conservation (SLL).

Objectives

(i) To find the best representatives of all Estonian forest site types and to evaluate them from the nature protection point of view.

(ii) To hold negotiations and to prepare the necessary documentation for presentation to the Estonian Government for the establishment of additional nature reserves if the strictly protected area of a site type was not sufficient to maintain the best examples of primeval and nature forests.

(iii) To disseminate knowledge and to increase public awareness about forest conservation.

Activities and results

(i) At first, a relevant selection from the database of the Estonian Forest Survey Centre was carried out to get an overview of old forests in Estonia, and the respective cartographic material was collected.
(ii) The methodology and organisation of the project was discussed in several joint Estonian-Finnish seminars. The main criteria for estimating the quality of a (possibly primeval) forest from the point of view of nature conservation were elaborated.
(iii) A questionnaire for field-work was designed on the basis of Finnish experience in a similar project.
(iv) Field inventory of old forest was carried out all over the country.
Special attention was paid on key habitats, including those which have become extremely rare elsewhere in northern Europe (alluvial forests, carrs, aspen-dominated forests) and which are unique in the whole Palearctic region (alvar forests). More than 60 Estonian and 25 Finnish specialists took part in the fieldwork. To make effective and comprehensively justified conservation proposals to the Estonian Government, a detailed inventory of forest areas with high conservation value was prepared, and expert assessments from various specialists gathered.
(v) A relevant database was compiled and linked into a geoinfo system (GIS).
(vi) Public awareness about old forest increased considerably. Before launching the project, very often even forestry officers did not understand clearly the special importance of old forests.
(vii) Due to good co-operation with the Nature Conservation Department of the Ministry of the Environment, the collected data has been actively used for the correction of boundaries and for the zoning of existing protected areas.

WETSTONIA – Estonian Coastal and Floodplain Meadows; 1993-1996

In Estonia we can still find numerous large areas of coastal and floodplain meadow which have been preserved in a rather good state, and which provide habitats for a number of species which either have become or are becoming extinct in the rest of Europe. Therefore, it is not only our desire but also an international responsibility to ensure their protection. That was also one of the main reasons that encouraged the Danish authorities to support this project. The project was implemented with the financial support of WWF-Denmark, the Danish Ministry of Environment and Energy, and the Danish Environmental Protection Agency (DEPA), co-ordinated by the Estonian Fund for Nature.

Objectives

(i) To elaborate the system of criteria for the assessment of the nature protection value of coastal and floodplain meadows.
(ii) To provide a field inventory of the habitats considered.
(iii) To create a relevant database of coastal meadows and floodplain meadows, and to link this with GIS.

Activities and results

(i) The whole coastline of the Estonian mainland and inhabited islands was inventoried.

(ii) The locations, boundaries, and state of all recently preserved coastal meadows were checked and/or verified.

(iii) Activities concerning floodplain meadows were similar, the mapping of the meadows being carried out according to river basins.

(iv) It was found that the total area of coastal meadows with high and medium nature conservation value is 5,100 ha and that of floodplain meadows is 12,000 ha. At the same time, 4,720 ha of coastal meadows and 15,000 ha of floodplain meadows are situated within the boundaries of current nature reserves.

(v) The recommendations for the protection and management of coastal and floodplain meadows were developed.

(vi) A database of 3,170 records was compiled.

(vii) The data obtained through the project was used directly for the establishment, or changes in status, of protected areas, e.g. the Soomaa and Karula National Parks, the Alam-Pedja and Muraka Nature Reserves, as well as for the development of proposals concerning protection regime and measures. The data was also forwarded to the Estonian database of the CORINE Biotopes Programme.

(vii) The results are also of importance on the European scale, as they provide precise data concerning the distribution, state, and development trends of habitat which has been preserved only in relatively few areas in this part of the world.

(ix) On the basis of obtained results a monographic report (Leibak and Lutsar 1996) was published, with parallel texts in Estonian and English.

Conservation and Management of Estonian Wooded Meadows, 1995-1996

Some of the world's highest plant community small-scale species-richnesses (more than 70 species in 1 m^2) have been recorded on old, regularly mown, temperate meadows, with a sparse tree layer, on neutral soils. The best still preserved examples of these communities are wooded meadows, particularly those on calcareous soils in western Estonia. Wooded meadows have been traditionally managed by farmers for not less than two millenniums; usually they were mown for hay, and grazed. In that way, they represent a perfect example of sustainable management, with a very long-term and stable multifunctional use of the land, and are, therefore, an important part of Estonia's cultural heritage.

At the end of 19th century, wooded meadows covered about 850,000 ha (18.8% of Estonia's surface area). After World War II, crucial changes in land usage and management took place, and vast areas of wooded meadows were abandoned, starting to overgrow with bushes and trees. Today they have been preserved only fragmentally and are in a great danger of total extinction. It is extremely important to maintain traditional management methods as well as to educate people about the value of wooded meadows.

The project was supported through the Earmarked Grants Program of the Regional Environmental Centre for Central and Eastern Europe (REC, project #20392).

Objectives

(i) To complete an inventory of the survived wooded meadow habitats in Estonia, focusing of their location, size, present state of management, degree of overgrowth, and conservation value, and to carry out a botanical analysis of the better preserved sites to evaluate their species biodiversity.
(ii) To organise teaching camps for the active management of wooded meadows and to educate volunteers through practical work in two well known wooded meadows of the highest conservation value.
(iii) To increase public awareness of the value of this unique habitat type, whereby attention is paid to the biodiversity, as well as the cultural and historical value of these habitats, and to their uniqueness in the European context.

Activities and results

(i) Preliminary data was gathered, and a questionnaire was compiled and distributed in the local municipalities and forestry offices to obtain information on the location and status of known wooded meadows.
(ii) A field inventory of 320 wooded meadows was provided. It is now possible to assert that in all of Estonia not more than 400-500 hectares of species-rich wooded meadows of high conservation value have been preserved. The majority of these are rather small in size – less than 5 ha on average.
(iii) 11 wooded meadows were found to contain more than 50 vascular plant species on a 1 sq. meter plot. Moreover, the highest number of species, 74 on a 1 sq. meter, was found in Pärnu county in 1996. This set a new European record of plant species diversity on that scale.
(iv) A database of wooded meadows, describing location, size, management activities, conservation value, etc. was compiled.
(v) Six successful practical camps were organised for the restoration of wooded meadows.
(vi) Recommendations for enhancing the sustainable management and conservation of wooded meadows were formulated.
(vii) Public awareness about wooded meadows was significantly raised. This has been due to several newspaper articles at the county and local level, 4 national radio programs, a special TV program ("Osoon", about 200,000 viewers). A homepage, in English, dedicated to wooded meadows has been compiled – http://www.zbi.ee/ecophys/wood.htm. Proposals were formulated to create a new Estonian NGO dedicated to the conservation of wooded meadows and other semi-natural cultural and traditional habitats in Estonia.
(viii) The results of the project were published as a monograph by Kukk & Kull (1997).

Estonian Biodiversity Country Study, 1996-1997

Despite the comparatively intense study of Estonian nature, for many taxa of organisms, as well as their communities, an overview is lacking or outdated. This project was launched for the purpose of getting a generalised conspectus on the diversity of various organism groups and communities on the basis of a synchronised approach. The final task of the project was to supply data for the compilation of the Estonian National Biodiversity Action Plan.

The project was supported by UNEP and administrated by the Estonian Ministry of the Environment with the assistance of the Resident Representative UNDP in Tallinn.

Objectives

(i) To get a possible comprehensive overview on the diversity of various groups of organisms, as well as plant communities and habitats.
(ii) To specify the state of different taxa and communities, and potential threats to them.
(iii) To elaborate recommendations for sustainable management and protection of biodiversity on species, communities/habitats and landscape levels.
(iv) To compile the Estonian National Biodiversity Action Plan.

Activities and results

(i) An expert working-group of leading specialists was created, covering almost all the main organism groups and community types, and the methodological problems were discussed.
(ii) An overview concerning fungi, lichens, bryophytes and vascular plants, invertebrate and vertebrate animals, domestic animals, game animals, cultivated and medicinal plants, plant communities, forests, mires, and coastal areas was compiled.
(iii) The general results were published in Külvik & Tambets (1998). Part of the results were published as separate monographs by Paal (1997) and Kukk (1999).
(iv) In 1999 the Estonian Biodiversity Strategy and Action Plan was compiled and published in Estonian and in English (Kull, 1999a,b).

Estonian Wetland Conservation and Management Strategy, 1997

Since the early 1990's, in connection with large political and economical changes, many drainage systems have fallen into disrepair in Estonia. On the basis of a World Bank loan the Government of Estonia has implemented the Agriculture Project, the main task of which is to support the rehabilitation of drainage systems on agricultural land; otherwise the benefits of the original investment in drainage will be lost.

At the same time, considering the value of nature conservation, water regulation and purification, as well as the cost of rehabilitation, it is obvious that numerous areas with decayed drainage systems should be allowed to revert into (sub)natural wetlands, and the selection of new areas for drainage must be discussed very carefully. To avoid potential environmental or social conflicts, and to ensure the positive result of the project, it was necessary to elaborate The Estonian Wetlands Conservation and Management Strategy. This is an important component of the Agriculture Project because the recommendations have been used to select and prioritise areas for drainage rehabilitation, the rehabilitation of areas exploited for peat mining, and wetland restoration projects to be funded by the Estonian Government.

The strategy study was carried out by the most competent Estonian institutions and experts, with Norwegian experts contributing as advisors and discussion partners. The project was funded by the Government of Norway, under the auspices of the Government of Estonia/World Bank Agriculture Project.

Objectives

(i) To develop a classification and identification system for the identification of the nature conservation value of wetlands, taking into account the current international conventions.

(ii) To characterise and evaluate Estonian wetlands, based on the aims of their future management and/or conservation, with special consideration of the environmental impact of the activities carried out under the Agriculture Project.

(iii) To develop the database and the GIS on Estonian wetlands.

(iv) To develop a national strategy for wetland management in Estonia

Activities and results

(i) Background data from all relevant institutions was collected.

(ii) A wetland classification and evaluation system was elaborated, to serve as the basis for activities under the Agriculture Project and for evaluation of all Estonian wetlands in view of their potential use in the future.

(iii) A unified data format for field inventory was designed (cf. Appendix 1), the cadastral maps (on a scale of 1:20,000) of study areas and their surroundings were prepared.

(iv) Supplementary field-work was carried out in wetlands which are likely to be influenced directly by the activities foreseen in the Agriculture Project, and/or in wetlands about which insufficient information was available.

Altogether, between June and November 1997, 1,376 wetlands were visited and described, totalling up to about 90% of all the areas planned to be studied. In addition, 184 data sheets based only on purchased data were compiled.

The following features were examined: 1) habitat type, 2) state of the shrub layer, 3) state of the tree layer, 4) human impact, 5) water regime, 6) value for the maintenance of biodiversity, 7) value for nature protection, 8) composition and state of the flora, 9) if possible, then also composition of (ornitho)fauna. For plant species, a standard registration list of the Estonian flora was used.

(v) A preliminary list of wetlands which might be adversely influenced by the activities in the Agriculture Project, or by other planned usage, was compiled.

(vi) Recommendations were proposed on measures necessary to protect valuable wetlands and prevent activities which might have negative impacts.

(vii) All data was added to the database using the program software VisualFoxPro 3.0. The GIS was developed on the basis of the program software MapInfo Professional 4.1 that directly links with the database format of VisualFoxPro.

(viii) It was found that, of the inspected localities, 419 have certain special value, making up about 21% of all the inventoried wetlands. 99 mires, 6 floodplain grasslands, and 21 coastal grasslands were recommended to be taken under protection. On 678 mires, 101 floodplain grasslands, and 60 coastal grasslands limited exploitation *resp.* traditional management should be continued or restarted.

(ix) As a result of the described project also

* recommendations for wetland conservation were formulated;

* a system of measures for reducing potential conflicts and negative environmental impacts of the future development of land amelioration in Estonia was proposed;

* the screening categories and criteria as well as the screening scheme for drainage rehabilitation areas were elaborated;

* recommendations for administrative, legal and procedural changes were proposed, as well as recommendations for future wetland research.

(x) Results of the project are published in English (Paal et al. 1998) as well as in Estonian (Paal et al. 1999).

Woodland Key Habitat Inventory in Estonia, 1999

A large part of the Estonian net export income is attributable to forestry, which therefore has a great socio-economic importance. At the same time, the forestry authorities recognise the importance and prestige of the maintenance and enhancement of forest biodiversity. It was necessary to elaborate the methodology for identifying the forest localities where the biodiversity is extraordinary high (so called key elements and key habitats). This will help to maintain a large amount of biodiversity in a cost-effective way.

The project was funded by the Swedish Environmental Protection Agency, the Swedish National Board of Forestry, the National Forestry Board in Estonia, and the Estonian Environmental Fund.

Objectives

(i) To develop the inventory methods and classification systems for woodland key elements and key habitats for Estonian conditions.
(ii) To get an overview of woodland key habitats.
(iii) To develop a scheme for the implementation of woodland key habitats in forest management plans and to find ways of financing a full-scale inventory in Estonia.

Activities and results

(i) The methodology for the woodland key habitat inventory was elaborated and published in Andersson et al. (2000).
(ii) The pilot inventory of woodland key habitats was carried out on 167,500 ha, representing all 15 counties in Estonia. In total, 569 woodland key habitats and 104 potential woodland key habitats were found, covering altogether 1247 ha or 0.74% of the total area of forests.
(iii) A popular book about Estonian forest key habitats (Palo & Külvik, 1999) was published.

Estonian Forest Conservation Areas Network, 1999-2001

According to the Estonian Forest Policy not less than 4% of the total forest area is to be taken under strict protection, but altogether not less than 18% of the forest area should have some protected status in order to ensure the maintenance of our forests' diversity. Recently protected forests are quite often not very representative from the viewpoint of forest typology or state (structure). Therefore, the stands that are valuable according to certain criteria of nature protection and/or are good examples of their site type must be identified, and the existing system of forest protection areas reorganised.

The project is funded by the Danish Ministry of Environment and Energy, and the Danish Environmental Protection Agency (DEPA). The responsibility for carrying out the project is put on the Forestry Department of the Estonian Ministry of Environment.

Objectives

(i) To establish criteria and indicators for the identification of valuable forest stands.
(ii) To carry out public consultation on a county level about new forest-conservation areas, in order to involve different interest groups in the decision making process, define problems and obstacles, gather information about additional nature assets.
(iii) To create a sub-optimal forest protection network that is representative in relation to species, habitats, and ecosystems and corresponds to the relevant international conventions and EU directives.
(iv) To increase the area of strictly protected forest to at least 4% of total forest area, and to increase the area of forest of any different conservation status up to 19% of the Estonian forest area.
(v) To create a relevant database connected with GIS.
(vi) To elaborate special management guidelines for supporting the biodiversity of protected forests.
(vii) To raise public awareness in issues of biodiversity protection in forest communities, through the media, educational materials, articles etc. To disseminate knowledge and experiences in biodiversity protection in forests, and in nature value assessment, for the use of all those interested, but especially for the forest and nature protection sectors.

Activities and results

(i) A special methodology for field-work was developed in order to register the assets of forest communities.
(ii) Around 300 persons have been educated in forest asset assessment and in the management of protected forests, 50 persons as forest assets guides, and 15 in the preparation of forest management guidelines.
(iii) In 1999 all strictly protected forests in recently created conservation areas, covering altogether ca 85,000 ha, were inventoried. It was established that only 3.5% of them have high biological value.
(iv) Special pre-selection criteria for databases covering altogether 1,600,000 ha of state and private forest lands have been worked out for identifying potentially valuable forest stands outside conservation areas, including forest habitats for the future *Natura 2000* project *sensu* Habitat Directive.
(v) In 2000, 81,678 ha of forest land outside of protected territories was selected and inventoried as potential areas for a future forest conservation network. It was also established that about 4% of them have high biological value.
(vi) Data from field inventories have been digitised into GIS for further analysis, as well as for the Forest Key Habitats Register and for the National Nature Values Register.
(vii) All forest areas proposed as potential constituents of the typologically representative forest conservation areas network have been introduced and discussed in the course of 15 county level public meetings.
(viii) To raise public awareness, the concept of the forest conservation area network has been introduced and discussed more than 85 times in different seminars, workshops, conferences, TV and radio programs, consultation days, etc. In addition, 16 special radio programs have been recorded in the current year to follow the development of the project. Concerning the project, it has produced more than 20 articles in different newspapers and magazines, 2 posters and educational materials for children; there are also 5 books published or prepared for publication. A video has been made about the old-growth forests and the project's home-page has been compiled: http://www.envir.ee/emkav.htm.

(ix) Report of the project, including a detailed overview of used methods and criteria, lists of forest protection network areas and their maps were published as a separate book by Viilma et al. (2001).

Estonian Semi-natural Grassland Inventory Project, 1999-2000

In the Estonian Environmental Strategy, a system of measures for the protection and management of semi-natural habitat types, like natural grasslands, is presented. Until now, this item in the strategy had been worked out in the course of inventories for only some regions of Estonia, like coastal and floodplain zones, wet grasslands, and wooded meadows in Western Estonia. A national strategy concerning these valuable habitats is lacking. Nevertheless, in the accession-period to membership of the EU, the CEEC have to prepare strategies dealing also with rural development, including agri-environmental programmes and management of rural areas. The Estonian Semi-natural Grassland Strategy will provide Estonia with a tool for setting priorities in the protection of the biodiversity of these habitats and for starting the necessary management in grassland areas.

The project has been launched in co-operation with the Royal Dutch Society for Nature Conservation; financially supported by the Dutch PIN-MATRA funds.

Objectives

(i) To develop a classification and identification system for establishing the value of four groups of semi-natural grasslands: wooded meadows, coastal meadows, floodplain meadows, and alvars.
(ii) To produce a characterisation and evaluation of Estonian semi-natural grasslands, depending on the aims on their future management and/or conservation.
(iii) To develop guidelines and recommendations for the best management practices of semi-natural grasslands, concerning the principles of sustainable management and conservation.
(iv) To deal with aspects of accession to the EU, regarding implementation of agri-environmental and other regulations.

Activities

(i) Data obtained by previous projects, like the Inventory of Estonian Coastal and Floodplain Meadows, the Inventory of West Estonian Wooded Meadows, and the Estonian Wetland Strategy, as well as all possible supplementary data, were analysed and the gaps were identified;
(ii) Field-work was carried out in areas which had not been investigated in the course of the last years; only semi-natural grasslands of considered groups and with an area of at least 1 ha were included in the inventory;
(iii) A classification and evaluation system was elaborated, and the grasslands were categorised according their protection and management needs.
(iv) Recommendations were elaborated concerning measures that are necessary to protect valuable semi-natural grasslands and to prevent activities which might adversely influence the grasslands.
(v) Several seminars and workshops were organised to discuss the details of the project with the stakeholders.

(vi) A database of the semi-natural grasslands, connected with the GIS in MapInfo format, was compiled similarly to the earlier wetland database (Paal et al. 1998). All field questionnaire (cf. Appendix 2) data, including notes, was put into the FoxPro database. The input programme contains procedures for data verification and a user-friendly menu system for inputting species names as well. The latter uses a digital checklist of Estonian vascular plants, mosses, animals, and more common lichens, and also a checklist of synonyms to make it easier to find the correct names. The FoxPro database consists of two coherent tables – one for site-related data, and another for species-related data. The spatial data (i.e. polygons on map layers etc.) is managed with MapInfo. The map layer with the Estonian Cadastral Map was used as a background for digitising the site boundaries to a separate map layer. The site ID code is the input in MapInfo used to associate the latter and FoxPro tables with each other (Mägi et al., 2000).

Regional Implementation of the EEC Habitats Directive (92/43) and the EEC Birds Directive (79/409) in Läänemaa and Raplamaa Counties, Estonia (Estonian Natura 2000 Pilot Project), 2000-2002.

The project concerns, as a main objective, the demarcation and designation of a network of protection areas, which are necessary for the full implementation of the EEC Bird Directive (79/409/EEC) and the Habitat Directive (92/43/EEC), in two counties of Estonia — Läänemaa and Raplamaa. During the preparation of the Terms of Reference for this project the Estonian Ministry of Environment was expecting to implement the Natura 2000 requirements, as stipulated in the relevant directives, over some 7 years. Still, it was decided by April 10, 2000, that no transition period for the implementation of the EU Bird Directive and Habitat Directive would be requested or granted and, consequently, Estonia is committed to completing the required activities by the date of accession. Therefore, the deadline set by the Estonian Government for completing pre-accession activities is set at December 31, 2002. In that way, the experience gained can be used immediately in other counties in 2001 - 2002 (Inception report 2000).

The project is financed by the Danish Environmental Protection Agency, and by the Danish Co-operation for Environment in Eastern Europe (DANCEE).

Objectives and activities

(i) The immediate objective of the project is to secure a basis for full implementation of the EEC Bird Directive and Habitat Directive in Läänemaa and Raplamaa counties, as well as to create a basis for managing localities of international importance in the region.
(ii) Description of biological diversity with relevance for the two directives and other international agreements in the two counties.
(iv) Assessment and improvement of the draft version of the "Interpretation Manual for Natura 2000 Habitat Types in Estonia", as well as compilation of the related documents.

(v) Analysis of the present protection regime for both protected and unprotected areas of international importance from the standpoint of the two directives mentioned. This must cover demarcation of areas, monitoring, management, costs, environmental impact assessments, and public participation in securing the necessary regime.
(vi) To increase public awareness, training courses and seminars for county authorities and key stakeholders are planned throughout the whole project implementation period; pamphlets and posters concerning important nature types and species in the two counties will be published; a video film concerning the Natura 2000 network will be produced, etc.

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ESTONIAN WETLANDS FIELD STUDY – 1997

SiteNo:...............Date:......................Investigator(s):...

1. General data

1.1.Administrative district, commune...

1.2.Name of area...

1.3.Number of mire...

1.4. Wetland type: 1 – bog, 2 – transitional bog, 3 – fen, 4 – floodplain, 5 – swamp forest, 6–paludified forest, 7– coastalmeadow ....

2. Flora and vegetation; fauna

2.1. Species list: 0 – not made, 1 – list of plants, 2 – list of animals enclosed ....

2.2. Red list/protected species: 0 – none, 1 – present, cf. species list ....

2.3. Habitat type number *sensu* Paal (1997) ....

2.4. Shrub layer: 0 – none, 1 – normal to the type, 2 – expanding

2.5. Species composition of tree layer (10 points formula)

2.6. Age of tree layer: 1 – young, 2 – immature, 3 – old/mature, 4 – of various age

2.7. Tree layering: 1 – sparse, 2 – multilayered with gaps, 3 – closed canopy

2.8. Decaying logs: 0 – none, 1 – < 5%, 2 – 5...20%, 3 – >20% of growing trees

2.9. Number of standing dead trees: 0 – none, 1 – < 5%, 2 – 5...20%, 3 – >20%

3. Human impact

3.1. Forest cutting: 0 – none, 1 – single trees, 2 – moderate, 3 – clearcutting

3.2. Grazing: 0 – none, 1 – weak, 2 – moderate, 3 – strong, 4 – overgrazed

3.3. Mowing: 0 – none, 1 – weak, 2 – moderate, 3 – regular

3.4. Burning: 0 – none, 1 – weak, occasional, 2 – strong

3.5. Drainage: 0 – none, 1 – weak, 2 – moderate, 3 – strong

3.6. Other impacts: trampling, building, rides/lines, etc., roads/winter-roads, peat-cutting, quarries, pollution, waste (old, during last 3 years, recent)

4. Hydrological type (water regime): 1 – stagnant, 2 – flooded (every year, irregularly), 3 – flowing over, 4 – flowing out, 5– flowing through

5. Field evaluation of the site

5.1. Typical (representative) for 1 – bog/fen region, 2 – phytogeographical region, 3 – development processes

5.2. Rare type in 1 – national scale, 2 – regional scale

5.3. Special value due to 1 – hydrological features, 2 – vegetation type(s) and/or structure, 3 – flora, 4 – fauna, 5 – development processes

5.4. Valuable due to diversity of 1 – landscapes, 2 – plant communities, 3 – species composition

5.5. Valuable for science as 1 – classical site (reference area for certain topics), 2– showing regeneration after peat-cutting, haymaking, etc., 3 – part of landscape or habitat type complex

5.6. Valuable for educational purposes (excursion sites, nature trails etc.)

5.7. Valuable for 1 – flood and water-table regulation/control, 2 – maintaining water quality, 3 – as a compensation area (recreation, tourism), 4 – local use of resources (haymaking, peat-cutting, berry-picking etc.)

6. Evaluation of natural status: 1 – totally intact, 2 – minor human impact, almost unchanged, 3 – minor to medium impact, but if set aside will regenerate, 4 – significant human impact

7. Summary: 1 – use allowed without restrictions, 2 – use should be restricted due to (cf. above), 3 – site is recommended for protection due to (cf. above)

ESTONIAN SEMINATURAL GRASSLANDS INVENTORY

Record no.....................Date: ....
Investigator(s):..
1.General data: 1.1. Name of area...
1.2.Village(s):...
2. Flora (species list on the other side) and vegetation:

2.2. **Shrub layer**	tree cover % typical to this plant community			tree cover developed after human impact		
Species	medium height, m	max height, m	cover (0-1)	medium height, m	max height, m	Cover (0-1)
1.						
2.						
3.						
4.						
5.						

2.1.Habitat type codes and/or name (Paal, 1997) ....
....
2.3. **Tree layer**: 0 – none, 1 – species composition ....,
cover (0,1 – 1,0)...
2.4. **Forestification**: covered .... % of the area
2.5. **Species richness of the grass layer** 0 – poor, 1 – secundarily poor, 2 – usual, 3 – rich
3. Humidity regime (if many codes, underline the main): 1 – dry, 2 – medium humid, 3 – paludified, 4 –swamp
4. Fitness for mowing (if many codes, underline the main): 0 – doesn't fit, 1 – only handwork, 2 – medium, 3 – good If 0-2, then why:.......... ....
....
5. Human impact (if many codes, underline the main)
5.1. Drainage: 0 – none, 1 – minor, 2 – medium, 3 – significant
5.2. Mowing: 0 – ended > 10 years ago, 2 – ended 4-10 years ago, 3 – mowed 1-3 yeasr ago, 4 – at present.
5.3. Grazing: 0 – ended > 10 years ago, 2 – ended 4-10 years ago, 3 – grazed 1-3 yeasr ago, 4 – at present.
5.4. Other impact (underline): buildings, barn(s), tramping, roads, wires, quarries, trash, stone fences,...
6. Evaluation of the nature protection value
6.1. Phytocoenological value: 0 – none, 1 – small, 2 – medium, 3 – high
6.2. Estetical value: 0 – none, 1 – small, 2 – medium, 3 – high
6.3.Other values:...
....
7. Additional comments:

Method of old-growth forest inventory in Finland

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Introduction

The Finnish nature conservation discussion has during the last 20 years concentrated on the question of the protection of old-growth forests. This has been a result of increased awareness on the biodiversity of forests. Recent Finnish inventories of threatened plant and animal species have brought to light certain deficiencies in the protection of forest species, particularly those specialized in old-growth forests, in a large part of the country. The protection of old-growth forests has not been only a Finnish question, but the same issue has been a topic of international interest.

Finland's forest vegetation zones vary in their degree of biodiversity. As a rule, there are fewer species in the north than in the south, but northern forests host certain species which are either extinct or not encountered in the south.

During the period from 1989 to 1996, an inventory of old natural forests was conducted in Finland. The name of inventory in Finnish was "aarniometsäinventointi", although the true aarniometsä (Urwald in German) was more an ultimate destination than reality.

The inventory of old-growth forests valuable for nature conservation was launched by the nature conservation research unit in National Board of Waters and the Environment in 1989. The compiling of a conservation programme for old-growth forests started in southern Finland in 1991, when the Ministry of the Environment nominated a working group for the protection of old-growth forests.

The results of inventories led to a principal protection decision of the Finnish government in 1996, after the work of the protection committee. The final formation of nature reserves continues even today (Lindholm 1999).

The basis for the protection was the knowledge that a great number of forest species had become rare and endangered. The reason to that was the active Scandinavian forestry, which gradually exploited all natural forest habitats outside nature reserves (Rassi & Väisänen 1987).

To proceed the inventory, which was desired by the Ministry of the Environment, a suitable method to identify the valuable forests had to be developed.

What was the target of inventory?

The inventory had to meet the following requirements:

1. It should reveal the habitats of endangered forest species
2. Due to the lack of time it should be in use during the whole fieldwork season, i.e. from spring to autumn.
3. The method should be easy and reliable enough so that in case a large number of different people with different background from biodiversity research or forestry could participate in the inventories.
4. The data should be in such form that a good database could be compiled as a basis for the analysis of the field data.

Finally, as a result based on those demands the method of inventories was developed. It was based on the structure of tree stands including all living trees, and standing and lying dead trees. In the analysis the knowledge of land use history of Finnish forest was used. The method was proofed to be satisfactorily good to be the basis for nature reserve establishment.

How to identify a valuable forest?

The inventory method was firstly developed for the southern part of the country (Lindholm & Tuominen 1991). The approach was to identify the quality of the forest according to the total structure of tree stand taking into account especially the role of dead trees in the forest. The method was further developed in northern Finnish inventories, where it was possible to use forestry databases, maps and false colour infrared aerial photographs (Lindholm & Itkonen 1997).

How to evaluate the inventory results?

To help the evaluation the material a special but pragmatic definition of "nature protection valuable old-growth forest" was developed (Rassi et al. 1992).

1. The tree stand of nature protection valuable old-growth forest is normally clearly older than the economical regeneration maturity age.
2. Trees in the stand vary in size.
3. There are several tree species and there are several canopy layers.
4. The stand can be also pure spruce stand of late succession stage.
5. Old stumps and other minor marks of human activity do not necessarily decrease the nature protection value.
6. Due to the high stand age or due to the self-thinning competition the stand contains much dead tree material.
7. Many trees are faulty or have diseases, and there may be much epiphytes.

How to find the potential old-growth forest

In the beginning there were difficulties to identify where the potentially valuable old-growth forests are located. Thus an inquiry was sent to diverse organisations and authorities. Often the answer was rather vague in location and in the field the first task was to identify the correct forest stand. In private forests normally no aerial photograps were available. In state forests at first Metsähallitus (Forest and

Park Service) officially nominated only a small amount of valuable forest areas, and many volunteers and NGO activists at the same time nominated a great number of state forest areas in different parts of the country. That lead to a conflict, which was solved finally by changing the role of Metsähallitus. So, finally in the state forests we could make inventory based on the forest stand database information and we could use fresh infrared aerial photographs in inventories. Thus it was easier to localise the old-growth forests and we had the basic forestry information on the stands.

How to conduct the inventory?

In the beginning it was clear that to proceed the inventory, a large number of people were needed. The regional environment authorities got the task to conduct the inventories in private forests. In state forests, the staff of Metsähallitus nature conservation division had the task to conduct inventories in state forests. In addition, the NGO Luonto-Liitto complemented that by doing voluntary inventories according the same guidelines as in "official" inventories. In reality same persons made rather often official and voluntary inventories. During the inventory period some of the people doing the inventories developed skills to identify important indicator species in addition to the studies of forest structure.

How to evaluate the inventory results?

The inventory results were calibrated and analysed manually (Lindholm & Airaksinen 1994). A score system was developed to be used in the analysis (Table 1).

Due to the heterogeneity of the material, quantitative mathematical analysis was not possible. Also time was a limiting factor. Revisiting a number of different forests by a steering group of the inventory, the scores given to the stands were checked.

Table 1. The score system used in South-Finnish Old-Forest inventory evaluation.

		scores
1	Degree of naturalness of the forest	0 - 10
2	The present status of the structure of tree stand	0 - 5
3	The structural elements of the old-growth forest	
3.1	Trees of the former tree generation	0 - 3
3.2.	Old deciduous trees in different forms	
3.2.1	Old deciduous living trees	0 - 6
3.2.2	Standing dead deciduous trees	0 - 4
3.2.3	Lying dead deciduous trees	0 - 4
3.3.	Dead coniferous trees in different forms	
3.3.1	Dead standing coniferous trees	0 - 3
3.3.2	"Kelo" or snag trees	0 - 3
3.3.3	Lying dead coniferous trees	0 - 4
3.4.	Quality of lying tree trunks	
3.4.1	The degree of decomposition	0 - 3
3.4.2	The size of tree trunks	0 - 3
3.5	Trees with fire scars	0 - 2
3	The total of scores of structural elements	0 - 35
	The total of scores 1, 2 and 3	0 - 50

In the field, maps and especially forestry maps were used when possible. Also infrared aerial photographs were useful in the inventory work. In the office, when the material was analysed, maps and images were also important in making the boundaries for the nature conservation proposal. By using images it was possible to distinguish the location of valuable forest and also it was easy to see cutting areas, and also pristine and drained mires.

Finally the working group for old forest conservation made in several steps different proposals for conservation. The Government of Finland made also several principal decisions of protection so that the total area of decisions was about 343 000 ha in about 500 different areas (Lindholm 1999).

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Development of strict nature reserves of Russia: evolution, revolution or regress?

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Introduction

The development of the structure of strict nature reserves (zapovedniks) in Russia has more than 80 years history and is expounded by many historiographers and scientists (Реймерс & Штильмарк 1978, Краснитский 1983, Соколов et al. 1986, Штильмарк 1996). Originally, nature reserves were created mainly for preserving and studying separate elements of ecosystems, e.g. Barguzin sable, minerals or waterfowl. After two "crisis" periods of the nature reserve system in 1951 and 1961, when many nature reserves were closed, a rather long period of progressive development begun. As evidence is great amount of literature devoted to this question edited during the period. A long-term network of nature reserves has been elaborated, the attempts to co-ordinate scientific researches and to optimise their staffs, regime and territories have been undertaken (Насимович & Исаков 1979, Забродин & Колосов 1981, Амирханов et al. 1985, 1988).

From the end of 1980s the activities of the nature reserves was began to review and this "evolution" is possible to see on the example of the Kostomuksha Nature Reserve.

Discussion

In 1983, the Kostomuksha State Nature Zapovednik was established covering 47569 ha rather close to the town of Kostomuksha. The area is small when compared to recommendations (Насимович & Исаков, 1979). A buffer zone is not created yet, and about one fifth of it are lakes, Lake Kiitehenjärvi being the largest.

The main tasks of the Kostomuksha Zapovednik have been defined to be:

· Preserving of taiga ecosystems and conservation of biodiversity;
· Studying of north-western ecosystems and their components;
· Conducting of long-term ecological monitoring.

The zapovednik's activities have begun from forming staff of its departments and boundary establishment. In 1986, a forest inventory was conducted and to the end of 80´s the amount of the main departments (of scientific research and of forest guarding) developed up to 7 and more than 10 persons, correspondingly. During these 10 years a good basis for preserving nature reserve's territory and its studying has been created, and it has begun to gain prestige as a nature conservation and scientific organisation. But from the very beginning, the zapovednik didn't forget its role in ecological education, and the staff, scientific researchers being the first, used the material collected by them for this work.

In 1990, the Kostomuksha Zapovednik was included into the international Nature Reserve "Friendship" (Kashevarov 1996). It stimulated the development of the zapovednik, scientific research primarily. Though there was no additional financing for these international activities, it was conducted successfully due to the redistribution of the resources and the support from Finnish colleagues.

From the end of 90s a more and more determined reorientation has started, which effected the scientific activities in the first place. As a result, its financing began to come true based on the rest principle, and instead of scientific research it became possible to employ any other personnel and to introduce into practice additional payments. All these didn't stimulate the creation of scientific department possessing a great capacity for work but on contrary orientated on its reducing.

At this time, a specialist of ecological education appeared in the nature reserves. In our nature reserve a special department was created. In general, the idea of the appearance of such departments (or specialist in the department of scientific researches) which are purposefully acting in this sphere should be considered expedient, though such activities of the zapovedniks, including Kostomuksha, have been always.[1] But these departments appeared without exact determination of their goals, tasks and financing.

In conditions of "perestroika" an overorientation of the zapovedniks on self financing of their main activities has begun. The easiest decision was so called "ecotourism" conducted in the zapovedniks as one of the forms of ecological education. In the federal law of Russia "About especially preserve areas" (1995) the differences between national parks and zapovedniks are clearly distinguished. The national parks are entrusted with the tasks of ecological education and creating conditions for regulated tourism and recreation as the main ones and, on the contrary, among the other tasks zapovedniks are entrusted with ecological education only. But in practice some zapovedniks began to include tourism in their plans as one of the points of ecological education as just with its help it is possible to earn money.[2]

Nowadays it is impossible to draw a distinction between zapovedniks and national parks. About priority of science in comparison with tourism, and ecological education in general, in accordance with the law it is reminded only in newspaper and on scientific symposiums. From the 6 main tasks of zapovedniks mentioned in the law 4 are connected with scientific research, but from the 7 tasks of national parks only one is about research. Nevertheless, in the end of 1996 in 13% of zapovediks there were no scientific departments at all, in 38% the staff of these departments including its leaders was less than 4 persons, 24% possessing the staff of 3 and less persons (Информационный бюллетень 1997). Kostomuksha zapovednik is in the last group. Nowadays an idea of total reduce of scientific departments in some zapovedniks is under discussion and arranging of researches only with the help of specialists from universities and institutes (Жуков 1997). Without any doubt this concept will lead to the loss of continuity of long-term investigations (monitoring) of ecosystems and to preservation of zapovedniks not as zapovedniks itself but as nature reserves.

In Kostomuksha zapovednik, after long discussions, tourist routes were established. They cross practically all the territory of it. Regulations and prices were worked out. For natives this area is not very interesting from ecological education point of view, especially if visiting is with requiring payment. Thus, it is commercial tourism mainly for foreigners and it has nothing in common with ecological education, as edu-

1 Museums and nature exhibitions have been in zapovedniks for many years, in some of them excursions were arranged in the most picturesque places. At that period there was no such term as "ecological tourism". And at that time ecological education was based on enthusiasm.

2 An account was done on foreigners as Russia at this period became more open and it became possible for western nature lovers to enjoy the nature of one fifth of land which was practically unknown. It was more interesting as zapovedniks knowing nothing about marketing arranged the trips on very low prices being glad of acquainting with the world.

cating should be aimed on fellow citizens first of all. The only Russian "ecological tourists" were sportsmen-floaters who arranged water-rally on the Kamennaya river and skiers who had 50 km trip along a trace created by snowmobiles. These activities maybe didn't disturb the preserved nature, and the nature reserve earned some money, but they didn't rise nature reserve's prestige.[3]

Very soon earning money in some nature reserves became the goal, and guarding, science and ecological education became only sources for it. In such conditions science in nature reserves became beyond competition compared with guarding and especially with tourism which give money in the form of fines and fees for usage of the preserved resources. These resources belong, to the point, not to exact zapovednik but to the state in general. Science and ecological education are profitable only in long-term perspective. But from such point of view the Hermitage and the Russian Museum are also not profitable and their collections should be sold. In such conditions, science in zapovedniks is not needed and this process has started already.

As an approval of this is a decision of liquidation of Scientific Councils in most of the zapovedniks which were based on democratic principles of electing its leaders. The statement about scientific-technical councils returned zapovedniks to the past when the director was also the head of this council. In Kostomuksha zapovednik this statement was "developed" and even scientific researchers were not included into its membership.

The same situation is with the department of guarding. Previously, educated specialists constituted the majority of the staff. Nowadays this percentage is much lower. Even the head of the department has no high education and enough experience of working in zapovedniks. The result is that the department in general is not interested in arranging any observations and is concentrated only on simple guarding. Is it possible to expect that the problems arising before the zapovednik will be solved on the high level of knowledge?

Looking from aside, the situation with zapovedniks is rather good due to arranging new protected areas and the crisis of the system in general is not seen. The situation is explained in a way that as many territories as possible should be preserved and then in future they will be developed (by whom and when?) in real zapovedniks. But such decision discredits both already existing zapovedniks, which do not care about their main tasks, and recently created ones, which do not begin to work with them.

What can be the way out from the situation with zapovedniks, with science, preserving nature and ecological education in them?

There is no simple answer, certainly, but from my point of view state organisation should have also state financing of its main activities, including scientific research. Maybe it is needed to join all scientific departments of the zapovedniks into united system of ecological monitoring like meteorological stations (Кашеваров 1990). The leadership of this system can be arranged via Academy of Science. Our foreign partners from the Finnish part of the Friendship Nature Reserve have an interesting experience. There is no special staff for guarding these 5 protected areas united into the Finnish Friendship Park and it is conducted by Forest and Park Service (Metsähallitus). For conducting and arranging joint research the Research Centre of Friendship Park was established. Thus, the arranging of research is very much alike with its arranging in Russian zapovedniks. But there is difference: it is under the charge of the other authorities and it has its own financing.

3 A problem of zapovedniks' prestige as nature conservation organisations is not only Russian problem. The same problem was discussed in Wichita Mountains Wildlife Refuge where much attention is paid to ecological education. Rock-climbing which is sport traditionally existing in the refuge comes in conflict to its tasks.

Thus, our Finnish colleagues have a progress in developing scientific research and in Kostomuksha zapovednik as in many other Russian zapovedniks the process is going in the other direction. Maybe to stop the process it is not needed to move scientific departments out of the zapovedniks but its financing and staff should be protected from redistributing.

It is of no doubt, that all kinds of tourism in the zapovedniks should be strictly regulated and separated from ecological education. And ecological education itself, as it was mentioned by many specialist of zapovedniks, should be oriented on explaining the role of the nature reserves in general and of zapovedniks in particular. Excursions in nature should be arranged mainly on adjacent areas. In few zapovedniks it is impossible but it should be exceptions from the rule.

In many zapovedniks there are objects that can't be stuffed into strict regulations of the zapoveniks. And even their own activities (researches and guarding) disturb nature proceeding from the principle of "absolute conservation" (Забродин & Колосов 1981). But it is not an occasion to arrange special tourist routes, to store firewood for them, to allow visitors fishing. When it was allowed for foreigners, even with very high fee, local people began to doubt about the goals of zapovednik.

For sure, the staff of zapovedniks should search for additional financial resources. But it should be done for special projects (non-state) and they should report about the results not only granter, but to department of zapovedniks also which must be in charge of zapovedniks' prestige.

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Geological background for biodiversity in eastern Fennoscandia

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Study of the way the biodiversity in Republic of Karelia and in whole Eastern Fennoscandia was formed, and up to present time preserved, shows two major factors controlling plant and living organism diversity: gradual extenuation of solar energy to the north and geological background.

Normally, the number of vascular plant, lichen and moss species decreases rapidly from the south to the north. In Poland, in Bialowiesza National Park (NP)(54°N) over 2000 vascular plant species have been counted, in North Estonia, Lahemaa NP (59°N) the respective number is 1200, in Karelia on the NW shore of Lake Ladoga (61-62°N) about 800, both Vodlozero NP (62-63°N) and Kostomuksha Reserve (64°N) 420 species, while on Spitsbergen (77-81°N) only 150 species of higher plants have been recorded. However, in several places in Eastern Fennoscandia the above-described regularity is disturbed. In Kenozero NP, to the east of Vodlozero NP, over 700 vascular plants have been recorded, and on Zaonezhje Peninsula of Lake Onega, to the west of Vodlozero NP, over 800 species are known. Exceptionally, in Paanajärvi NP (66°N), only 12-40 km to the south of the Arctic Circle and 250-300 km northward of Kostomuksha Reserve, the biodiversity is unusually rich for this latitude, comprising total 570 of vascular plants, and about 400 lichen and as many moss species.

In Eastern Fennoscandia, the habitats of rare and endangered plant species are disposed irregularly. These are related mostly to the outcrops of the Early Proterozoic volcanic-sedimentary bedrock, while no rare plant species are found in outcrop areas of the Archean granite and gneiss basement rocks (Fig. 1). This conforms well to the results of plant geochemical investigations. For plant healthy growth and development different major and trace elements are required (Thornton 1983). The basic supplier of nutrients needed is the soil, which is formed on bedrocks and Quaternary deposits. The bedrocks are of different composition and this is reflected in the soils as well. The Archean granites, diorites, gneisses and granite gneisses widely distributed in Karelian Craton and Belomorian Folded Belt, cover about 70% of the territory. They are rich in SiO_2 and Al_2O_3, but contain insignificant amounts of P, S, Mg and micronutrients needed (Fe, Mn, Cu, Zn, B, Cl, Co, I, Mo, Se, Ni, Sn, W, As, F). In the volcanic and sedimentary rocks forming the Late Archean greenstone belts the content of the above-cited elements is higher, but these rock types crop out in small areas only and are botanically poorly studied.

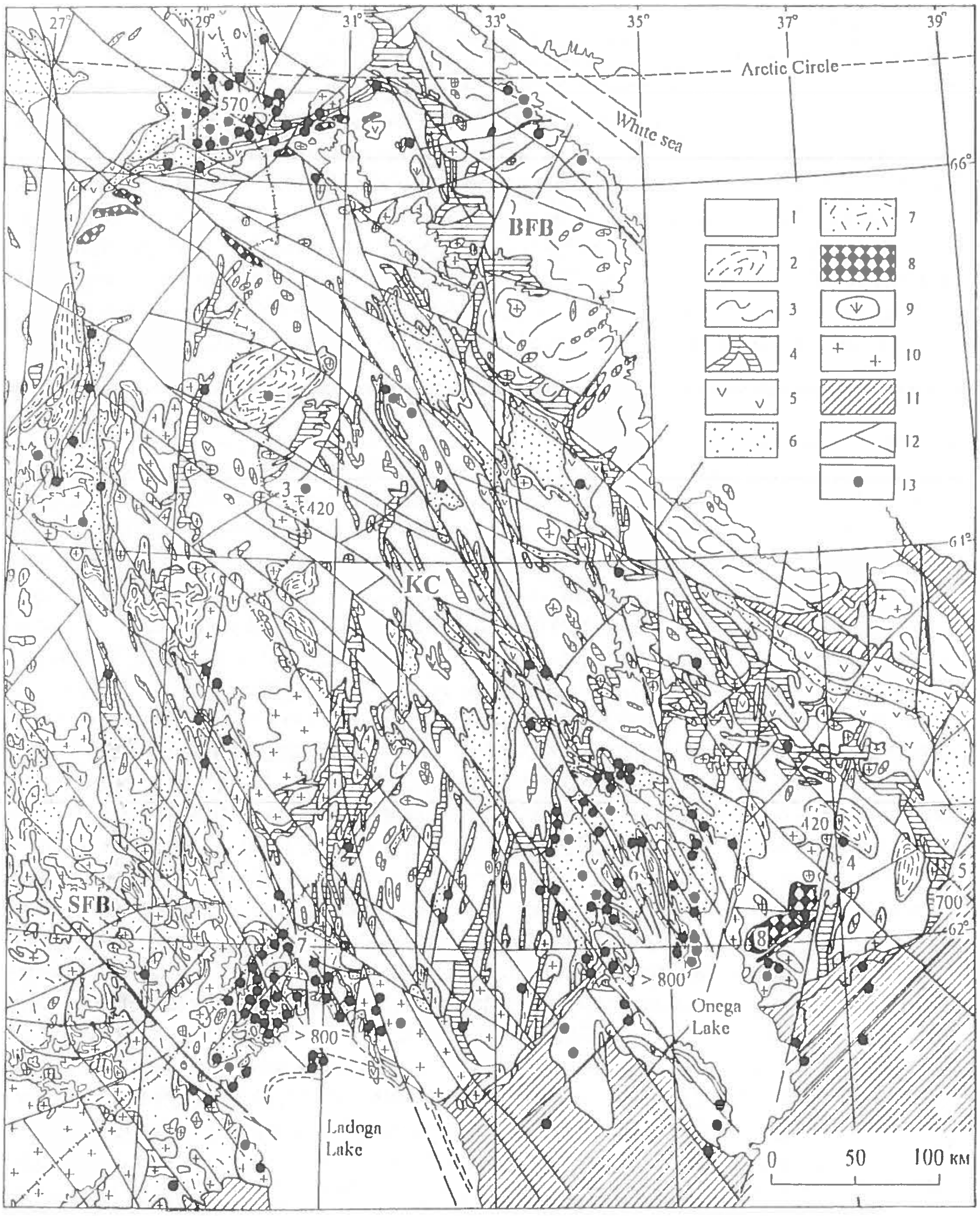

Figure 1. Rare vascular plant finds in the Eastern Fennoscandia on geological map. 38 species from Red Data Books of Eastern Fennoscandia (Kotiranta et al. 1998) and Karelia (Ивантер & Кузнецов 1995) are shown. To exclude the latitude influence, species developed only in north (Silene furcata ssp. angustiflora, Salix pyrolifolia, Cotoneaster cinnabarinus etc.) and only in south (Anemone vernalis, Ulmus laevis, etc.) are excluded.
Geological complexes:
1-2 – Early Archean: gneissic granites and diorites, migmatites (1), granulites, migmatites, biotite and alkaline gneisses (2). 3 – migmatized Belomorian gneiss-amphibolite complex, 4 – Late Archean Greenstone Belts. 5-6 – folded Early Proterozoic cover of the Karelian Craton: volcanites (5) and sedimentary rocks (6). 7 – Svecofennian flyschoidal sedimentary rocks, 8 – 2.4 Ga layered peridotite-gabbronorite massifs, 9 – Jeletozero alkaline gabbro massif, 10 – granites of different age, 11 – Vendian-Paleozoic platform cover, 12 – main fault zones, 13 – rare plant finds.
***BFB** – Belomorian Fold Belt, **KC** – Karelian Craton, **SFB** – Svecofennian Fold Belt. Numbers 1-8 show geological objects and structures: 1 – Oulanka-Paanajärvi area, 2 – Oulujärvi, 3 – Kostomuksha Reserve, 4 – Vodlozero NP, 5 – Kenozero NP, 6 – Onega synclinorium, 7 – Northern Lake Ladoga area, 8 – Burakov layered peridotite-gabbronorite massif. Total number of vascular plants is shown in places where these have been counted.*

The rare plant finds are mostly related to the Early Proterozoic Svecofennian Folded Belt, and to the areas where occur rocks coeval with those forming the upper floor of the Karelian Craton and preserved from the long-term erosion only in the zone along the craton margins and in the cores of the deep synclines in its central part (Сыстра 1991). The Early Proterozoic rocks in this area are represented by acid and andesitic basalt volcanites, basalt sills and flows, carbonate rocks, black schist, flyschoidal sediments, quartzites and sandstones, layered peridotite-gabbronorite, gabbro and alkaline gabbro intrusions. These rocks differ in composition, but all of them are rich in Ca and Mg, Fe, Mn, Ni, Co, Cr, Cu, Zn, V, Mo. Since in the Quaternary deposits transported material is mainly of local origin, the bedrock richness is reflected in the composition of soils: on outcrops of the Early Proterozoic rocks the soils are rich in all nutrients needed for plants (and animals). For example, on Zaonezhje Peninsula in the central part of the Onega Synclinorium, soils are enriched with a number of elements, including Mn, Zn, Cu, Mo, V, Cr, U, Co, B and Se.

The most important conclusion of our study is that rich biodiversity can develop only on the bedrocks, which contain all macro- and micronutrients needed for plants.

There are some other geological features influencing biodiversity in the Eastern Fennoscandia. One of these is the relief and orientation of relief forms. Along the Finnish-Russian border runs the Maanselkä Ridge, the highest hills of which are Nuorunen (576 m a.s.l.) and Mäntytunturi (550 m). The ridge divides the Atlantic vegetation on the western slope from the Arctic vegetation on the eastern slope in the Northern Russian Karelia. Mixing of these vegetation types started 9500 years ago, after the melting of the last ice-sheet, and is continuing nowadays, since there still is noticeable difference between the vegetation on western and eastern slopes. The important feature for mixing is the long deep Lake Paanajärvi–Oulankajoki River valley, cutting the ridge from the east to the west. The valley bottom lies less than 200 m a.s.l., while hill tops along the valley reach 400-500 m. It forms a specific mixing corridor for plants, birds and animals. In this valley, protected by hills from the cold north, north-east and north-west winds, the summer-time sun heats the dark rocks on the steep slope. This creates remarkable greenhouse effect and the temperature here is some degrees higher than on surrounding hills. In the valley there have been found wild strawberry, lily-of-valley and other southern species, the distribution area of which is normally 300 km southward. From the other side, Paanajärvi NP is located only 10-40 km southward of the Arctic Circle and hills rise into mountain tundra zone (above 450 m a.s.l.). The vegetation changes to tundra, where trees are missing and typical tundra species are present (Loiseleuria procumbens, Phyllodoce caerulea, Diphasiastrum alpinum, *etc.).*

Microclimatic conditions are different on sunny southern slopes and constantly cold and wet northern slopes and fault scarps. On northern slopes and deep fault depressions M. Fadejeva has found northern species of lichens in Kostomuksha Reserve and A. Maksimov mosses near Lake Ladoga. V. Zimin has met some bird species, normally nesting in Southern Karelia, nesting on the sunny southern slope of Kivakkatunturi Hill (500 m).

The fault zones are important for biodiversity as a relief-forming factor, since groundwater carrying out different mineral nutrients for plants can circulate only in fissured crystalline bedrocks of fault zone. Very often small mires occur near springs, displaying very rich vegetation, including several rare plant species, especially when the bedrocks contain sufficiently carbonaceous material.

The stability of the crystalline Precambrian rocks and numerous fault zones with scarps and depressions, fissured near-fault rocks, and movements along faults are the main relief-forming factors. Relief and mineralized waters of the fault zones enrich the biodiversity of the Eastern Fennoscandia. Relationships between geology and soil-plant-animal systems need future study.

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Crystalline basement of Nature Reserve Friendship

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Introduction

Friendship Park, which lies near the Finish-Russian border, consists of five separate territories in Finland and Kostomuksha Nature Reserve in Russian Karelia. The latter one is in itself the largest.

As a whole, the area of Friendship Park provides a geological link between two Late Archaean structures which are well known greenstone belts: the Kuhmo-Suomussalmi in Finland and the Kostomuksha belt in Russian Karelia.

In general the study area is dominated by the Earth's oldest geological deposits having an absolute age of 3.15-2.7 Ga. These crystalline strata are overlain by 9500-10200 years old Quaternary deposits. They are widespread over the entire this area.

Results of mapping

The crystalline rocks of the Early Precambrian complexes occur on three structural storeys: 1) Early Archaean gneiss and gneiss-granitoid complex; 2) Late Archaean volcano-sedimentary crystalline rocks and granitoid complexes; and 3) Early Proterozoic supracrustal units (Fig.1).

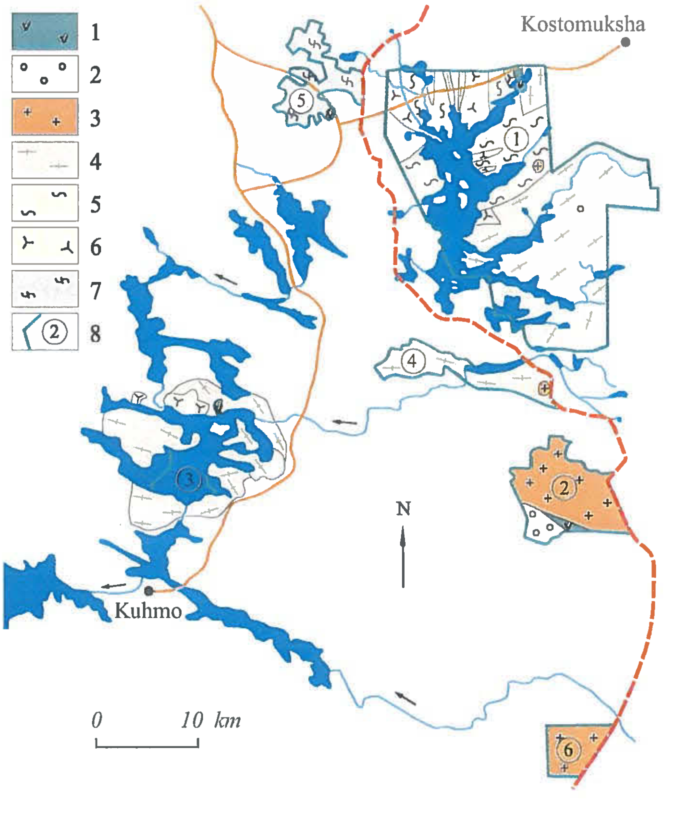

Fig 1. Geological sketch map of the Nature Reserve Friendship.
1 - basalts, andesitbasalts;
2 - polymictic conglomerates and breccia conglomerates;
3 - potassium granite;
4 - greissose granite, migmatites;
5 - tonalite, migmatites;
6 - migmatitic and gneissose granodiorite;
7 - biotitic mica gneisse, migmatites;
8 - boundaries of Nature Reserves.
Nature Reserves (in circle).
1 - Kostomuksha;
2 - Elimyssalo;
3 - Lentua;
4 - Iso-Palonen and Mariansärkät;
5 - Juortanansalo-Lapinsuo;
6 - Ulvinsalo.

Early Archaean rocks are gneiss diorites, gneissose granites and tonalites that form a basement for volcanic-sedimentary strata in Upper Archaean greenstone belts.

Relics of Saamian (Early Archaean) units occur as the oldest geological unit, Vuokkiniemi block. In this block Saamian units are formed by amphibole-bearing gneisses, amphibolites, enderbites, biotite- and hypersthene-biotite plagiogneisses, gneissodiorites. The rocks are metamorphosed to granulite and amphibolite grade and migmatized by various granites.

All the rocks listed above occur as inequidimensional remnants and relics in migmatite, granite, and gneissose-granite fields. The primary nature and sequence of formation of the gneisses are open to debate because their original genetic characteristics have been lost.

Early Archaean mica gneisses and diorite-gneisses cut by plagiogranite-gneiss, tonalite-gneiss, charnockite as well as plagiomicrocline and microcline granite bodies are present as numerous remnants in the migmatite fields.

The Saamian rocks are found in Northern part of Kostomuksha Reserve and Juortanansalo-Lapinsuo Mire Reserve. These Reserves are situated in the South part of Saamian Vuokkiniemi block.

The second structural level is formed by Late Archaean (Lopian) supracrustal units which persist as small remnants and xenoliths in Kostomuksha and Lentua Nature Reserves, as well as widespread granitoid and migmatite complexes. Isotopic datings for the upper age boundary of these units are over 2700 Ma (Fig. 2).

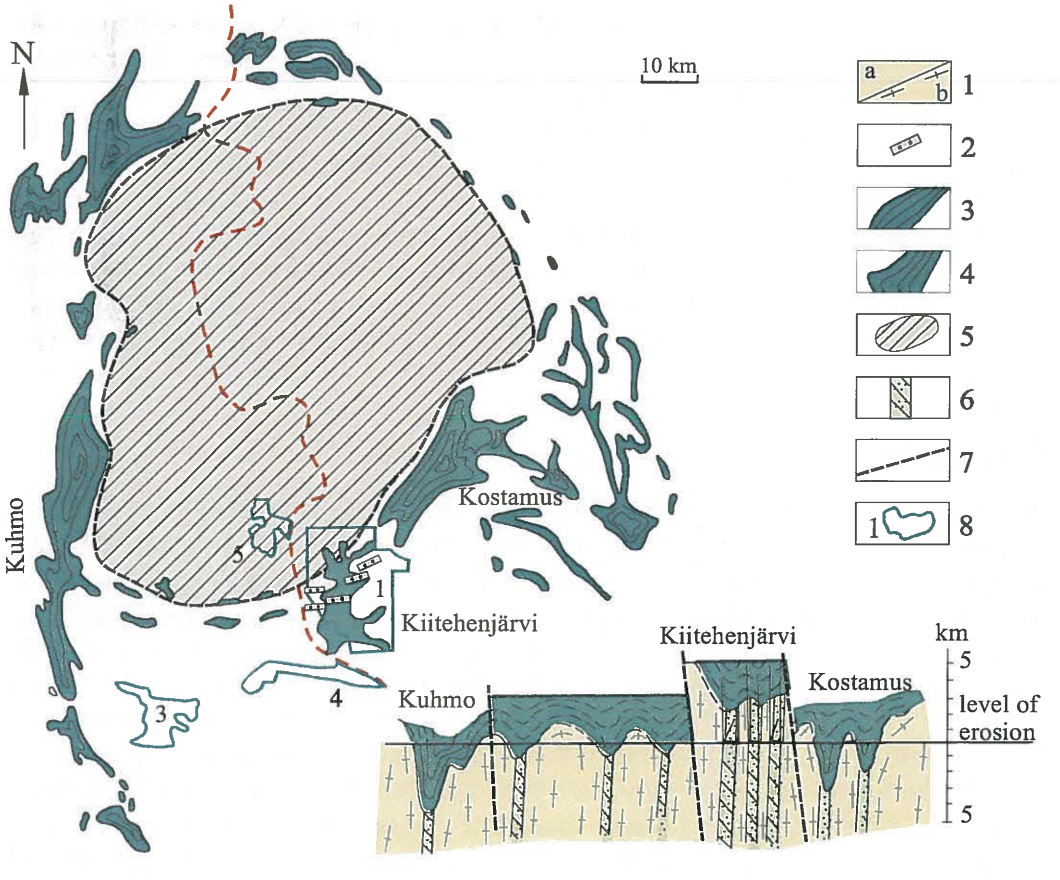

Fig 2. Structural scheme of the Kuhmo-Suomussalmi-Lake Kiitehenjärvi-Kostomuksha area. (1 - gneiss diorites, gneissose granites and tonalites and migmatites formed after them; 2 - metadolerite dyke swarms; 3 - volcanic-sedimentary strata in Late Archean greenstone belts; 4 - reconstructed Late Archean volcanic-sedimentary strata; 5 - Vuokkiniemi block rocks; 6 - dyke of feeder channels; 7 - tectonic dislocations; 8 - Nature reserve boundary.

The Late Archaean rocks occur as wedging-out band and are represented by basalt pillow lavas. Pillow lavas under discussion are highly altered in which new minerals, e.g. hornblende, plagioclase and quartz and structure develop. Sometimes pillow contours are visible because their monomineral (hornblende) margins ("chill zones") are darker, but they are only an exception to the rule.

In the centre of Lake Kiitehenjarvi, numerous boudinated metadolerite dyke swarms can be found. These dyke bodies are intensely reworked and boudinated and seem to form the intensely altered roots of feeder channels for Late Archaean tholeiitic basalts that developed in the Kostamuksha and Kuhmo-Soumussalmi greenstone belts.

The third structural storey is composed of Lower Proterozoic units.

The early Proterozoic unit occurs in Saari-Kiekki greenstone belt, in Iso-Palonen and Maariansärkät Nature Reserve of Friendship Park. There is a deformed remnant of a NW-SE-tranding elondate structure 15 km long and up to 3 km wide. The volcano-sedimentary sequence of the belt include conglomerates, arcosic sandstone and volcanic rocks (andesite), basalts and andesitbasalts. To the north and south of the belt there occur leucocratic granodiorite, granite and cataclostic tonalite.

In all PNP, Early Precambrian complexes are cut by Archaean and Proterozoic gabbro-dolerite and dolerite bodies.

Structural differences in crystalline rocks of Friendship Park suggest a long term and intricate structural evolution with multiple folding.

One of the most striking features in the geological structure of the entire reserve is the abundance of cross-cutting rupture dislocations (paleodislocations) interpreted as evidence for vigorous tectonic processes. Ca. with N-S, ca. E-W, N-E and N-W trending dislocations are topographically distinct. They gave rise to groove-shaped depressions varying in width from several meters to a few hundred meters and bounded by subvertical scarps along their flanks.

Tectonic dislocation is responsible for elongation of lakes, rivers and creek channel patterns and the bizarre outlines of lakes including Lake Kiitehenjärvi bays.

Tectonic zones are fairly old. They remained active for a long period of time, as shown by the fact that basic rock dikes of different ages such as old and younger dolerites, microcline pegmatites and quartz veins are confined to them. Since rupture dislocations form a dense network, it is safe to assume that fault zones are easily permeable and that they serve as channels for migrating deep gases and juvenile water.

Discussion

Analyses of available geological materials in the geological structure of the Kostamuksha greenstone belt (Горьковец et al. 1981, Горьковец et al. 1991) and the Kuhmo-Suomussalmi greenstone belt (Hanski et al. 1983), rock assemblages in the Lower Archaean Vuokkiniemi block (Лазарев & Кожевников 1973, Свириденко 1974) and Late Archaean volcanism (metabasalts and dolerite dyke swarms), using small-scale gravimetric and magnetic maps have led us to conclude that Kostamuksha Nature Reserve is a fragment of tectonic rimmed domal structures of the unique type (Fig.2). This tectonic structure came to exist at the Early Archaean - Late Archaean boundary. Its characteristics differ from those of typical Late Archaean rimmed granite domal structures (Конди, 1983). The unique feature of the structure is that its central part is composed of the oldest Lower Archaean infracrustal and supracrustal complexes such as granulites, tonalites and amphibole, pyroxene and mica-alumina gneisses rimmed by a concentric (circular) and radial system of long-lived tectonic zones along which magmatics of different ages and compositions are intruded.

The area between Kostomuksha Nature Reserve and Kostomuksha iron deposit has unique geological localities and most complete Precambrian rock sequences. These are Late Archaean supracrustal rocks, used as reference.

The geological section near Kostomuksha is highly demonstrative - there are some centeres of ultrabasic (komatiitic), basic (basaltic) and acid (rhyodacitic) volcanism surrounded by rocks with primary textural characteristics (relics of textures); the Archaean areal crust of chemical weathering (Archaean paleosoils); Archaean sedimentary rocks and various genetic types of iron- siliceous rocks such as iron formation.

Geological localities in the study area are highly significant for earth scientists, and for the public at large who appreciate the role of natural ecosystem. This area could also play an important educational role: students specializing in geology could come to Kostomuksha for training; environmental trips could be arranged as well.

Acknowledgements

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Soil cover in the north-taiga Nature Reserve Friendship

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Introduction

Soil is one of the main biogeocenosis components responsible for tree stand productivity. The soil cover in Eastern Fennoscandia is patchy and comprised of small fragments, which is due to frequent alteration of landforms and parent rock. Homogeneous soils areas are quite rare, and the study of the soil cover is thus a topical task, particularly for protected areas.

Materials and methods

Studies were carried out from 1995 to 1999 in the Nature Reserve Friendship. Soil properties and soil cover structure were studied. Soil profiles were made, soil cores were sampled and their chemical composition and particle-size distribution were analysed (Агрохимические методы исследования почв 1975, Manual for Integrated Monitoring 1993). Topographic and Quaternary maps (Niemelä et al. 1993) were used, together with diagrams of forest stands and forest types, to prepare soil maps of the area.

Results

As a result, a 1:50 000 soil map of the "Kostomukshky" nature reserve territory, Ulvinsalo, Juortanansalo, Lentua, Maariansärkkä and Elimyssalo was produced. It shows the distribution of soils across the area, their particle-size structure and combinations. The legend is presented in accordance with the FAO-UNESCO classification (Soil map of world 1990).

The soil cover in each of the study areas has its own pattern related primarily to the type of topography, parent rock and vegetation. The area is generally dominated by fine-textured, commonly bouldery soil-forming rocks, with occasional bedrock exposures. The terrain has a rugged topography and a complex structure. Forest soils are very diverse in the area (Table 1).

The following soil combinations are common: Leptosol + Epy-Rudy-Podzol, Cambic-Podzol + Ferric Podzol, Ferri-Carbic Podzol + Ferric Podzol, Fibric Histosol + Fibric-Terric Histosol.

Podzolic soils of various subtypes and genera are widespread in the soil cover of the Kostomuksha Reserve segment of the Friendship Park. There, the prevalent soils are sandy and sandy loam Carbi-Ferric Podzols. The hydromorphic type covering the largest area is Terric-Fibric Histosols. Sandy, heavily bouldery Ferric Podzols dominate the Maariansärkkä (Palonen) area. The largest part of the Lentua locality is occupied by Ferric Podzols and Ferri-Carbic Podzols. Elimyssalo locality has a highly motley soil cover with large areas occupied by Fibric Histosol and Terric-Fibric Histosol. The soil cover in Juortanansalo is noted for a combination of Ferri-Carbic Podzols and Ferric Podsols, and plentiful Fibric-Terric Histosols. Carbi-Ferric Podzols are common. Ulvinsalo soils are represented by the most varied combinations of next to every Podzol on the taxonomic list. A large proportion of swamp soils (Histosols) and swamp-podzolic soils (Gley Podzols) have been reclaimed (Table. 2, 3).

Table 1. Taxonomic list of soils in the Nature Reserve Friendship.

Leptosol	(LP)
Epy-Rudy-Podzol	(PZre)
Haplic Podzol	(PZhf)
Ferric Podzol	
Cambic Podzol	(PZb)
Carbi-Ferric Podzol	(PZfc)
Ferri-Carbic Podzol	(PZcf)
Carbi-Gley Podzol	(PZGc)
Epi – Histosol	(HSe)
Fibric Mini-Histosol	(HSlf)
Fibric Histosol	(HSf)
Gley Terric-Fibric Histosol	(HSfgt)
Gley-Terric Gistosol	(HSgt)
Fibric-Terric Histosol	(HStf)
Terric Histosol	(HSt)
Umbric	(PZGt)

All the soils studied in the Nature Reserve Friendship are noted for a high actual, metabolic and total acidity. Mineral soils are poor in organic matter, the bulk of which is stored on the surface as forest litter. The percentages of mobile potassium and phosphorus compounds are quite high in organogenic horizons, whereas podzol mineral horizons are poor in nutrients. The low organic matter content of the mineral horizons indicates that they contain little nitrogen, its percentage being the lowest in coniferous north-taiga forest soils.

Table 2. pH value, total acidity , nutrients, total carbon and loss on ignition* in mineral soils of the Nature Reserve Friendship

Horizont	Depth cm	pH H_2O	pH KCl	P_2O_5	K_2O	Aci_ETB	C%
				mg.100^{-1} g		me. 100^{-1}g	
Ferric-Podzol Sandy							
O	0-4	3,85	2,95	68,0	200,0	60,6	92,8*
E	4-10	4,20	3,15	2,0	1,5	4,8	0,07
Bsh	10-18	5,35	5,12	7,5	2,7	3,5	0,68
Bsl	18-31	5,65	5,12	17,5	1,5	1,7	0,43
BC	31-60	5,78	5,30	14,1	1,4	1,7	0,29
C	60-90	5,95	5,65	22,3	1,5	1,5	0,12
Ferri-Carbic Podzol Sandy							
O	0-5	3,5	2,8	38,0	112,4	59,0	93,9*
E	5-21	4,5	3,4	2,0	1,0	2,2	0,54
Bsh	21-38	5,4	5,0	17,5	2,3	1,7	1,33
Bs	38-60	5,8	5,2	11,5	1,0	1,7	0,46
BC	60-81	5,3	4,6	33,0	1,8	1,3	0,25
C	81-100	5,4	4,9	42,5	1,1	1,1	0,07
Carbi –Gley Podzol Sandy							
H	0-11	4,05	2,8	35,0	97,0	85,9	95,9*
E	11-16	4,65	3,8	1,5	2,6	6,4	1,51
Bhsg	16-24	4,70	3,9	1,5	1,4	8,0	1,28
Bsg	24-50	4,85	4,0	1,5	2,2	5,5	0,93
BCg	50-70	5,40	4,5	12,0	5,6	2,6	0,17

Table 3. pH value, total acidity , nutrients, total carbon and loss on ignition* in the organic soils of the Nature Reserve Friendship

Horizont	Depth cm	pH H_2O	pH KCl	P_2O_5	K_2O	Aci_ETB	C%
				mg.100^{-1} g		me.100^{-1}g	
Terric-Fibric Histosol							
H	0-7	4,0	3,0	19,0	61,0	75,8	96,8*
T1	7-18	4,0	3,5	19,0	55,0	79,6	94,9*
T2	18-45	4,5	3,6	11,5	29,0	74,3	90,0*
Cg	45-75	4,9	3,0	-	-	-	1,04
Fibric Histosol							
T1	0-11	3,8	2,9	19,0	61,0	75,8	87,9*
T2	11-32	3,2	2,9	18,0	51,0	71,4	87,1*
T3	32-44	3,3	3,3	6,0	12,0	85,3	85,3*

Conclusion

Our research revealed considerable heterogeneity of the soil cover in the Nature Reserve Friendship as regards both morphological and chemical characteristics. Soil fertility in general is low, since they formed on poor silicate rocks, which predetermined their high acidity and nutrient deficiency in mineral horizons.

Acknowledgement

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Morphological characteristics of soil organic matter in Eastern Fennoscandia

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Introduction

There are now two major lines in the study of organic matter in soils: biochemical approach (Александрова 1980, Stevenson 1982, Schnitzer 1985, Flaig 1988, Орлов 1990) and morphologo- (micromorphologo-) ecological approach (Kubiena 1970, Bal 1973, Babel 1975, Гришина 1986). The first approach is far more wide-spread, and the main emphasis is placed on finding out the chemical mechanisms of organic matter humification processes, and studying the properties of humic matter in various soil types. The second approach is comparatively very little used, though it allows to consider the whole variety of organic matter forms at all stages of its genesis and transformations as affected by soil formation factors. The study of soil organic matter morphology provides the possibility to observe interactions between various organic derivatives and the soil mineral component. This, in turn, enables researchers more accurately to describe the processes going on in the soil.

Material and methods

The goal of our project was to study podzols formed on sandy and sandy-loam deposits in the north- and mid-taiga subzones of Eastern Fennoscandia. These soils are most common at the area under consideration. Soils of north-taiga subzone at Russian-Finnish Reserve "Friendship", and those of mid-taiga subzone at Forestry and Biology Research Station (Forest Research Institute of Karelian Research Center, Russian Academy of Sciences) were investigated. Having different climatic conditions, the objects under study are similar in vegetation, as they are located in pine biogeocenoses.

The methodological basis for the research was the hierarchical approach to the study of different levels of the soil material organization, from the soil profile in general to primary soil particles. Different levels of the soil material morphological organization (profile – horizon – aggregate – primary particle) are responded to by different research levels (macro-, meso-, micromorphology).

The soil profiles were studied following the technique developed by Таргульян et al. (1974) and completed further by Карпачевский et al. (1980). This technique helps to follow spatial changes in the soil material organization. Dimensions and outlines of morphons, variation of the horizon thickness were recorded at the macromorphological level. Morphons were identified mainly by the color, structure, density and homogeneity.

Mesomorphological stage yielded a description of the soil material morphological elements. Soil samples were taken both by genetic horizons and structure elements. Besides, samples were taken from heterogeneous morphons found on the section wall.

Micromorphological research was done with soil columns sampled from all horizons, morphon, transitional areas and other zones of interest. Soil columns were sampled both from the vertical and horizontal sections. Soil structure and composition were studied micromorphologically in thin sections using polarizing microscope, and individual soil particles were examined on electron microscope.

Results and discussion

The organic profiles in all the soils examined are of a raw-humus type. The litter is clearly stratified by the degree of decomposition (stratotypes L, F and H) (Fig. 1). The decomposition of plant residues in the litter is relatively poor. The upper part of stratotype L shows a local transformation of vegetative tissues (emerging hollows and cracks); the residues are actively colonized by fungal microflora and less intensely by bacterial and yeast cells; some protozoan shells were found. Moderately and heavily decomposed and deformed residues with abundant fungal mycelium on the particle surface appear in the stratotype F. Fungal hyphae tightly envelope vegetative tissues and penetrate inside through hollows. Stratotype H of the organogenic horizon is composed of both semi-decomposed residues and loose aggregates made up by heavily decomposed organic material. Protozoan shells, fungal spores and chitinous shells are common. Brown flocculent humus clods and excreta of small soil animals accumulate in areas where vegetative residues are most actively decomposed.

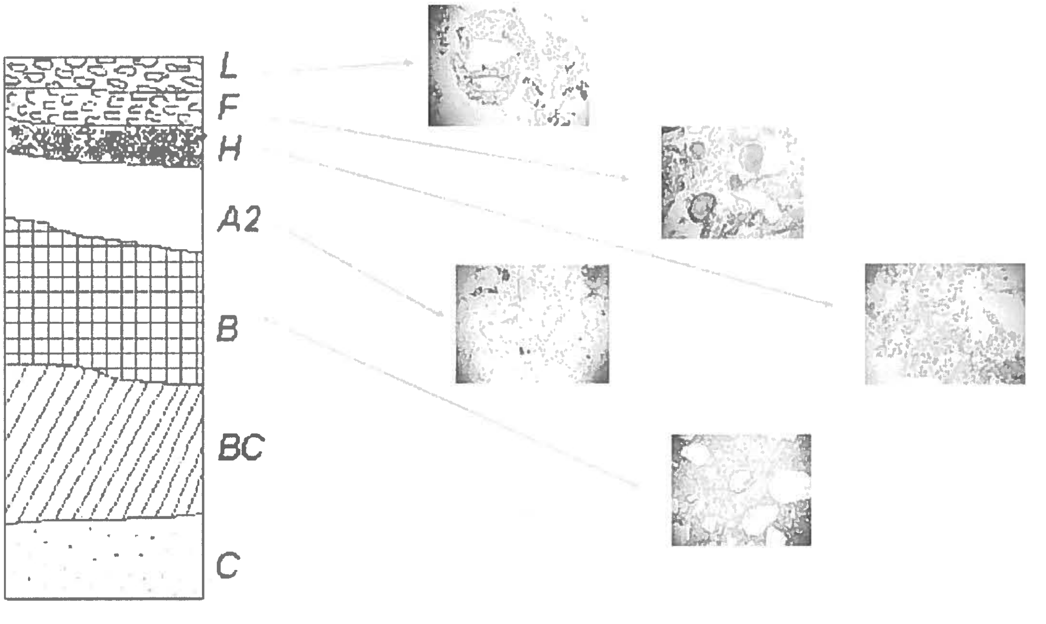

Figure 1. Morphological structure of podzol profile

The podzol horizon is built up by corroded grains of parental minerals with scarce inclusions of fungus hyphae and fine roots. Individual grains are coated with a fine brown film found also in hollows and cleavage cracks that arise from the release and oxidation of iron compounds from space lattices.

One distinctive feature of the microstructure of the illuvial horizon in the soils studied is a "classical" colloform appearance of organogenic films with abundant dehydration cracks. The colloform humus in the organic matter profiles is jelly-like because it is not mature enough ("condensed").

If the soils are considered successively along the catena, the thickness and density of organogenic horizons are observed to grow with increasing moisture. The soil fauna is most active in the litters of the iron-illuvial and humus-iron-illuvial podzols. They contain the largest amounts of excreta, particularly mite excreta (Fig. 2). Further along the catena, the number of mites decreases, but protozoan shells appear.

The thickness of the podzolic horizon also increases downwards along with the extent of mineral material corrosion. The lower portion of the catena in the illuvial horizon turns warm-grey, indicating groundwater moistening. More humus, which is mainly present as colloform-shaped cutans, is accumulated on the surface of mineral grains. Colloform matter commonly forms globular clods - evidence for their dominantly ferric composition.

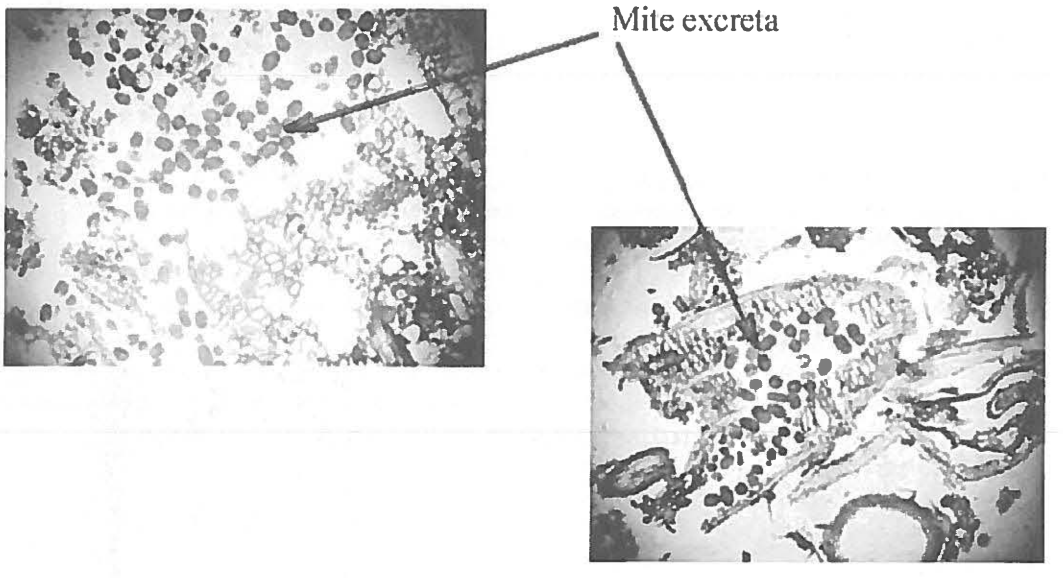

Figure 2. Excreta of soil animals in forest litter.

The structural integrity of the organic profile depends on the agreement between the morphological constituents of the complex, which, in turn, depends on the combination of environmental factors. Among the many factors responsible for the structure of the soil organic profiles studied the most important role is played by the position in the mesorelief, forest type and groundwater level.

The above data have led the author to conclude that:

1. The organic profiles in all the soils examined are of a raw-humus type. The soils differ in the degree of litter transformation and the amount of humus lost and retained by the illuvial horizon.
2. Vegetative residues are converted into humic matter rather slowly due to low biological activity and the dominance of fungal cenoses. This results in accumulation of organic matter on the soil surface and the formation of the soil litter.
3. The colloform humus in the organic matter profiles is jelly-like because it is not mature enough ("condensed").
4. Among the many factors responsible for the structure of organic profiles the most important role is played by the position in the mesorelief, forest type and groundwater level. The rate of mineralization and humification of plant material is the highest in the central part of the catena (given optimum moistening). As soil moisture increases or decreases, the conditions for litter transformation deteriorate.

Acknowledgement

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Primaeval forests along the Finnish-Russian border: natural pattern, present situation and protection prospects

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Introduction

The last westernmost huge primeval forest areas in the Eurasian taiga zone have survived only in the Republic of Karelia and in the Murmansk region . There are no such areas in other parts of Fennoscandia. Similar forests occur as very small fragments in northern Finland and Sweden in low-mountain landscapes. However, they have suffered a few selective cuttings in the past. These primeval communities are highly significant for North Europe as "biotic" and recreational resources.

Location and main natural patterns of forests

The territory along the Karelian part of the Finnish - Russian border has several types of landscapes :1) low-mountain north-taiga landscape dominated by spruce forests, 2) hilly-ridge denudation- tectonic landscape dominated by pine stands (in the north- and mid-taiga subzones), 3) hilly-ridge denudation- tectonic and morainic landscape dominated by spruce stands and 4) pine-dominated rocky landscape. At least two highly contrasting forest areas are located near the Karelian part of the Finnish-Russian border (Fig. 1).

1. Unique uneven-aged spruce low-mountain taiga (in and near the Paanajärvi National Park (NP).

Spruce stands account for about 85% of the forested area, rupicolous blueberry and fresh blueberry spruce stands clearly dominating. Forest cenoses were formed in a large burned-out area at least 350-400 years ago. The uneven-aged structure of stands is now being formed. The average age of stands varies from 160 to 200 years. It is the main spruce generation in terms of wood stock. However, the trees that build up the upper storey vary substantially in age from 80 to over 270 years (maximum age reported so far from mineral soils). This evidence shows that the formation of the absolutely uneven-aged structure of stands, a basic indication of climax forest communities, is gradually coming to an end. The forests are poorly productive (average quality class is V, 6 and wood stock at the age of 120-140 years are 115 m^3/ha.

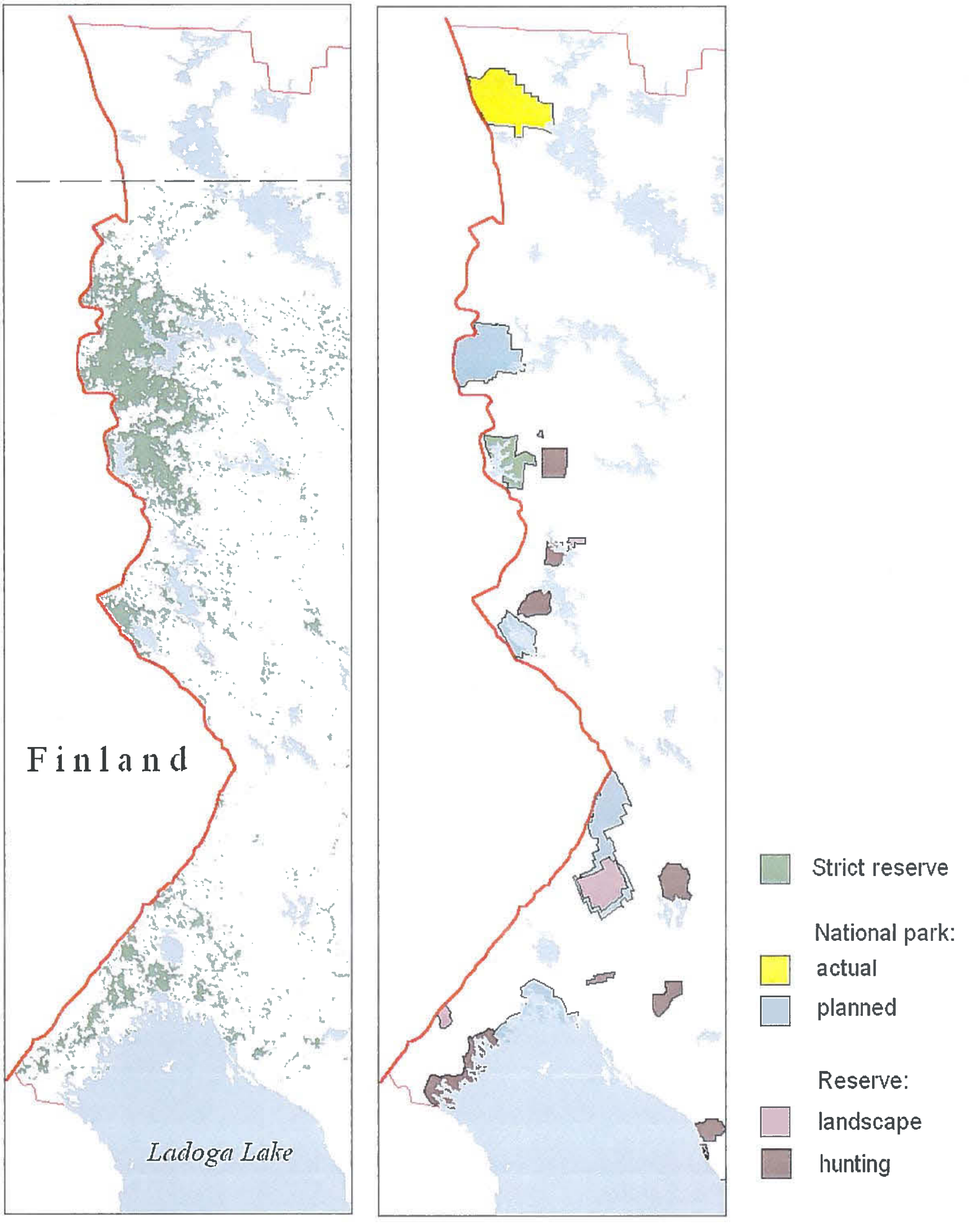

Fig. 1. Left: High density coniferous forests along finnish - russian border (According to satellite image data).Right: Nature reserves.

Spruce stands are practically unaffected by selective cutting. In Karelia, these spruce forests, including spruce-birch forest-tundra communities, are unique. They grow in extreme low-mountain environments with thin soils in the coldest part of Karelia. They are floristically specific, highly sensitive to human activities (or atmospheric pollution), capable of regenerating naturally after clear cutting and are resistant to recreational impacts).

2. Typical even-aged pine taiga in a denudation-tectonic landscape (Kostomuksha Strict Nature Reserve and Kalevala National Park to be established).

Pine stands cover about 85% of the forested area. Large pine stands with small spruce fragments, growing dominantly along the hydrographic network, are common. The forest communities that occur in this territory represent almost all forest types known in Karelia. Generally speaking, the territory has a topo-ecological chain of forest phytocenoses most characteristic of East Fennoscandia. Phytocenotically, the forest communities discussed are typical of the north-taiga subzone of East Fennoscandia. The composition of their stands (absolute dominance of conifers) and the living ground cover (occurrence of common plant species) are typical. Abundant spruce undergrowth, or a second spruce storey, is present beneath the canopy in about 1/2 of rupicolous blueberry and fresh pine stands. There, pine does not regenerate. As a result, pine is being gradually replaced by spruce. In nature, stable dynamic equilibrium between pine and spruce formations has been maintained by periodical fires.

Age of forests

Stands growing on most mineral soils vary in age from less then 100 to 220 and more years. The maximum age reported for some trees growing on the periphery of paludified habitats is estimated at 450 years. The age structure of stands varies considerably from one habitat type to another. For example, rupicolous pine stands commonly display at least 2-3 and more tree generations with ages ranging from 80 to over 300 years and wood stock varying substantially. Fresh blueberry pine stands are normally from 120 to 160 years, but some pine-trees are over 300 years old. In ravine spruce stands, some trees vary markedly in age, and several age groups are formed in terms of the number of trunks. The oldest age reported for ravine spruce stands is 270 years. However, 160 to 200 year-old trees dominate clearly in terms of wood stock. The forests discussed are productive for north-taiga conditions (average quality class is IV.5 and wood stock at the age of 120 to 140 years are 140 cubic metres/ha). Generally speaking, the territory displays a complete natural spectrum of forest cenoses ranging from unclosed plant groups growing in burnt-out areas to climax spruce stands existing in ravine habitats that can hardly be affected by fires.

Forest growth conditions are fairly uniform and favourable for both pine and spruce over most of the area. Considering that spruce is a shade-tolerant species, the area covered by spruce stands tends to increase owing to spruce undergrowth, a second spruce storey which penetrates the upper pine canopy. Rupicolous, sedge-*Sphagnum* and other types of habitats that are extreme with respect to forest growth conditions are an exception. However, the present-day area distribution of pine and spruce stands is basically due to the fire regime formed in the past millenium.

Modern forest cenoses thus represent different stages of pyrogenic successions ranging from pioneer plant groups occurring in open burned-out areas to relatively stable 300 year-old phytocenoses with at least 2-3 tree generations that have survived several fires.

Not less than 1/2 of forests growing on mineral soils were affected by selective cutting, low-intensity cutting being dominant. They did not have an evident effect on the structure of cenoses, but resulted in a higher percentage of spruce in areas where pine was cut down most intensely.

Other fragments of primeval forests survived: 1) to the north from Paanaijarvi NP, 2) to the south from Kostomuksha strict reserve and 3) between Tulos lake and border - in special boundary zone with width 2-3 km only. The forests around northern part of Lake Ladoga shore are absolutely secondary.

Current situation

The total area of primeval taiga along Finish-Russian border is 500 000 ha in the least. About 25 % are reserved now for national parks in accordance with government decision.

From south to north the situation is as follows:

1. In different variants, the Ladoga Skerries National / NaturePark to be established is expected to cover an area of 62 to 120 thousand hectares, about ½ being occupied by the Ladoga Lake aquatorium. Practically all the forests are secondary and are considered water-protective forests;
2. The active Tolvajarvi Landscape Reserve (44.5 thousand hectares). Half of its forests were cleared a few decades ago, and the main part of preserved forests are water-protective stands surrounding the lake-river system;
3. Koitajoki National Park to be set up (32.5 thousand hectares). Its forests were practically cleared a few decades ago.
4. Tuulos National Park to be established (38.5 thousand hectares). 2/3 of forests were cleared several decades ago. Primeval forests have survived mainly in the 2-3 km wide strip which extends along the boundary between Lake Tuulos and the border. The rest of preserved forests are water-protective stands around Lake Tuulos and on the islands.
5. Kalevala National Park (95 000 ha). It is the only large forest massif of commercial value in the protected areas to be established.

Conservation problems

After all, the only final decision on the establishment of a new park concerns Kalevala National Park.

The economic value of the last primeval forests is the main obstacle for establishment of new national parks. For example, about 7.5 mln/m^3 mature and overmature wood grow in "Kalevalski" planned NP only. The forest production from this area is worth hundreds of millions of US-dollars.

In general, the cardinal problem of projecting of nature reserves network is its optimisation not only on ecological, but also on economical criteria. The establishment of parameters of this network should implement as by a principle of "ecological sufficiency", and principle of territory "minimum". First principle guesses that dimensions of the area must provide normal functioning of the natural-territorial complex in the natural regime. Second demands the feasibility of minimum of this area because the organisation of nature protected territories eliminates industrial utilisation of natural resources. It entails by a straight and usually very large economical damage, which one is necessary to attempt to minimise on the initial stages of organisation of protected object.

There are two alternative versions of forest use - traditional industrial development of wood resources with a large-scale clear cutting or the use of landscape as a national park. The methodical approaches to economical calculations of these scenarios of nature management have not been developed yet. Apparently, these assessments should be based on the "what we will gain and what we will lose" principle. In principle, it is easy to calculate the cost of wood resources including in money's worth . However, detection of the economical benefits of utilisation of ecological, biotic and recreational resources (functions) of forests are integrated to principal methodical problems. These resources (functions) are difficult to evaluate in cost expression and to compare them to the effect of the use of timber.

Contrasting boreal forest landscapes in the central border region of Finland and Russia

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Abstract

This study describes landscape level forest conditions along the Finnish/Russian border by Viena Karelia, which harbors some of the most extensive old growth forests in Europe and contrast starkly the neighboring fragmented forest landscape on the Finnish side of the border. The Vienansalo forests have not known intensive, modern forest management practices until recently, and thus their current and future economic, conservation and ecological research potentials are high. A fifteen year time series of Landsat images documents phases of land-use change, including an increase in the rate of industrial clear-cutting at the periphery of the Vienansalo region's core. Our field and remotely sensed surveys also suggest that the Vienansalo forest region will evolve forests of three distinct types: near-natural forests in the core Vienansalo region if the area will be protected, a patchwork belt area of multi-aged forest compartments created by a mix of Karelian and Finnish silviculture practices, and an area to the east characterized by the unmanaged maturation of large Soviet era cut-blocks.

Introduction

Some sections along the border region between Finland and Russia appear to show remarkably well in satellite imageries because there is a sharp discontinuity between two types of forest landscape between the two countries. In the Finnish side, vast clear-cuts and young regeneration stands extend to the border while on the Russian side, major extensions of old-growth forests are still present. This contrast was first noted in the early 1980s in a couple of polemic papers (Punkari 1984a, 1984b), which were based on the interpretation of low resolution satellite imagery. On the southern part of the border region near the former Finnish Karelia, the Russian side forests are to a great deal old managed forests which have been left to grow freely during the post-war period. In the middle and the northern border area relatively large extents of near-natural forest landscapes are also present, particularly in the region of Viena Karelia. With their sharp contrast to their neighboring Finnish counterparts, the presence of the two types of forest landscape can be considered as a unique ecological experiment and a special case for conservation (Lindén 2000).

In this paper we apply space-born Earth-observation data and field documentation to give a landscape level description of forests in this unique border belt. We focus on the Vienansalo region near the city of Kostamuksha in the Karelian Republic, Russia Federation. The extensive Karelian near-natural forests of this region have escaped intensive, modern forest management practices until recent times. We hope that by providing a broad description of the forest conditions found in this area, we will enhance the sustainable utilization of this exceptional landscape for cultural, economic, conservation and ecological purposes.

Material and methods

Study area

The region addressed in this study is located between the latitudes 64° to 65° North and longitudes 29° to 32° East (Figure 1). The border of Finland and Russia crosses this area in almost north-south direction. Most of our analyses refer to the Vienansalo 'core' area (marked by a 'C' in Figure 1) which has an extension of approximately 1500 km^2.

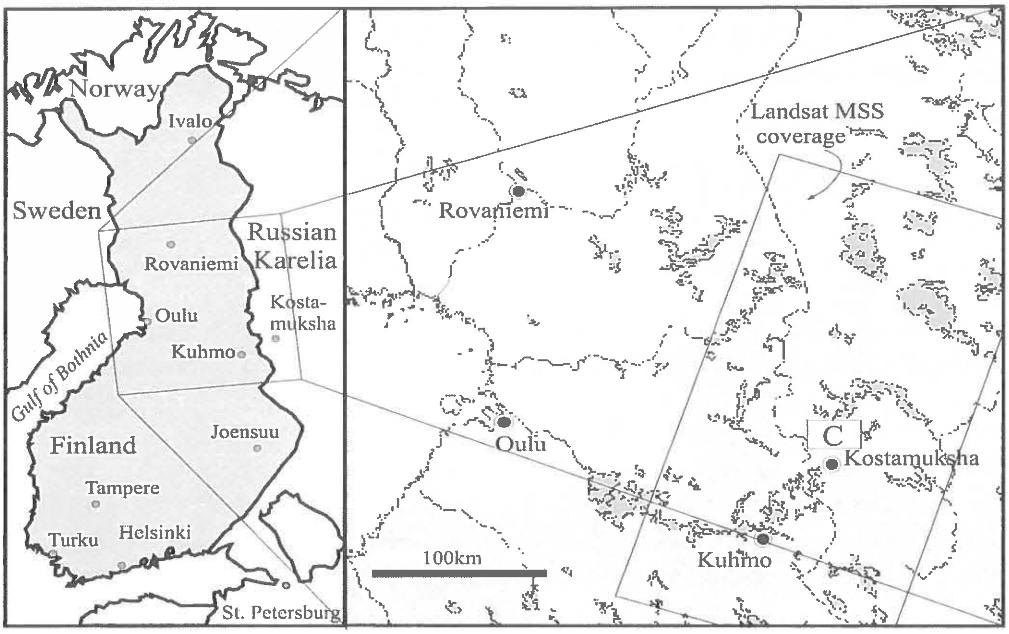

Figure 1. Location map of the region addressed in this study. The tilted quadrangle shows the area of Figure 2 and 'C' identifies the Vienansalo core area.

Climatically, the study region belongs to the middle boreal zone with long cold winters and dry cool summers. Western and south-western winds prevail, the average annual temperature is approximately one degree Celsius, annual precipitation is 550 mm and the average snow depth in February is 70 cm (Atlas of Finland 1987). Prequaternary rocks in the study region mainly include granitic veins in basement gneiss, which are in most places covered by gravelly and sandy ground moraine, glacifluvial sands or peat (Atlas of Finland 1990). Local geomorphology is characterized by glacigenic landforms consisting drumlin fields and fine sediment plains in esker and sandur formations (Atlas of Finland 1990, Quaternary deposits...1993). The relief is shallow and gentle, with the highest elevations reaching 300 meters above sea level. The surface elevation of the major lakes is 100-200 meters above mean sea level, and relative elevation differences at the local scale usually vary close to 50 meters. The national border follows the Maanselkä drainage divide, separating the headwaters of the two major water systems flowing to the Baltic Sea and the White Sea/Arctic Ocean. The Russian side of the border belongs to the Viena Kemi's river basin, and the Finnish side comprises sections of both Kemijoki and Oulujoki river basins. Lakes are abundant in both sides of the border, the most important including Lentua, Änättijärvi and Ontojärvi on the Finnish side, and Ylä-Kuittijärvi, Kiitehesjärvi, Venehjärvi and Luvajärvi in Russia. The major rivers in the region include the Vuokkijoki, Venehjoki, Tollojoki and Kivijoki.

The biogeographic conditions have favored the formation of extensive coniferous forests and scattered small peatlands. Scotch pine (*Pinus sylvestris*) is the most abundant tree species in most areas. Norwegian spruce (*Picea abies*) occupies stands in valleys and is also common in those areas where the soils are formed of fine-textured deposits. Birch (*Betula pubescens*, *B. pendula*) and aspen (*Populus tremula*) are common in mixed forests but do not form pure deciduous forest stands beyond human-disturbed areas. Scattered small mires are frequently found in valleys between the shallow hills while some flooded swamps occur in river margins and along lakeshores. The flora and fauna of the region represent species assemblages of poor forest and mire types, including species typical to both middle and northern boreal zones.

The human impact on the Russian side of the border is characterized by three types of activities: forest use, agriculture and mining. The largest population center in the region is the town of Kostamuksha, which was mainly constructed in the 1970s and has a population of 31,000 inhabitants. The city was established to support the exploitation of the large iron ore deposits that were found in the region. The industrial complex includes a large open mire area with high waste mounds, an extensive dammed lake and a large ore processing complex. Other population centers relevant to the Vienansalo core area include the traditional Viena Karelian villages of Vuokkiniemi, Venehjärvi, Tollonjoki, Vuonninen and Latvajärvi. Vuokkiniemi has 500 habitants, while the rest of the villages are occupied by only a few families. Conservation efforts in the region include the Strict Nature Reserve Friendship (see e.g. Lindholm et al. 1997) with its major component being the Kostamuksha Nature Reserve (Kostamuksha zapovednik, 47,569 ha). This reserve was founded in 1983 for the conservation of wild reindeer (*Rangifer tarandus fennicus*) populations and to compensate for the environmental damage the ore mine was to bring to the surrounding areas (Tynkkynen 1999). The Vienansalo forests are being considered for inclusion within the planned Kalevala National Park and since 1996 it has been temporarily removed from official forest management plans while delimitation of the proposed park boundaries are discussed. Despite the moratorium, forestry activities have continued in these areas, as we will discuss in a later chapter, and the area has not been removed from forest lands available for the calculation of annual allowable cut (Mr. Boris Kashevarov, personal communication in August 2000). The Vienansalo forests have also been included in a proposed 'Green Belt', an effort driven by non-governmental organizations to link patches of preserved forests along the Finnish-Russian border into a major protection system with high ecological value.

Data sources and analysis

The study is based on field surveillance and the use of space-born Earth observation imagery and cartographic data (Table 1). The digital spatial data analyses were conducted in the Laboratory of Computer Cartography of the University of Turku using image processing (ERMapper, Erdas Imagine) and Geographic Information System (Arcview) software. All the digital spatial coverages were rectified into zone 4 of the Finnish coordinate system (Kartastokoordinaattijärjestelmä or KKJ). Satellite data covering a time period of 13 years were used in the overall characterization of the landscape and in a time series analysis. Enhanced image products (color composites, hybrid ima-

Table 1. Principal Earth Observation and cartographic data used in the study

Category	Acquired / published	Description
Satellite image	19.08.1985	Landsat MSS path 187 row 14
Satellite image	08.06.1988	Landsat MSS path 187 row 15
Satellite image	12.08.1994	Landsat TM path 187 row 14
Satellite image	19.05.1998	Landsat TM path 187 row 14
Satellite image	03.08.1994	Spot XS path 077 row 216, 217
Satellite image	03.08.1994	Spot pan path 077 row 216, 217
Topographic map	1982	Russian map sheet "Kostamuksha" Q–36-121-A,B, scale 1: 50000
Road map	1996	Karjala. Motoring road map. Scale 1: 8 mill. Karttakeskus.
Digital base map	1998*	PerusCD. Digital base map of Finland (1:20 000)

of two satellites) were prepared to facilitate visual interpretation of the landscape features. The elevation contour lines of the Russian topographic maps (10 m contour line interval) were digitized and gridded to create a digital elevation model.

Field work included extensive reconnaissance field surveys in the study region during the years 1997-2000, consisting of five field excursions of a few days duration. During these visits, virtually all trafficable roads and their nearby forests in the core study area were explored to assist the overall interpretation of the satellite images. Field plot locations were recorded on printed satellite images and by GPS (Global Positioning System) coordinates. Approximately 150 areas were delimited in the satellite images and documented in the field with simple descriptive information of their vegetation. Detailed surveys were made in 43 forest sites, which represented a subjective selection of all the major forest and mire types in the region. In these places, three observation points were established in 30 m intervals for relascope surveys, identifying the tree species counting separately healthy and standing dead individuals. The vegetation in each point was also described, regarding the forest site type and the canopy, shrub, dwarf-shrub and ground layers.

Results

Regional landscape pattern and change

The border between Finland and Russia is clearly discernible in the 1986/1988 Landsat MSS mosaic (Figure 2). Generally, the Russian side has larger and more uniform landscape entities than the Finnish side. Extensive clear-cut and regeneration areas prevail in the

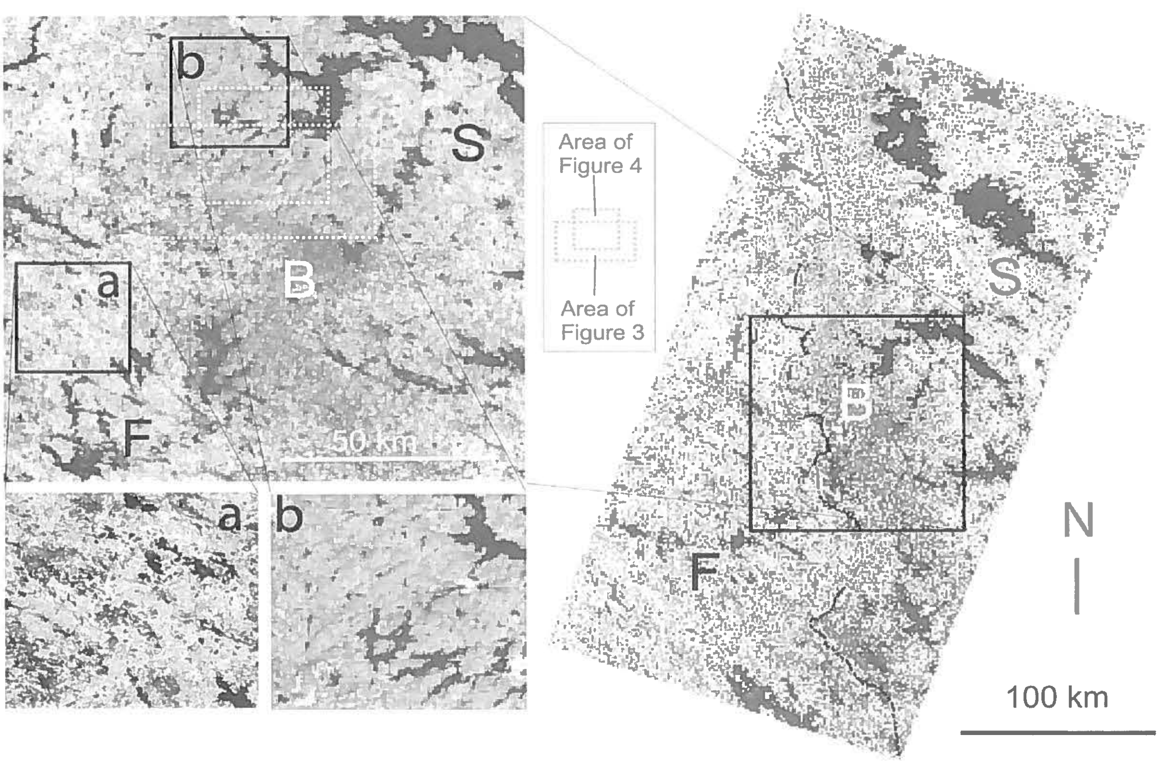

Figure 2. Large-scale view of the central border region between Finland and Russia on the basis of data from Landsat MSS (mosaic of images from the years 1985 and 1988). Black areas are water bodies, dark gray areas are mature forests and light tonalities indicate clear-cut areas, young forest stands and other non-woody ground cover. The border between Finland and Russia is shown with dotted line. S = area dominated by Soviet clear cuts, B = near-natural border forests, F = Finnish managed forest landscape.

east ('S' in Figure 2), representing Soviet forest felling that expanded on a broad frontier in a progressive manner. The border belt ('B' in Figure 2), on the Russian de, contains major extensions of old-growth forests with smooth textured forest landscape pattern interrupted by water bodies and mires (Figure 2a). On the Finnish part of this image ('F' in Figure 2), a patchy sharp-edged landscape prevails (Figure 2b), composed of recent clear-cuts, even-aged regeneration stands, young plantation stands and scattered remnant patches of old-growth forest.

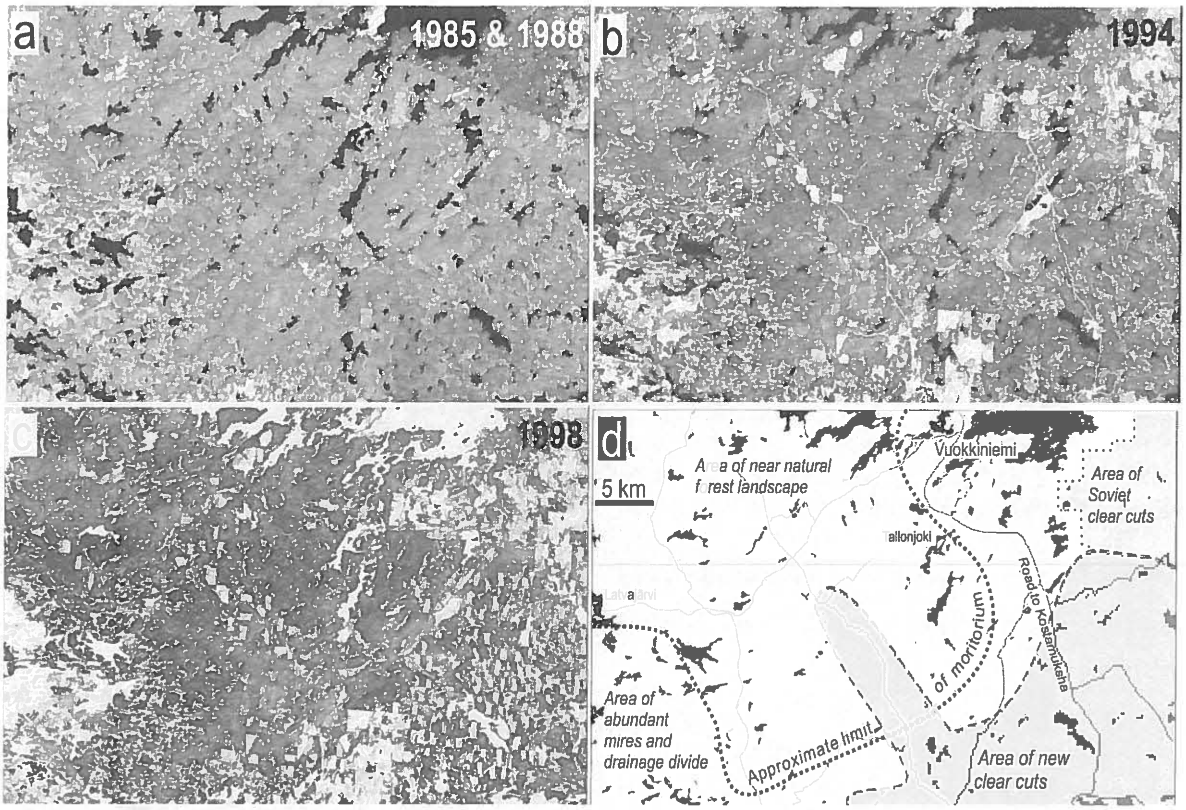

Figure 3. Changes in the Vienansalo core area in satellite images from the 1980s and 1990s. The overall interpretation key for the imageries is the same as in Figure 2. The image from 1998 is a spring scene where snow covered lakes and clear cut areas are white against the dark coniferous forests. Panel 'd' distinguishes some major landscape types in the region.

The southern part of the Vienansalo core area has been subjected to several phases of forest clear felling during the recent years (Figure 3). In the late 1980s the region was a vast forest area but the late 1994 and 1998 landscapes are characterized by heavy intrusion. Multiple small cutting areas can be found along the roadsides amidst the larger matrix of old-growth forests. Our most recent satellite image (Figure 3c) is a spring scene, with snow covering lakes and clear-cuts. It shows a chess-board-like distribution of clear felled forests in the south, where relatively fertile soil areas support spruce dominated forests. The clear-cuts of this region have a typical quadrilateral form, which make visible the kvartal system of Russian forest management. Kvartals with a size range of 0.5-1 km to 0.5-2 km have been the basic unit used in forest inventory and management planning in Northwest Russia. Road extension into this area (compare Figures 3a and 3b) suggests that fellings were poised to penetrate into the very center of the Vienansalo area prior to the moratorium decision. However, evidence from our August 2000 field visit suggests that forestry activity in the area may increase since numerous new logging roads have appeared radial to the main NW trunk road.

Forest landscape types in the Vienansalo core area

Near natural forests

The relatively natural condition of the Vienansalo forests is confirmed by Earth observation images where varying border and ecotone types are found in areas when one woodland type changes to another (Figure 4). These limits may be gradual or

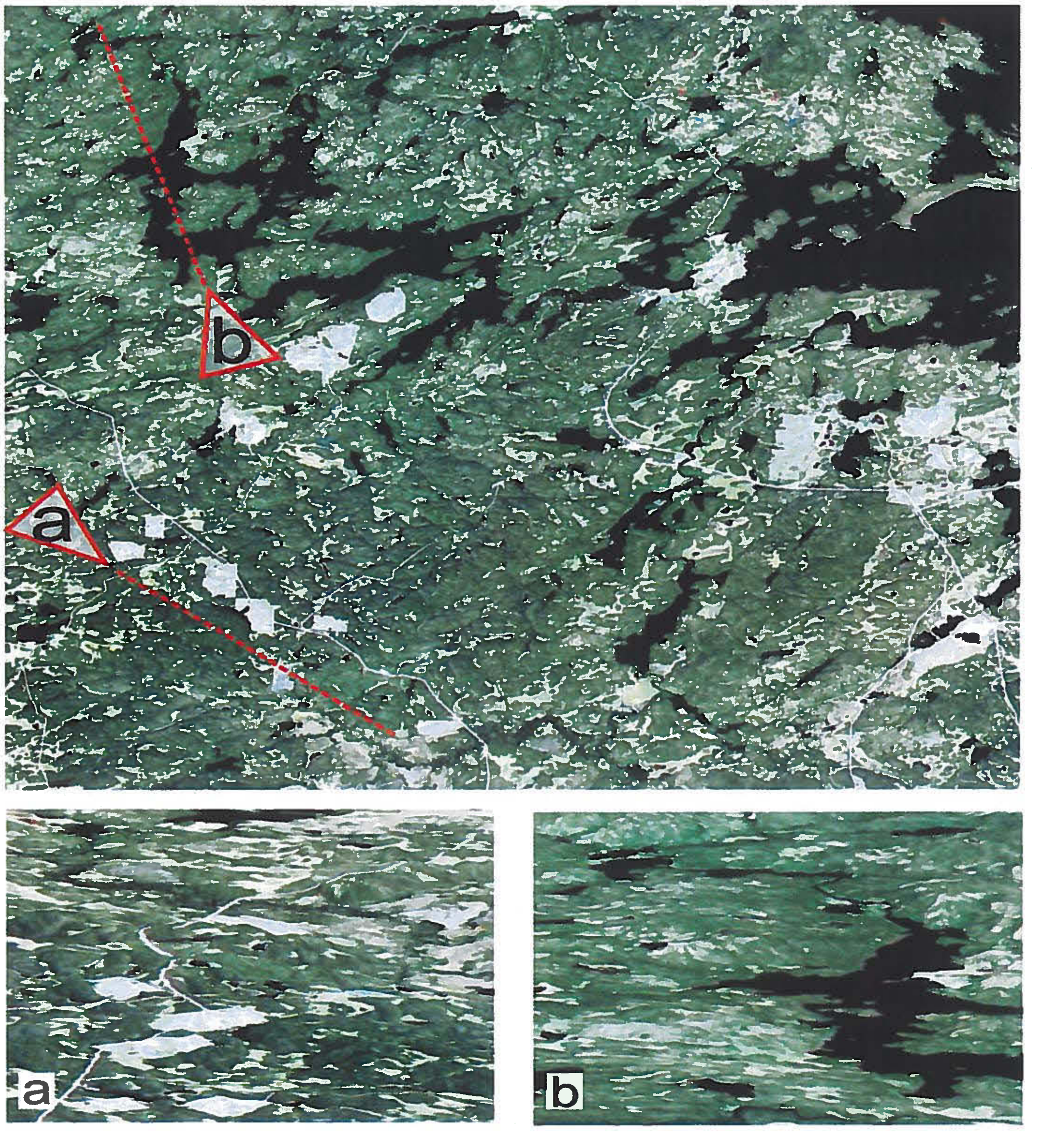

Figure 4. Details of the near natural forest landscape of the Vienansalo core area; a color composite hybrid image based on data from Landsat TM (RGB = principal components 1,2,3 from the bands 4, 5 and 7), and Spot panchromatic (intensity layer). Dark green areas are spruce or mixed forests, lighter green areas are pine forests, mires are yellow, clear-cuts are light pink or light green depending on age, roads are white and lakes and rivers are black. Triangles in large image show direction of 3D perspective image subsets a & b, which were created by draping the satellite image above over a hill-shaded digital elevation model. Subset a looks south along the main road into the 'core' area. Note the mire systems in the foreground valleys and the lighter green (pine) forests in the distance. Subset b looks north over Lake Venehjarvi. Note the lightening of the green color with elevation, as spruce forests change to pine dominated forests along the hill-tops.

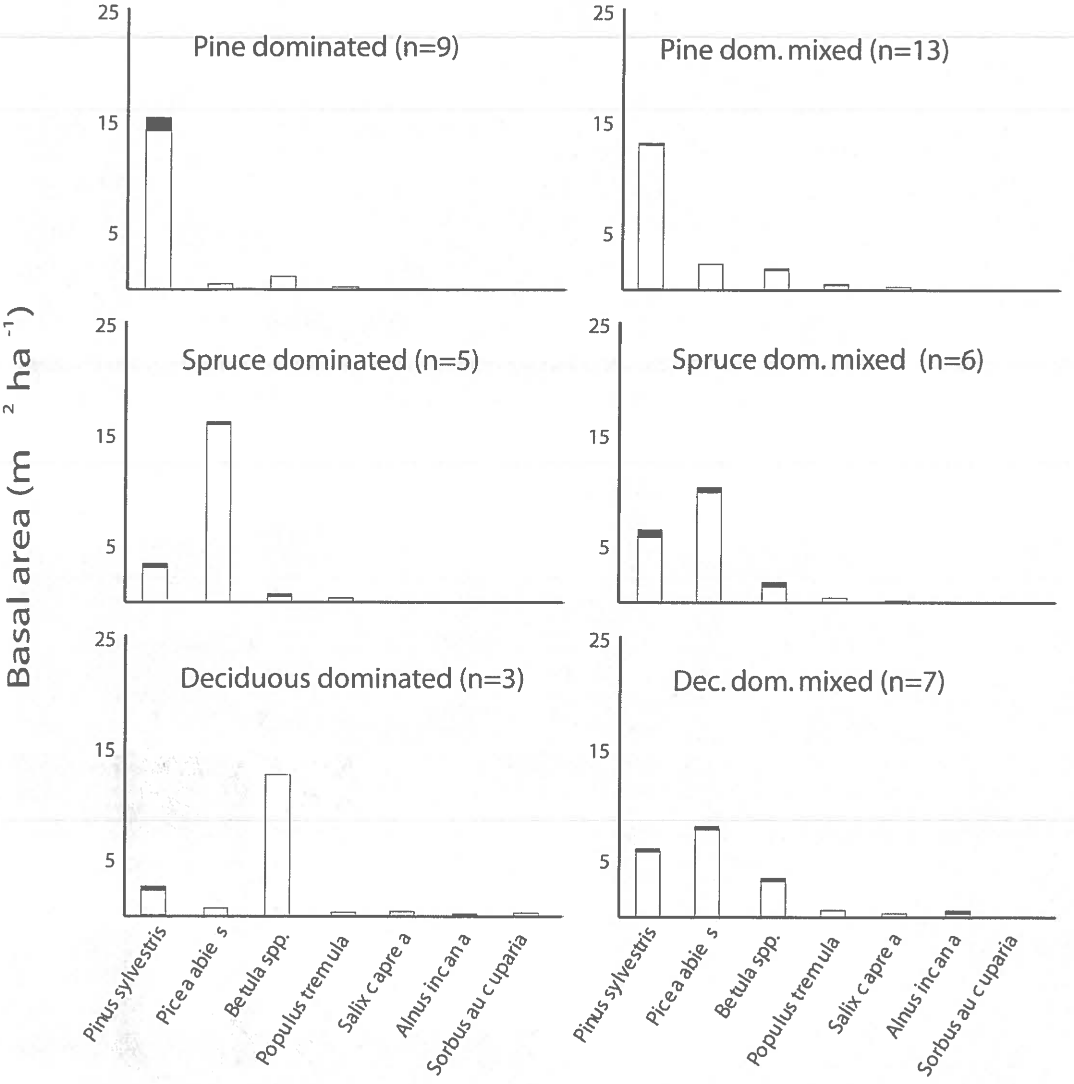

Figure 5. Forest structure as based on basal area in different forest types of the region. Black tops in each bar indicate dead individuals in standing volume. n = number of forest sites studied, in each site three relascope surveys were conducted.

sharp, corresponding to fire disturbance and local edaphic site factors such as topography, geomorphology and soil texture. Pine dominated forests are usually found on sorted sedimentary soils and on hilltops (Figure 4b), and spruces occupy valleys and finer-textured soils (Figure 4a). Deciduous trees are common in river margins and other areas where human disturbance has been intensive. Most of the forest sites studied were mixed and presented characteristics of self-thinning, as evidenced by frequent dying and dead trees in the standing volume (Figure 5). Usually, the trees are also notably uneven sized, gaps are common, and coarse wood debris on the ground abounds. Late successional features are apparent in many stands, i.e. with large aspens and pines present, yet with younger trees mainly consisting of spruce (Figure 6a-c). Charcoal was frequently found in the humus and topsoil of all forests, and multiple fire scars on old pines confirm the re-occurrence of fire in these woodlands.

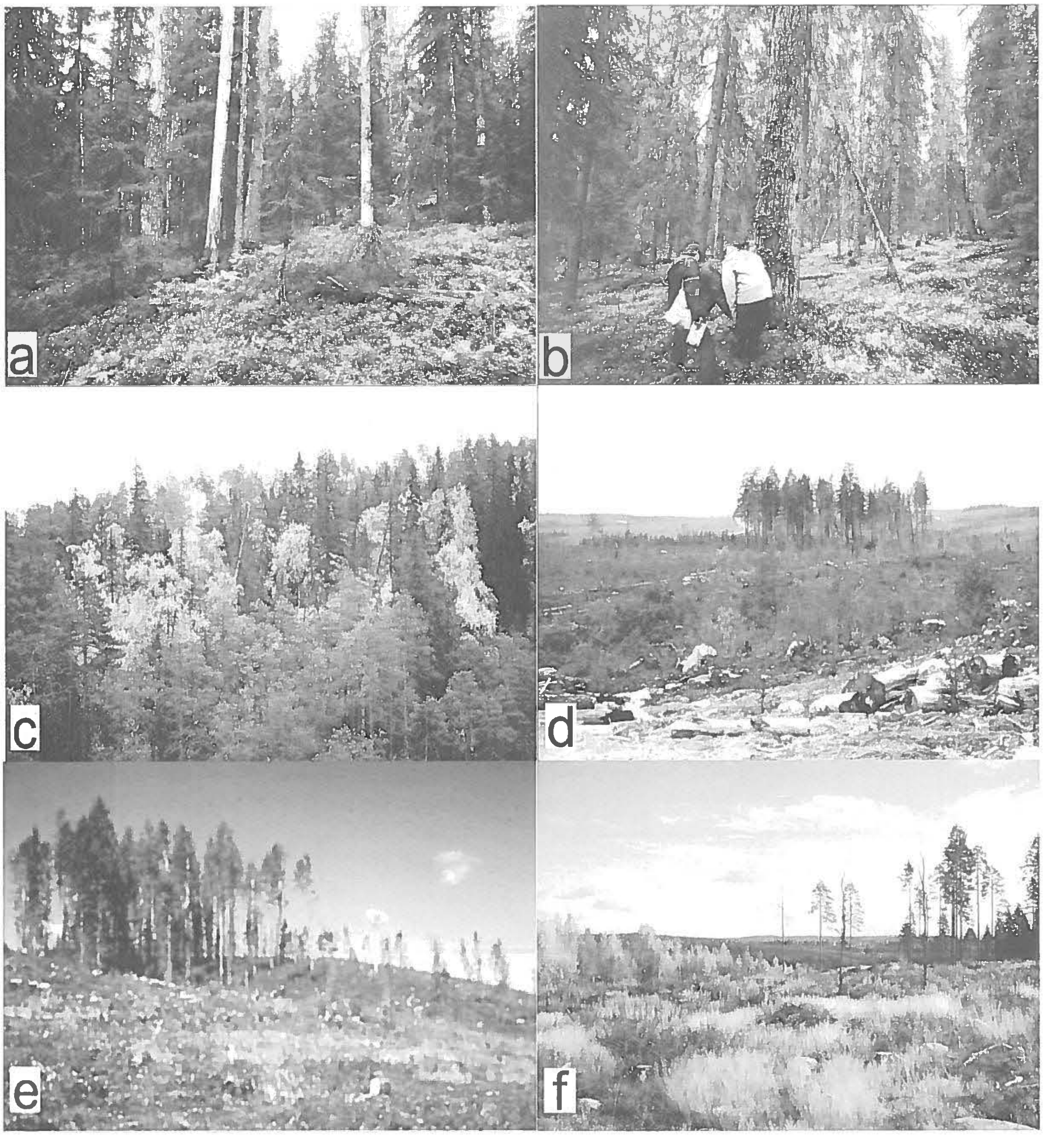

Figure 6. Pictures illustrating details of the Vienansalo forest region; a. old pine-rich mixed forest, b. spruce dominated mixed forest, c. mixed forest landscape of successional nature, d. large-scale Soviet clear cuts near Kostamuksha, e. Russian clear cut area with remnant trees of the understorey and an untouched forest island, and f. Russian/Finnish clear-cut prepared for forest regeneration.

Although the above characteristics confirm that much of the woodland landscape structure expresses natural condition and processes, these forests are not untouched by humans. Scattered stumps resulting from selective cutting are abundant in many places, especially near waterways. In addition, pine resin tapping has been practiced at an industrial scale from the 1920s and it has been obligatory prior to final felling until the late 1980s (Strakhov & Pisarenko 1996). The commonality of tapped pines throughout the Vienansalo region suggest that massive forest felling operations were planned for the area in the late 20th century.

Soviet clear-felled areas

Vast clear-felled lands from the Soviet era are present in the eastern part of our study area (Figure 2). These areas are extensive open landscapes that extend over hills and valleys, interrupted only by thin remnant forest patches by rivers, brooks and lakes, and by scattered island-like untouched tree groups (Figure 6d). Abundance of previously suppressed trees that are left as the de facto canopy is a characteristic feature of Russian clear-felled areas (Figure 6e) and coarse woody debris is often found in large quantities. Wood transportation from the forest has been performed in the form of tree-length hauling, which has disturbed the forest undergrowth. Especially near sawing sites, logging waste and abandoned wood piles are common.

In none of the Soviet clear-felled areas that we visited did we record regeneration silviculture measures, rather they were as a rule left to regenerate naturally. The former undergrowth trees often do not show obvious signs of increased growth speed, even in those areas where the felling operation took place more than a decade ago. Rather, the forests regenerate naturally by mostly broad-leaved species (birches, aspen) that often seem to form low-value stands where polycormic trees and sprouting bushes are common. In these areas, the forest develops toward a mixed forest type characterized by a remarkably patchy distribution of trees, including both dense thickets where self-thinning takes place and areas of relatively sparse wood cover.

Post-Soviet clear-felled areas

In the late 1990s, logging operations near the border have been practiced by mainly Finnish/Karelian companies. Logging areas within an old growth forest matrix have given rise to an archipelago of clear-felled areas surrounded by near-natural primary forest (see Figure 3b & c). Modern harvesters have been used in the logging where also undergrowth trees have been removed before mechanical soil preparation and nursery stock seedling plantation (Figure 6f). Also burning has been used to prepare some soils for the planting. Waste wood of rotten stems is abundant and drainage dikes are rarely encountered. Another contrast to typical clear-cut areas in Finland in the 1990s is the occurrence of patches of intact forest (seed patches) left inside the clear felled areas.

Discussion

Contrasting forest landscapes near the border

We have utilized satellite imagery to illustrate details of one of the most dramatic vegetation frontiers in Northern Europe. This frontier is mainly created by differences in the utilization intensity and methods of forest management between two countries. Due to major changes in forest management and use in the Russian Karelia, the patterns documented in our Earth observation imageries will soon disappear.

Anthropogenic disturbance has a long history in Fennoscandian forests. For example, the clearing of the most productive land for agriculture during the 19th century has significantly altered the boreal forest landscape. Forest fire frequency has fluctuated due to the human influence and it has favored the growth of broad-leafed trees over vast areas in Fennoscandia (Heikkinen 1988, Lehtonen et al. 1996, Parviainen 1996). The extraction of tar, saw wood and other forest products has also been intensive in many forest areas, yet their impact has never been as comprehensive as that of the modern forestry. During the late 20th century, Finnish forest management has relied on the use of particularly intensive management techniques including clear-cutting, soil preparation, artificial regeneration of trees, thinning, optimal rotation of stands, drying of peatlands and fire suppression. The cumulative effect of these techniques at the landscape level (Sigurdsson 1999) is now clearly discernible in space-born earth observation data.

The border region addressed in this study has witnessed a variety of forest use practices according to different cultures but it still contains some extensive near-natural forest areas. Given the baseline conditions described here, some implications for future forest succession become apparent. While the intensely managed Finnish border forests will eventually grow up to larger cohort of mature coniferous stands, the Russian border forests are likely to evolve along three distinctive paths. Some of the forests will escape logging due to nature protection, and we anticipate two kinds of forest succession for the clear felled areas in the Vienansalo region. The Soviet clear-felled areas will grow patchy mixed forests with abundant woody debris. Another type of succession will result in those areas which have been clear felled and planted according to Finnish standards modified by Russian silviculture regulations, but which may suffer from lack of post-harvesting silviculture measures. Since licenses for forest land are commonly not granted for longer periods than 5 years (Piipponen 1999), the incentive for long term management of the planted compartments is absent. In consequence, replacement plantation, elimination of undesired broad-leaved trees and artificial thinning are not likely to occur until the Russian forest sector is reformed and land tenure issues are addressed.

Turbulence in forest management in Karelia

During the period from the 18th to mid-20thth Centuries, Karelia was a poorly developed region of the Russian periphery. Local processing of timber was small-scaled until industrial saw mills began to develop. Later, northwest Russia developed an increasing strategic role in the Russian forest sector. In the mid 1990s about half of the Russia's pulp and paper products and about one fifth of the sawn goods were produced in this region (Anon 1996). The most important forest use practice was logging of mature and overmature coniferous forests. The volume of annual wood harvested in the Republic of Karelia was at its highest at the end of the 1960s, when about 20 million m^3 were harvested annually. It was quite common that the annual allowable cut at this time was exceeded by 20-30% in old coniferous forests, whereas about 60% of the hardwoods were left unharvested (Piipponen 1999).

Related to the political turbulence in the transition from Soviet to Russian state, the forest industry sector in Karelia has undergone drastic organizational changes, including ministerial reorganizations, corporatisation and reorganizations of regional sectors and enterprise units (Piipponen 1999). Under the current conditions there are severe malfunctions in the institutional setting impeding the attempts by forest industry actors to restructure towards a better capability to function in international high quality- and certification-oriented forest product markets. This situation is problematic from the point of view of sustainable forest management and biodiversity conservation. Although forest regulations in Russia contain strong of biodiversity protection measures the forests suffer from high rates of illegal logging and negligence (Piipponen 1999).

In terms of geographic location and forest resources, Karelia could develop a competitive forest industry comparable to those of the Nordic Countries. This requires that the wood should be largely processed in the region. Only in this way can capital for re-investment (i.e. silviculture) be accumulated. However, a significant decline in timber harvesting by Karelian firms has taken place since the beginning of the Perestroika in 1986 (Piipponen 1999), which has strongly favored foreign companies working in the area, particularly Finns. Finnish forest companies have been quick to purchase logging rights to any mature forest area, the institutional vacuum and subsequent lax controls existing in Karelia making it possible for them to obtain cheap wood supplies. The opening of new possibilities to log wood from Russia was particularly welcomed in Finland because most mature forests in its own border region had been already cut and conservation pressures concerning the remaining ones was increasing. The possibility to log on the Russian side may have been considered by some as a rare opportunity that should be utilized as fast and comprehensively as possible, realizing that public opinion might put a stop to the whole log removal activities in the area (Tynkkynen 1999).

Our field observations from the Vienansalo region evidence a high rate of cutting during the late 1990s and booming round wood export to Finland. Modern harvesters worked almost uninterruptedly and only non-rot parts were selected for their transportation to Finland. Finnish timber trucks constituted the most common type of vehicle on some roads of the region and even some significant road maintenance and construction work was conducted by timber companies.

In spite of these developments, the Vienansalo region still possesses a unique opportunity to combine economic development with the protection of an ecologically and scientifically important forest landscape (Lindén et al. 2000). Wood harvesting should be directed to areas of low natural and cultural conservation value and avoided in areas which have a high value for biodiversity conservation or which constitute part of a major undisturbed forest matrix. The unique values of these forests as a biodiversity store and landscape-level research area are significant and their potential as an European level tourist attraction is apparent. Two questions remain. Can and will the Karelian and Russian forest sectors restructure quickly enough to embrace ecologically and socially sustainable forestry? The corollary of this is, of course, whether Finnish (and other European) actors are motivated to participate the sustainable development in this region through economic investment and political pressure.

Aknowledgments

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Structural characteristics and diversity of natural, selectively cut and managed old Pinus sylvestris -dominated forests in Kuhmo

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Introduction

Structural heterogeneity of forests has become an important factor both in the research and management of forest ecosystems (McComb et al. 1993, Angelstam 1998, Zenner and Hibbs 2000). This is because the structure of tree stands defines their habitat characteristics, thus directly influencing the diversity of forest-dwelling organisms. Structural complexity of tree stands also affects the pattern and rate of important ecological processes, like the activity of decomposing organisms, and pathogens and pests causing fine scale disturbances. Quantitative descriptions of structural characteristics of natural forests, and the factors shaping them, is needed to outline the silviculture and management practises that would restore structural patterns typical of natural forests (Fries et al. 1997, Angelstam 1998, Kuuluvainen et al. 1996). However, at present we lack quantitative descriptions of structural heterogeneity of natural forests, and how they differ from managed forests.

The purpose of this study was to quantify and compare structural diversity characteristics of old *Pinus sylvestris* -dominated forests in Kuhmo. The studied old (age > 100 years) *Pinus*-dominated forest classes were (1) natural forests, lacking any signs of human influence, (2) selectively cut forests, which have developed a long time without human intervention, and (3) managed forests, which are old selectively cut forests treated to become production forests.

Material and methods

The research area is situated in the mid-boreal vegetation zone in Kainuu, eastern Finland (63°45'-64°15'N 29°00'E). The length of growing season is 140-145 days and the temperature sum is 900-1000°C (5°C threshold). Annual precipitation varies between 650-700 mm. The bedrock is composed of granite and gneiss. The area is located in a watershed area, 200-300 m above sea level.

Both shifting cultivation and selective logging was common in the forests of the study area until the beginning of the 20th century. In selective loggings only the most valuable large timber trees were harvested. In the 1960's and 70's large areas of forest were clearcut. However, in Kuhmo there are still considerable areas of natural or near-natural (old selectively cut forest) left. The field work was done in the lands of Finnish Forest and Park Service in southern Kuhmo and in the Ulvinsalo strict natural reserve. The criteria for selecting forest stands were that in the dominant tree layer trees were over 100 years of age and *Pinus sylvestris* was the dominant tree species (based on basal area), and the site was the medium fertile *Vaccinium-Myrtillus* –type or the dryish *Em-*

petrum-Vaccinium -type. Stand age maps of the Forest and Park Service and aerial photographs were used in locating suitable forest stands and stands filling the above-mentioned criteria were sampled in the order they were found in the field. The sample consisted of 32 plots, 5 in natural forests, 17 in selectively cut forests and 7 in managed forests. The sample sizes reflect the abundances of these forest groups in the study area. The age range was in natural forests 120-184 years, in selectively cut forests 102-175 years and in managed forests 104-144 years.

The sampling unit was a plot of 20 m x 100 m, which was randomly located in the forest stand, with a restriction that no part of the plot located closer than 30 m from stand edge. All living and dead trees were measured within the plot. However, a larger sampling area of 40 m x 100 m was used for *Pinus, Picea* and *Betula spp.* with DBH>40 cm, for *Populus tremula* with DBH>15 cm, and for *Salix caprea, Alnus incana* and *Sorbus aucuparia* with DBH >10 cm. For the measurements the plot was divided into 10 m x 10 m quadrates.

Results and discussion

The volume of living trees was highest in natural forests (mean 225,6 m^3/ha, 181,9-294,6 m^3/ha) and old selectively cut forests (mean 246,4 m^3/ha, 194,8-351,6 m^3/ha), and lowest in managed forests (mean 159,7 m^3/ha, 145,0-178,8 m^3/ha). Based on volume, *Pinus* and *Picea* were the dominant tree species in all forest groups, but the proportion of *Picea* and deciduous trees was much higher in natural and selectively cut forests compared to managed forests.

Natural and selectively cut forests were characterized by a multi-sized diameter distribution and a multi-layered canopy structure, while in managed forests trees of the dominant or co-dominant canopy layer were most abundant (Fig. 1). The average Shannon diversity index for the tree size distribution was highest in natural forests (1.8), followed closely by selectively cut forests (1.7) and lowest in managed forests (1.4). The difference in the tree size distributions and tree species proportions among the forest groups are obviously a consequence of thinnings done in managed forests when the understory layers have been removed.

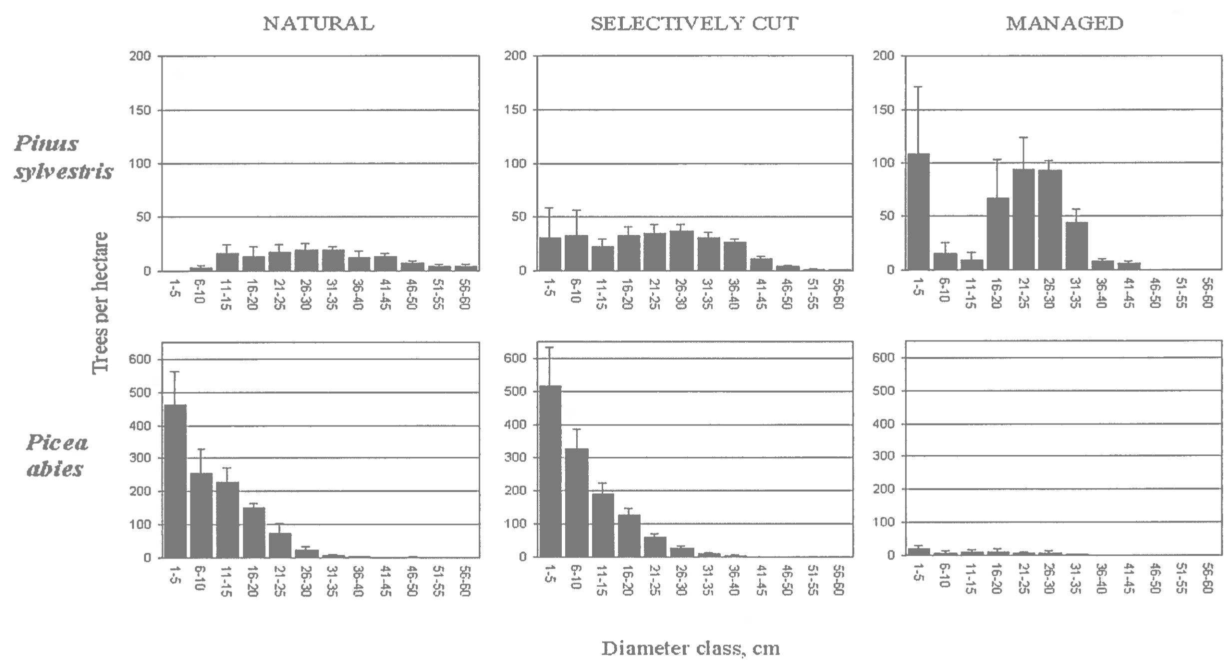

Figure 1. Distribution of pines and spruces in diameter classes in natural, selectively cut and managed forests

Natural and selectively cut forests had more deciduous trees and large trees (DBH>40 cm) than managed forests. The mean density of coniferous or deciduous trees with DBH>40 cm was in natural forests 36/ha (range 33-38/ha), in selectively cut forests 20/ha (range 5-43/ha) and in managed forests 5/ha (range 0-13/ha). In managed forests the density of large trees was only 14% and volume about 10% of the values of these characteristics in natural forests. The amount of burned living trees was highest in natural forests (10 m^3/ha), while the two other forest classes had very little or no burned trees.

The volume of dead wood (standing & down) was highest in natural forests and lowest in managed forests. The volume of dead wood was in natural forests 98.4 m^3/ha (range 83.0-118.4 m^3/ha), in selectively cut forests 55.3 m^3/ha (range 26.1-92.8 m^3/ha) and in managed forests 27 m^3/ha (range 6.0-67.8 m^3/ha). It is noteworthy that the amount of dead wood in managed forest is quite high compared to average values (3-7 m^3/ha) measured in managed forests in Finland. The difference reflects the short history of intensive forest utilization in Kuhmo, as the sampled managed forests are most likely old selectively cut forests, which still carry structural legacies from the natural forest.

Structural diversity characteristics of trees, like broken, crooked or leaning stems, were much more common in natural and near-natural selectively cut forests, compared to managed forests (Table 1). The density of trees in which structural diversity characteristics were recorded was in managed forests was 389/ha (range 275-530/ha), in selectively cut forests 474/ha (range 240-850/ha) and in managed forests 181/ha (range 15-425/ha). The proportion of crooked and leaning trees were in natural forests 10% and 8%, and in selectively cut forests 8% and 7% respectively. From basal area trees with structural diversity characteristics comprised of 34% in natural forests, 29% in selectively cut forests and 15% in managed forests.

Table 1. Structural diversity characteristics in the studied forest types: mean density (per/ha), range and standard error of the me

Tree structural characteristic	Natural			Selectively cut			Managed		
	Density	*Range*	*SE*	*Density*	*Range*	*SE*	*Density*	*Range*	*SE*
Top dead, malformed or broken	46	25-85	11.7	54	20-110	5.9	10	0-15	2.2
Rounded crown top	-	-	-	1	0-10	0.6	-	-	-
Multiple stems	44	35-55	3.7	38	10-90	5.0	16	0-50	7.5
Stem broken	15	0-40	7.1	8	0-40	2.8	3	0-20	2.9
Stem canker or damage	77	50-110	11.1	91	35-190	10.1	70	0-225	33.7
Crooked-grown stem	142	50-215	29.3	141	40-380	24.1	36	0-105	13.2
Leaning stem	115	50-185	25.7	130	10-455	26.4	18	5-40	4.7
Large or upright branches	33	10-60	10.2	20	0-40	2.5	7	0-20	2.6
Popypore fruitbodies on stem	4	0-10	1.9	9	0-20	1.8	1	0-5	0.7
Stem cavities	1	0-5	1.0	1	0-5	0.4	-	-	-
Stem base malformations	3	0-5	1.2	5	0-15	1.2	1	0-5	0.7
Sprouting groups	32	0-60	9.8	106	0-310	24.8	51	0-130	20.2

Conclusions

The results indicate that based on structural characteristics and diversity, natural forests are likely to host the highest amount of biological diversity. In terms of structural characteristics the examined old selectively cut stands do not differ significantly from natural stands. However, managed forests, which are most likely old selectively cut stands treated with thinnings from below, had a clearly lower structural diversity compared to natural or selectively cut forests.

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Secondary succession in the Scots Pine stands in northwestern Russia affected by fires

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Introduction

Fire is often thought to be one of the leading factors for boreal-forest dynamics (Engelmark 1999, Bergeron *et al.* 2001), determining the age structure, biodiversity parameters, release of nutrients etc. Different fire frequencies and intensities occur in a locally and regionally statistically predictable way, thus forming fire regimes that are allowed to work out the conceptual models based on the natural wildfire dynamics for different landscapes (Bergeron & Dansereau 1993, Angelstam 1997, Engelmark 1999). For Scots pine forests surface fires, rapidly burning fires that sweep quickly over an area, consuming litter and the aboveground parts of herbs and shrubs are the pattern of natural disturbance.

At present the natural fire frequency varies in both directions caused by the human activities: fire suppression in Scandinavia and high fire frequency in Russia. Different harvesting techniques significantly affect the variation of fire severity caused by the loss or accumulation of the fuel on the ground (Фуряев 1973).

Understorey vegetation of the forest ecosystems is characterized by heterogeneity of horizontal and vertical structure. The horizontal heterogeneity of understorey vegetation among other factors is affected by the presence of the trees. Trees determine biophysical (light, moisture, temperature regimes etc.), biochemical processes producing nutrition through aboveground and underground litter accumulation and leached nutrient elements with pluviolessivage (Учватов & Глазовский 1984). Living trees that survive the fire may function as an important source of nutrition for understorey vegetation.

The hypothesis and aims of the study

The hypothesis of the present study is: selective cutting slows down the post fire succession in the pine ecosystem. The two aims of the study are to investigate the post fire succession of the understorey vegetation and soil nutrition parameters in the anthropogenically modified pine tree stands and to observe the role of the trees in the process of post fire ecosystem regeneration.

Study area

Area of the study is located on the territory of Kovdozero forest timber subdivision in Murmansk region (Fig. 1). The study sites were selected in Scots pine (*Pinus sylvestris* ssp. Laponica Fries) stands classified as Vaccinium type according to Cajander classification in time gradient after fire, which originated 5 (P1), 10 (P2), 20 (P3), 30 (P4), and more than 70 (P5) years after nonrepeated surface fire of moderate severity. Selective cutting preceded fires on the study sites. The branches and stems were removed from the surface after cutting. As a control was chosen a pine stand that had not been affected by fire or any types of harvesting for more than 80-90 years in Enskoe lesnichestvo. The information on dead wood distribution was measured by Aulikki Lipponen in the Lapland forest (Laplandskii les) – one of the biggest old growth forest massives in Northern Europe. The term old growth forest is used for the forest with the age of the dominant tree layer older than 200 years.

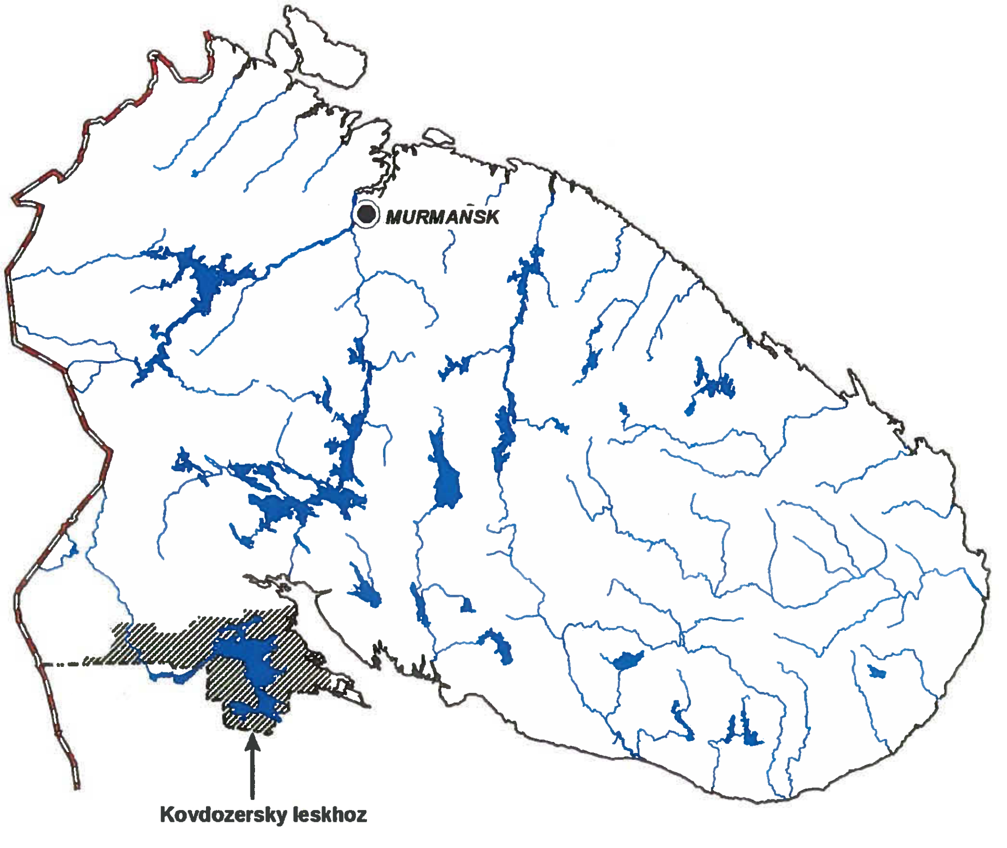

Fig. 1. Map of Kola Peninsula showing the location of the study sites

Methods

Sampling was carried out at the end of growing season in August-September 2000. Study sites of 1 ha were selected within the burned stands. DBH of the trees and the radius of the canopy projection were measured. Fire scars were cored to verify the age of the trees and the age of the fire. Understorey aboveground vegetation was sampled within the frame 25x25 cm in two positions under canopies and in the gaps (20 replications per each plot). Biomass of understorey vegetation was measured separately for each taxon.

The soil organic horizon was sampled also in two positions: under the canopies and in the gaps (20 replications per each plot). Slightly decomposed litter was extracted, oven-dried (at 105º C) and weighted.

Non-buried coarse woody debris were inventoried, the diameters and classes of decomposition were measured along 30 m transects forming the triangle (3 triangles per each plot).

Chemical analyses

Organic matter content was determined by combustion at 450C°. Soil acidity was determined in a soil fraction <0.1mm. pH was measured in the water extraction potentiometrically. Plant available forms elements of Ca and P were determined in A-L (pH=4,65). Ratio between soil and solution was the same as used for pH determination. Plant available forms of the elements were measured trilonometrically.

Statistical methods

Descriptive statistics were applied to soil patterns and biomass accumulation. The analyses of distribution were also produced (program Minitab). The correlation between soil parameters (acidity and nutrient elements) and litter accumulation along the time gradient for each plot (program STATISTIKA) was tested. One-way ANOVA was used to test the significance of the difference between the sites impacted by fire along time gradient. The Kruskal-Wallis test was used to estimate the role of the trees along the time gradient.

Results and discussion

Coarse Woody Debris

Coarse woody debris (CWD) inventory helps to reconstruct post fire dynamic of the ecosystem. We found that the dead wood for 2 classes of decomposition and a wide range of diameters was dominate the first 5 years after fire. It is interesting to notice the abundance of the trees with broken stems but root systems remaining in the ground. It may be suggested that these were rotten dead standing trees that fell after being damaged by fire. The next stage -10 years after fire is distinguished by decomposition of the fallen trees of the previous stage and an insignificant amount of the newly-fallen trees. The stage 20 years after the fire is characterized by the peak amount of fall. The trees of the 1 and 2 class of decomposition dominated and most of them were of diameter from 0-5 to 10-20 cm. The branches of mature trees were often covered by green needles. Thus we could suggest that mature trees and the thin-barked young trees are less resistant to fire in this type of the pine stand. Shallow root system of mature trees might be easily damaged by fire due to the thick layer of the litter consisting mostly of the slightly decomposed needles which increase the fire severity. The consequent post-fire stages characterized by predominance of the dead wood of 4 and 5 decomposition classes over the slightly decomposed trees.

The process of mass fall of the old trees was attended by intensive trees defoliation. The litter accumulation has a polynomial (R=0,6307) tendency - it was rather low for the first 5 to 10 years after fire and maximum litter accumulation at the stage of 20 to 25 years after fire with further decline. Obviously litter amount was higher under the canopies. The process of litter decomposition went slowly and was only limited by moisture deficits due to only atmospheric source of precipitation and high drainage rate.

Soil patterns

Podzol soil is characterized by the shallow profile thickness about 20-40 cm. This type of the soil is distinguished by organic matter accumulation with a slow its decomposition processes. The thickness of humus layer varies from 10 to 20 cm. This type of the soil is subject to erosion caused by disturbance dynamics such as fires and windfalls.

It was reported by Foth & Ellis (1996) that post fire soil process generally depends on the intensity of the fire, the amount of organic matter consumed, and the buffering capacity of the soil. Loss of organic matter is one of the most important effects of fire on soils especially as it speeds up the process of ash leaching and deflation. However fire in the North is also reported to make soil nutrients more available to plants through the increases of the normal process of mineralization of organic matter containing in the forest floor and CWD (Foth & Ellis 1996).

Heterogeneity of fire severity causes heterogeneity of the soil characteristics thus standard deviation of soil patterns is high especially first years after the fire. The first 5 to 10 years after fire I observed the lowest mean organic content through the whole chronosequent row. The first 5 years after the fire organic matter content was lower under canopies against the gaps that could be the indirect confirmation of higher fire severity under canopies against the gaps. The maximum organic matter content was measured 20 years after fire, which is corresponded with the peak of litter accumulation income. I found high correlation (p=0,9778) between organic matter content and litter accumulation along the time since fire.

In our study the actual acidity decreased after fire and its mean extent was 4,6. 20 years after fire it increased to 5,6 which corresponded to the increase of Ca. I assume that Ca high content may decrease soil acidity. On the next succession stages acidity raised up and in the final succession stage of present study it was measured as 3,9 that is typical extent for this nature zone. Further acidification process could be mostly determined by biogenic factor which is typical for northern ecosystems.

Calcium is one of the most required elements for plants and plays a significant role in the soil processes. Ca is characterized by a high migration capacity, high value of bioaccumulation and intensive involvement in exchangeable reactions. Post fire Ca concentration in humus layer is affected by several factors. For the first 5-to10 years after fire Ca concentration is high caused by transformation of Ca accumulated in the litter from organic to mineral forms (Table 1). The absence of the homogeneous vegetation cover capable of fixing Ca in the biomass affects its loss with leaching and deflation occurring 10 years after fire. The peak of litter accumulation and the highest Ca concentration distinguished the stage 20 years after fire. The next succession stages were marked by the gradual decrease of Ca concentration in the humus layer. Finally on the site more than 70 years since fire the Ca concentration showed the most significant decline compare to the non-disturbed ecosystem - 1000 mg/kg and 1644 mg/kg respectively (Никонов *et al.* 2002) Through the all age stages the higher Ca content was measured under the canopies.

Pre fire P content contained in organic matter and minerals is converted during the fire decomposition into forms available to plants. P is a volitle element with low migration ability. In the present study, the tendency of P_2O_5 content in the humus layer during the first 30 years of postfire regeneration doesn't show any sharp peaks but only slight fluctuations (Table 1). Furthermore, it gradually declines. P_2O_5 content has little correlation with litter accumulation. We didn't find any significant tree impact on P_2O_5 content in humus layer.

Table I. Plant available forms of nutrients in the organogenic horizon *under the canopy **in the gaps ***mean concentration/standard deviation

Time since fire	Ca	P_2O_5
5 years	1555.7*	283.2
	1343.8**	555.6
	1540.8***/567.4	230.9/256.7
10 years	1737.1	432.3
	1648.0	225.5
	1979.8/618.2	327.4/249.6
20 years	4058.9	1150.4
	2589.2	313.3
	3324.0/1007.7	678.4/454.1
30 years	1392.0	159.0
	1266.9	147.3
	1329.5/1775.5	153.1/79.0
70 years	973.5	245.6
	1000.2	291.6
	1059.9/373.9	267.4/86.7
non disturbed pine ecosystem	1644.0	100
	1340.0	78

Understorey vegetation

Plant biomass is an informative indicator of the ecosystem status. One of the major features of the forest northern ecosystems is the high amount of biomass accumulation in the understorey layer. Thus it has been reported that for understorey biomass can attain up to 25% of total biomass of a forest ecosystem and ranges from 0,7 to 1,3 kg/m^2 (Манаков 1978).

The rate of postfire succession mostly depends on fire severity, abundance of the plant residues remaining after fire, and microrelief of the topography affects the process of regeneration.

In accordance with our observations, the surface fire destroyed 90% of understorey vegetation remaining in the small patches of vegetation occurred mostly in the micro-relief depressions of topography or adjacent to large stones. In 5 years after fire the understorey vegetation is discrete; the total vegetation cover approximated 20%. Pioneer species: *Vaccinium myrtillus* L., *Vaccinium vitis-idaea* L. and species of *Polytrichum* genera are dominate. It was reported that mineral substrate is favorable for *Polytrichum* genera post disturbance regeneration (Васенев & Таргульян 1994)

Vaccinium vitis-idaea is considered (Пушкина 1938) to be one of the early succession species, regenerating mostly vegetatively, the rate of its regeneration is high because of its deep root system that survives the fire. *Vaccinium myrtillus* is reported as one of the pioneer species also with both types of regeneration - by seeds and vegetatively (Пушкина 1938). The rate of their regeneration is closely related to the presence of different forms of microrelief. Shrub recolonisation goes in the mixed compartments. 5 years after fire *Polytrichum* formed monospecies compartments and its biomass contribution was 46% out of total understorey biomass - the highest along the post fire successional row. 10 years after fire the situation was similar to the previous one - the same shrub species and *Polytrichum* dominated. 20 years after fire 40% of the territory was not covered by vegetation. *Deschampsia flexuosa* L. formed monospecies compartments, which averaged around 22% of total biomass. On the next succession stage (30 years) understorey vegetation formed a homogenous cover dominated by dwarf shrubs and *Deschampsia flexuosa. Empetrum hermaphroditum* Hagerup. was also present and contributed 15-20 % out of shrub biomass instead of nondisturbed conditions where

Empetrum hermaphroditum biomass could reach 70 % of shrub biomass (Никонов *et al.* 2002). Zackrisson *et al.* (1995) reported that late successional species *Empetrum hermaphroditum* is a highly inflammable species, intolerant of fire, and charcoal originating from forest fire could reduce the negative effects of phenolic compounds produced by conifer litterfall which are favourable for crowberry germination. On the last site we estimated the equal ratio between *Vaccinium vitis-idaea* and *Empetrum hermaphroditum* biomass. Green mosses form thick layer of 15 to 20 cm. Thus we found the linear (R=0,6699) growth of understorey biomass over the 70 years post fire period (Fig.2).

In the undisturbed nature conditions contribution of feather mosses gives up to 75% out of total biomass (Манаков 1978). In our study we found the traces of feather moss regeneration 20 years after fire when their contribution was about 1% of total biomass, Feather mosses biomass grows slowly and more than 70 years after fire it was only 20% of the total biomass. Feather mosses regeneration is strongly related to the microrelief depression of the topography and optimal moisture conditions.

Fig.2 Understorey biomass transformation in the term of postfire succession. During the first 30 years since fire it is only Polytrichum

Conclusion

In our case study we suggest that selective cutting could disturb the natural rate of function of fire dependent ecosystem. It breaks the time continuity of the dead trees gradual accumulation decreasing source of nutrition. Fire has a long-term effect on soil nutrition pattern and ecosystem production. The trees that remain after fire become the major source of nutrition thus it is essential to find the correct forest management strategy to account for the density of remaining tree stands for each type of forest ecosystem. Soil nutrition and understorey biomass parameters could be a useful tool to determine this strategy.

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Plant phenology in slightly disturbed forests of northern taiga

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Study area

From 1986, monitoring of vegetation on constant sample sites is conducted in the Kostomuksha nature reserve, which is situated in a belt of enlightened forests of a northern taiga subzone of Eastern Fennoscandia (Раменская 1960). The sample sites situated along the route for carrying out various investigations (Кашеваров 1989) represent various plant associations of the nature reserve (Adrianova 1997). In this work, 10-year data collected in the four main forest types is given. They are the following: lingonberry-bilberry pine forest, lichen pine forest, heather-lingonberry pine forest and green-moss spruce forest. The stand of the lingonberry-bilberry pine forest is represented mainly by pine-trees of 100 years (about 60%) and pine-trees of 200-250 years (30%), with few birches and spruces a little younger than 100 years. The forest stand of the next group (lichen pine forest) is constituted from pine-trees of 200 years only. On the third sample site (heather-lingonberry pine forest) grow pine-trees with the age of 110 years with few spruce-trees and birches of the same age. The forest stand of the last sample site that represents green-moss spruce forest is occupied by spruce-trees with the age of 100 years (about 60%) and pine-trees 150 years old (about 40%), with few birches.

Methods

For correlating phenological data from the Kostomuksha nature reserve, meteorological data from the nearest meteorological station (Kalevala) situated at a distance of 100 km was used. During the whole year, elementary meteorological observations were conducted on the sample sites also. These observations included measurements of maximum and minimum temperatures on the surface of the soil and at the height of 2 m. From the beginning of the vegetation season all vascular plants growing on the sample sites were observed and all phenological phases were registered (Бейдеман 1974).

Results and discussion

Totally, observations were conducted on 13 grass-shrub species growing on these sample sites. The most interesting and beneficial are long-term observations of four forest berry species. The 10-year observations showed that budding of lingonberry (*Vaccinium vitis-idaea*) begins in lichen pine forest, a long-term mean date being 17th of May (Table 1). The latest date (30.05) was registered in green-moss spruce forest. The difference in the beginning of flowering is smaller, only 5-8 days (from 22.06 in heather-lingonberry pine forest to 30.06 in green-mossy spruce forest). The same difference is for ripening.

A long-term average date for bilberry (*Vaccinium myrtillus*) budding is 25.05. Only in green-moss spruce forest this phase begins 4 days later. Flowering of bilberry begins as a mean on the 04.06 in the pine forests and 3 days later in green-moss spruce forest. Fully ripen berries appear in lichen pine forest on the 23.07 and in other pine and spruce forests 2-7 days later.

Budding of bog-bilberry (*Vaccinium uliginosum*) begins on average in all studied pine forests the 6th of June. Flowering starts in lichen pine forest on 19.06, and 1-2 days later in lingonberry-bilberry and heather-lingonberry pine forests. The first ripen berries of this species are registered on 04.08 in lichen pine forest and in the other two on 07.08.

Crowberry (*Empetrum nigrum*) begins to bud on an average the 12th of May in lichen and heather-lingonberry pine forests, a little later in lingonberry-bilberry forest, but blooming begins at the same time. Fully ripened berries in the first two types of forests appear on the 18-19th of July and the third 5 days later.

The observations of plants developing showed the correlation between the occurrence of phenophases and meteorological conditions (Table 1, Fig.1). During the decade (1986-1995) the most favourable year for plant developing was 1989. During this year the course of temperatures determined the early approach of vegetation sea-

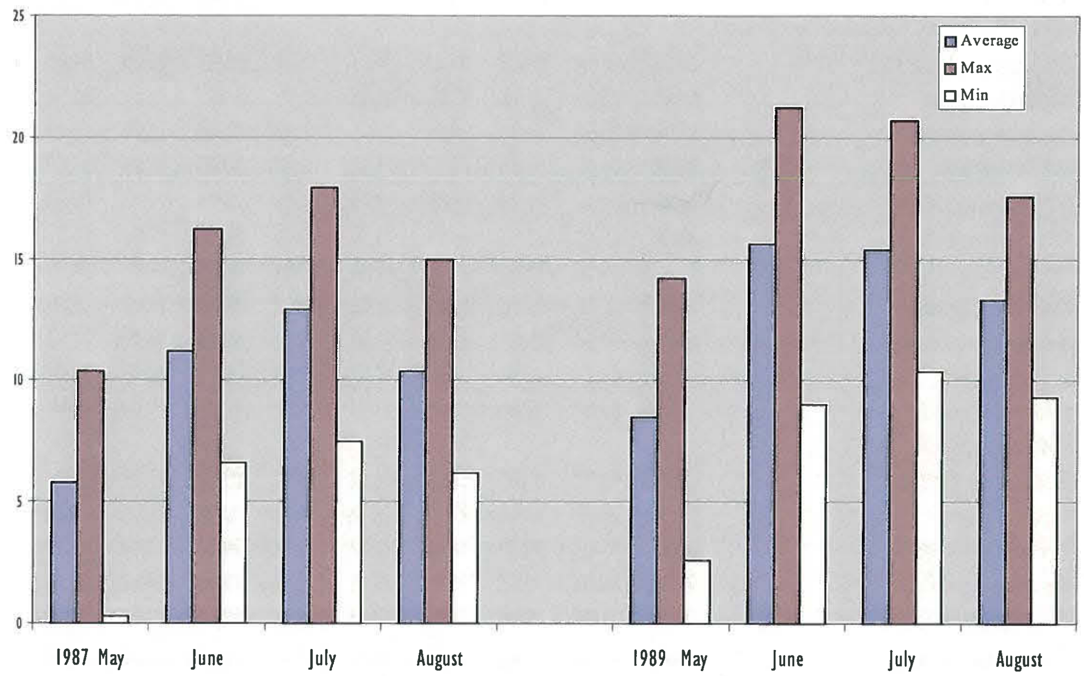

Fig. 1. Temperature characteristics of the coolest (1987) and the warmest (1989) summers.

Table 1. Phenology of some plant species in the forest of the Kostomuksha nature reserve (1986-1995)

Species	Dates of phenomenon (beginning)								
	budding			blooming			fruit formation		
	earliest	latest	mean	earliest	latest	mean	earliest	latest	mean
lingonberry-bilberry pine forest									
Deschampsia flexuosa	23.06	12.07	04.07	11.07	30.07	22.07	24.07	25.08	11.08
Goodyera repens	17.06	26.07	01.07	24.07	13.08	04.08	10.08	22.08	15.08
Empetrum nigrum	08.05	24.05	15.05	11.05	30.05	20.05	25.05	19.06	05.06
Calluna vulgaris	01.07	22.07	13.07	24.07	25.08	07.08	26.08	18.09	05.09
Ledum palustre	12.05	12.06	03.06	13.06	28.06	22.06	28.06	14.07	10.07
Vaccinium vitis-idaea	08.05	09.06	27.05	16.06	05.07	26.06	28.06	19.07	08.07
Vaccinium myrtillus	18.05	05.06	25.05	21.05	10.06	03.06	06.06	28.06	19.06
Vaccinium uliginosum	29.05	15.06	05.06	11.06	01.07	21.06	19.06	19.07	04.07
Trientalis europaea	05.06	21.06	13.06	11.06	01.07	22.06	28.06	19.07	07.07
Melampyrum pratense	04.06	22.06	13.06	19.06	12.07	30.06	09.07	07.08	25.07
Linnaea borealis	10.06	23.06	19.06	20.06	15.07	05.07	04.07	01.08	20.07
Solidago virgaurea	11.06	11.07	21.06	09.07	24.07	18.07	31.07	02.09	15.08
lichen pine forest									
Deschampsia flexuosa	28.06	12.07	05.07	11.07	26.07	20.07	24.07	26.08	09.08
Empetrum nigrum	04.05	22.05	12.05	11.05	29.05	21.05	22.05	19.06	07.06
Pyrola chlorantha	22.05	22.06	14.06	28.07	15.07	07.07	04.07	27.07	18.07
Calluna vulgaris	01.07	22.07	15.07	24.07	25.08	07.08	25.08	03.09	30.08
Vaccinium vitis-idaea	04.05	30.05	17.05	05.06	03.07	22.06	26.06	19.07	08.07
Vaccinium myrtillus	18.05	05.06	25.05	21.05	15.06	04.06	09.06	01.07	20.06
Vaccinium uliginosum	29.05	14.06	06.06	11.06	27.06	19.06	19.06	21.07	06.07
Melampyrum pratense	08.06	29.06	14.06	16.06	15.07	08.07	07.07	06.08	25.07
Linnaea borealis	11.06	07.07	23.06	20.06	15.07	02.07	14.07	12.08	27.07
Solidago virgaurea	10.06	15.07	23.06	04.07	26.07	17.07	31.07	25.08	14.08
heather-lingonberry pine forest									
Deschampsia flexuosa	20.06	12.06	03.07	04.07	30.07	19.07	24.07	26.08	07.08
Empetrum nigrum	04.05	22.05	12.05	11.05	29.05	21.05	25.05	19.06	06.06
Pyrola chlorantha	16.06	08.07	23.06	04.07	21.07	12.07	08.07	16.08	25.07
Calluna vulgaris	30.06	06.08	13.07	24.07	23.08	06.08	30.08	18.09	05.09
Ledum palustre	19.05	01.06	27.05	11.06	17.06	12.06	28.06	22.07	08.07
Vaccinium vitis-idaea	08.05	05.06	22.05	16.06	05.07	25.06	28.06	19.07	10.07
Vaccinium myrtillus	18.05	05.06	28.05	21.05	15.06	04.06	06.06	27.06	19.06
Vaccinium uliginosum	01.06	12.06	06.06	10.06	27.06	22.06	19.06	13.07	02.07
Melampyrum pratense	04.06	24.06	13.06	19.06	12.07	23.06	08.07	06.08	21.07
Linnaea borealis	10.06	01.07	20.06	20.06	15.07	02.07	04.07	30.07	20.07
Solidago virgaurea	13.06	02.07	23.06	04.07	23.07	17.07	20.07	02.09	13.08
moss spruce forest									
Deschampsia flexuosa	29.06	12.07	05.07	11.07	06.08	24.07	02.08	17.08	10.08
Goodyera repens	06.06	21.07	23.06	28.07	20.08	06.08	07.08	31.08	20.08
Vaccinium vitis-idaea	19.05	05.06	30.05	16.06	12.07	26.06	29.06	27.07	16.07
Vaccinium myrtillus	21.05	05.06	29.05	29.05	15.05	07.06	10.06	04.07	22.06
Trientalis europaea	06.06	19.06	13.06	11.06	12.07	26.06	29.06	14.07	08.07
Melampyrum pratense	06.06	28.06	17.06	19.06	14.07	07.07	18.07	19.08	04.08
Linnaea borealis	11.06	08.07	28.06	28.06	28.07	10.07	07.07	16.08	29.07
Solidago virgaurea	16.06	04.07	26.06	06.07	28.07	19.07	24.07	26.08	10.08

son. The mean daily temperatures of spring-summer season were 3-4 C⁰ higher than in 1987 and the minimum temperatures were 2-3 C⁰ higher (data of Kalevala meteorological station).

The course of extreme temperatures obtained from microclimate observations on permanent sample sites gives the same picture. The early end of frosts and rather high mean daily temperatures of spring-summer months led to the fact that the start of budding and blooming of all observed plants began on 4-7 days earlier compared with the long-term average dates. Ripening of berries in 1989 began earlier also (Fig. 2).

In 1987, the frosts during spring occurred much longer. On the 11th of May a snow-storm happened and the last snow-fall was on the 24th of May. Frosts were observed in June and July. In the beginning of June minimum temperatures 1-1,5 C⁰ below zero were registered on the sample sites. In July they were around 0,5-1,8 C⁰ below zero. Such temperatures resulted in a slow processes of plant growing. The beginning of phenological phases of the majority of observed plants began later. Only 4 species were developing near to the mean dates.

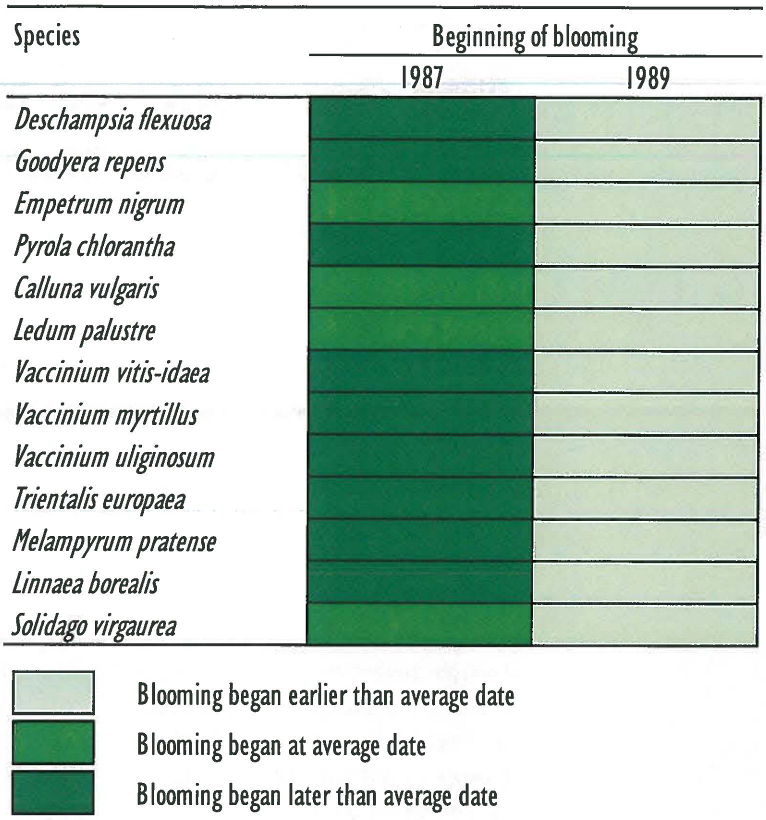

Fig 2. Correlation of blooming and temperature characteristics.

Conclusion

In general, analysing the development of plants in a study of plant associations, it was marked that the most early dates of phenological phases are characteristic for the pine forests, for the lichen type especially. The slowest processes of plant development are in the spruce forests. This data is correlated with the ecological (biotic and abiotic) conditions of the coenoses. These data gives a possibility to forecast the time of forest berries ripening correlating it with blooming.

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The Calendar of Nature of the Kostomuksha Nature Reserve

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Objectives

The Calendar of Nature is one of the main sections in the main theme of the strict nature reserves – Chronicles of Nature. It is a generalising section giving a picture of annual development of the whole nature complex. The programme Calendar of Nature includes observations of abiotic (weather, snow cover, waters and soil) and biotic components. Information for the Calendar of Nature is provided not only from the scientific researchers but from the forest guards also.

Study area and methods

In 1986, from the moment of establishing of scientific department, for conducting detailed phenologic observations in the Kostomuksha Nature Reserve, a combined phenologic route (7,5 km long) with 8 permanent sample sites was arranged (Кашеваров 1989; Adrianova 1997). These sample sites represent as well the main biotopes (forests and mires) of the nature reserve as rare habitats (meadows). In addition to phenological observations (temperature, precipitation, snow cover), registrations of small mammals, soil invertebrates and birds are conducted on the route. The permanent sample sites for berries productivity monitoring are placed near the phenologic route also.

There are more than 80 species of vascular plants (trees, bushes, herbs and grasses) under the observation, including both dominant and rare species for the nature reserve. Phases of budding, vegetating, blooming, ripening of fruits and seeds and changes of colour of leaves are registered according to the method proposed by Бейдеман (1974). Zoological observations are conducted not only in the reserve but on adjacent territories also upon appearance and disappearance of migrating birds and some insects, reproduction activity etc.

In this work, 15-year facts are summarised. Long-term mean dates of certain phenomenon's comings give a notion about the sequences of these phenomena and their dependence from weather and microclimate conditions, about the course of seasonal processes in the region of the nature reserve.

Results

Generalised data of our phenological observations is presented in the table.

Table. Calendar of nature of the Kostomuksha Nature reserve (1986-2000)

Phenomena	Dates mean	earliest	latest	Amount of observed years
Winter				
Snow cover, permanent – appearance	04.11	08.10	13.12	16
Snow cover – depth more than 30 cm	17.12	20.10	25.01	14
Snow cover – depth more than 60 cm	29.01	01.12	08.04	9
Capercaillie – snow drawings, first	05.03	08.02	08.04	13
Craters around tree trunks in the forest, first	12.03	07.02	04.04	14
Salix caprea – buds, the first	16.03	20.02	18.04	13
Spring				
Thawed patches around trunks, first	24.03	20.02	26.04	12
Capercaillie – mating, beginning	30.03	22.03	15.04	8
Rain of water, first	02.04	07.03	22.04	12
Formation of hard snow crust	04.04	12.03	25.04	12
Whooping swan – first encounter	05.04	11.03	20.04	14
Black grouse – mating, beginning	08.04	16.03	10.05	10
Snow melting – beginning	13.04	16.03	29.04	8
Snow-storm, last	15.04	10.03	15.05	14
Brown bear – leaving the den	15.04	06.03	16.05	12
Chuffinch - first encounter	16.04	27.03	28.04	15
Bean goose – first encounter	20.04	03.04	10.05	14
Mallard – first encounter	21.04	03.04	06.05	9
Ant hills – coming to life	24.04	14.04	06.05	15
Bramble finch – first encounter	25.04	07.04	08.05	14
Snowfall, last	26.04	02.04	17.05	13
Goldeneye – first encounter	28.04	14.04	10.05	12
Betula pubescens – appearance of sap	28.04	20.04	07.05	15
Yellow hammer – first encounter	29.04	13.04	10.05	15
Alnus incana – appearance of pollen	29.04	19.04	11.05	15
Snow cover – less than 30 cm	30.04	13.04	13.05	8
Wagtail – first encounter	30.04	20.04	14.05	14
Gull – first encounter	02.05	24.04	12.05	12
Snow melting – the end	03.05	18.04	16.05	12
Song thrush – first encounter	04.05	23.04	22.05	15
Tussilago farfara – blooming, beginning	04.05	22.04	23.05	9
Redwing – first encounter	06.05	26.04	22.05	14
Bumblebee – first encounter	07.05	26.04	23.05	15
Willow warbler – first encounter	09.05	28.04	22.05	12
Mosaic snow cover in the forest	10.05	26.04	27.05	11
Brown frog – first encounter	11.05	29.04	22.05	15
Tree pipit – first encounter	12.05	04.05	22.05	14
Mosquitoes – first	13.05	02.05	05.06	9
Chiffchaff – first encounter	13.05	01.05	25.05	10
Salix caprea – blooming, beginning	13.05	26.04	24.05	15
Snow cover – total disappearance	15.05	04.05	29.05	15
Eriophorum vaginatum – blooming, beginning	15.05	29.04	30.05	14
Lakes, small – cleaning from the ice, total	16.05	10.05	30.05	10
Lakes, mean-sized– cleaning from the ice, total	17.05	10.05	30.05	14
Empetrum nigrum – blooming, beginning	17.05	08.05	30.05	14
Frost – last	18.05	20.04	05.06	14
Common lizard – first encounter	19.05	09.05	03.06	14
Cuckoo – cuckooing, first	19.05	15.05	27.05	15
Swallow – first encounter	20.05	10.05	01.06	15
Chamaedaphne calyculata - blooming, beginning	20.05	04.05	30.05	15
Betula pubescens – greening, beginning	21.05	09.05	03.06	14
Vaccinium myrtillus – vegetating, beginning	21.05	08.05	06.06	14

Phenomena	Dates mean	earliest	latest	Amount of observed years
Luzula pilosa – blooming, beginning	21.05	08.05	29.05	13
Padus racemosa – vegetating, beginning	22.05	11.05	03.06	14
Gyromitra esculenta - first	23.05	26.04	29.05	10
Daphne mezerum– blooming, beginning	23.05	16.05	03.06	12
Salix caprea – vegetating, beginning	24.05	11.05	04.06	13
Sorbus aucuparia – vegetating, beginning	24.05	11.05	06.06	14
Betula nana – vegetating, beginning	25.05	11.05	06.06	12
Snowfall after melting of the snow cover	26.05	20.05	04.06	11
Thunderstorm – first	26.05	10.05	08.06	12
Caltha palustris – blooming, beginning	27.05	17.05	05.06	15
Vaccinium myrtillus – blooming, beginning	30.05	18.05	08.06	15
Vaccinium uliginosum – vegetating, beginning	31.05	21.05	10.06	15
Swift – first encounter	02.06	21.05	10.06	8
Rubus chamaemorus – blooming, beginning	02.06	24.05	11.06	15
Scarlet finch – song, first	03.06	25.05	09.06	11
Padus racemosa – blooming, beginning	04.06	21.05	15.06	15
Picea abies – growing of needles, beginning	06.06	29.05	12.06	14
Taraxacum officinale – blooming, beginning	06.06	21.05	24.06	15
Trollius europaeus – blooming, beginning	06.06	25.05	15.06	15
Ranunculus acer – blooming, beginning	08.06	31.05	16.06	15
Viola tricolor – blooming, beginning	08.06	29.05	27.06	14
Gnats – appearance	10.06	04.06	19.06	14
Andromeda polifolia – blooming, beginning	10.06	04.06	17.06	15
Trientalis europaea – blooming, beginning	11.06	05.06	19.06	15
Pinus sylvestris – appearance of pollen	13.06	26.05	24.06	15
Geranium sylvaticum – blooming, beginning	13.06	06.06	21.06	15
Anthriscus sylvestris – blooming, beginning	13.06	06.06	22.06	15
Dragonfly – first encounter	14.06	20.05	05.07	15
Vaccinium uliginosum – blooming, beginning	14.06	06.06	20.06	15
Alchemilla – blooming, beginning	14.06	06.06	26.06	15
Veronica chamaedrys – blooming, beginning	14.06	07.06	26.06	15
Sorbus aucuparia – blooming, beginning	17.06	06.06	28.06	15
Ledum palustre – blooming, beginning	17.06	08.06	01.07	15
Menyanthes trifoliata – blooming, beginning	17.06	06.06	26.06	15
Gadfly – first encounter	18.06	06.06	02.07	12
Anthoxanthum odoratum – blooming, beginning.	18.06	08.06	08.07	15
Maianthemum bifolium – blooming, beginning	19.06	06.06	26.06	15
Cornus suecica – blooming, beginning	19.06	06.06	01.07	15
Rumex acetosa. – blooming, beginning	19.06	11.06	04.07	14
Eriophorum vaginatum –ripe foetus	20.06	06.06	06.07	13
Vaccinium vitis-idaea blooming, beginning	20.06	08.06	04.07	14
Goldeneye –broods, first	21.06	14.06	01.07	6
Rubus saxatilis – blooming, beginning	21.06	11.06	26.06	13
Corallorhiza trifida – blooming, beginning	21.06	09.06	04.07	10
Vicia sepium – blooming, beginning	21.06	04.06	08.07	13
Dactylorhiza maculata – blooming, beginning	22.06	04.06	02.07	14
Juniperus communis – appearance of pollen	24.06	11.06	06.07	10
Moneses uniflora – blooming, beginning	24.06	11.06	04.07	12
Boletus edulis – appearance	25.06	13.06	08.07	7
Calla palustris – blooming, beginning	25.06	11.06	12.07	12
Oxycoccos quadripetalus – blooming, beginning	26.06	11.06	09.07	14
Vicia cracca – blooming, beginning	27.06	08.06	12.07	15
Hazel hen – broods, first	28.06	17.06	15.07	10
Melampyrum pratense – blooming, beginning	29.06	19.06	12.07	14
Rubus idaeus – blooming, beginning	30.06	16.06	12.07	15

Phenomena	Dates mean	earliest	latest	Amount of observed years
Stellaria graminea – blooming, beginning	30.06	20.06	09.07	14
Summer				
Rosa majalis – blooming, beginning	01.07	19.06	19.07	15
Platanthera bifolia – blooming, beginning	01.07	19.06	09.07	13
Linnaea borealis – blooming, beginning	01.07	19.06	11.07	14
Hieracium umbellatum – blooming, beginning.	01.07	20.06	15.07	12
Stellaria palustris – blooming, beginning	01.07	20.06	12.07	11
Achillea millefolium – blooming, beginning	01.07	11.06	15.07	14
Poa pratensis – blooming, beginning	03.07	16.06	15.07	12
Leccinum – first	04.07	24.06	15.07	11
Comarum palustre – blooming, beginning	04.07	11.06	18.07	12
Leucanthemum vulgare – blooming, beginning	06.07	26.06	15.07	14
Galeopsis speciosa – blooming, beginning	06.07	27.06	12.07	10
Phleum pratense – blooming, beginning	06.07	18.06	18.07	13
Chamaenerion angustifolium – blooming, beginning	08.07	24.06	23.07	15
Campanula rotundifolia – blooming, beginning	08.07	28.06	23.07	14
Urtica dioica – blooming, beginning	09.07	28.06	23.07	14
Heracleum sibiricum – blooming, beginning	09.07	27.06	23.07	13
Nymphaea candida – blooming, beginning	11.07	25.06	27.07	13
Nuphar lutea – blooming, beginning	11.07	25.06	18.07	14
Solidago virgaurea – blooming, beginning	11.07	29.06	26.07	14
Polemonium caeruleum – blooming, beginning	13.07	29.06	23.07	9
Filipendula ulmaria – blooming, beginning	13.07	02.07	23.07	14
Empetrum nigrum – ripening, beginning	16.07	07.07	25.07	15
Knautia arvensis – blooming, beginning	18.07	07.07	07.08	13
Rubus chamaemorus – ripening, beginning	19.07	09.07	27.07	14
Vaccinium myrtillus – ripening, beginning	19.07	04.07	27.07	15
Drosera anglica. – blooming, beginning	21.07	12.07	06.08	10
Drosera rotundifolia – blooming, beginning	22.07	14.07	06.08	10
Centaurea jacea – blooming, beginning	29.07	20.07	15.08	12
Calluna vulgaris – blooming, beginning	29.07	15.07	16.08	14
Vaccinium uliginosum – ripening, beginning	03.08	22.07	16.08	15
Goodyera repens – blooming, beginning	04.08	21.07	20.08	12
Padus racemosa – ripening, beginning	05.08	01.07	27.08	15
Rubus idaeus – ripening, beginning	08.08	24.07	19.08	15
Rubus saxatilis – ripening, beginning	10.08	24.07	26.08	13
Autumn				
Betula pubescens – yellow leaves, first	14.08	22.07	24.08	15
Betula nana – autumn colour	15.08	02.08	25.08	12
Cornus suecica – ripening, beginning	16.08	30.07	30.08	10
Salix caprea – autumn colour	17.08	01.08	03.09	15
Vaccinium myrtillus – autumn colour	20.08	31.07	03.09	14
Thunderstorm – last	22.08	03.08	30.09	13
Sorbus aucuparia – ripening, beginning	23.08	12.08	03.09	10
Vaccinium uliginosum – autumn colour	24.08	13.08	06.09	15
Padus racemosa – autumn colour, first	25.08	11.08	03.09	14
Vaccinium vitis-idaea – ripening, beginning	27.08	13.08	05.09	15
Betula pubescens – leaves falling, beginning	01.09	24.08	13.09	15
Frost – first	03.09	05.08	01.10	14
Padus racemosa – leaves falling, beginning	07.09	29.08	16.09	14
Betula nana – leaves falling, beginning	08.09	25.08	14.09	12
Betula nana – autumn colour, total	10.09	31.08	20.09	10
Salix caprea – leaves falling, beginning	12.09	02.09	25.09	13
Vaccinium myrtillus – leaves falling, beginning	13.09	31.08	25.09	10

Phenomena	Dates mean	earliest	latest	Amount of observed years
Oxycoccos quadripetalus – ripening, beginning	14.09	30.08	26.09	15
Sorbus aucuparia – leaves falling, beginning	15.09	01.09	25.09	13
Padus racemosa – autumn colour, total	19.09	06.09	30.09	8
Snow – first (wet)	22.09	07.08	27.10	13
Betula pubescens – totally yellow	22.09	31.08	08.10	14
Vaccinium uliginosum – autumn colour, total	23.09	13.09	30.09	11
Sorbus aucuparia – autumn colour, total	25.09	15.09	30.09	12
Wagtail – encounter, last	28.09	14.09	13.10	9
Betula nana – leaves falling, end	29.09	15.09	08.10	14
Padus racemosa – leaves falling, end	01.10	15.09	19.10	14
Red squirrel – moult	03.10	21.09	14.10	12
Snow – first	05.10	10.09	30.10	15
Chuffinch – encounter, last	09.10	21.09	18.10	11
Betula pubescens – leaves falling, end	10.10	04.10	19.10	15
Goldeneye – encounter, last	12.10	06.09	30.10	11
Whooping swan – encounter, last	13.10	19.09	27.11	7
Salix caprea – leaves falling, end	13.10	02.10	19.10	13
Sorbus aucuparia – leaves falling, end	13.10	04.10	31.10	12
Vaccinium myrtillus – leaves falling, end	13.10	02.10	21.10	9
Mallard – encounter, last	14.10	04.09	04.11	12
Snow cover – temporal	17.10	24.09	05.11	13
Lakes – ice, first	17.10	28.09	01.11	14
Red squirrel – winter fir	17.10	05.10	04.11	9
Brown bear – encounter, last	22.10	27.09	13.11	10
Snowshoe hare – winter fir	23.10	14.10	20.11	8
Lakes – ice cover	31.10	20.10	29.11	10

Conclusion

Observations during 15 years allowed to collect data about phenologic phenomena on the territory of the reserve. This data gives possibility to make first analysis using statistics. But for getting more precise results, observations during not less than 25-30 years are recommended (Прохненко 1986). Thus, only in the future we shall know how the nature processes are going on in northern taiga conditions.

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Influence of rejuvenation cutting on sustainability and biological diversity of native spruce forests

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Introduction

According to federal law "Об особо охраняемых природных территориях" National park Vodlozerski was divided into five zones with different regime of permitted activities. The Central state forest inventory enterprise in 1995-1997, with due regard to the main tasks of the park, carried out certain silvicultural work and planned forest management activities (thinning in the young stands, thinning, rejuvenation cutting, selective sanitary cutting and landscape design cutting) in the forest economic zone and zone of traditional nature use, which make up to 27.8 per cent of the park's territory.

Rejuvenation and re-structuring cuttings are recommended in the economic zones of national parks. According to "Наставление по рубкам ухода..." (1994), and "Рекомендации по проведению лесохозяйственных работ..." (1998), the rejuvenation cutting should be aimed to form sustainable, long-lasting, mainly native stands that possess the best ecological and recreational properties. Rejuvenation cuttings should be done according to individual plans.

Analysis of the existing recommendations and instructions shows that some of organizational and technical elements concerning the rejuvenation cuttings should be elaborated more specifically for concrete forest growing conditions, especially for the park's forests. Provision of wood for fuel and construction to the people living in the park is another important factor for carrying out rejuvenation cutting.

Silvicultural and ecological evaluation of the results of rejuvenation cutting using the cut-to-size felling technology in native spruce stands was the main objective of the present study.

Objectives and methods

Different variants of trial cutting in native spruce forest on 4 pilot sites of total area 37 hectares were performed to determine the sustainability, dynamics of accretion, mortality and ecological consequences.

Mostly mature and overmature, faulty and damaged trees were earmarked for felling when examining the plot. Cut-to-size logging technique was used. First the main skids and skids in swaths of 4-meter width were cut, then the trees in the swaths were felled with chain saws, the trunks de-branched and cut to size. Transportation of logs was done by log carriers LT-189 M (designed by Karelian research institute of forest industry) strictly along skidding ways. The cutting waste was partly dumped in the skids and partly left on the felling site.

Permanent reference plots were arranged on the pilot plots with inventory of stock, density, thickness grades and other factors according to the forest survey methods. Evaluation of natural reproduction and condition of trees of various height groups was done to determine the qualitative and quantitative composition of the undergrowth. The trees left to grow and preserved undergrowth were counted after the cutting. Damaged trees were counted separately, giving the nature, extent and cause of the damage. Description of the grass-brush storey and moss cover on the permanent plots was done according to the existing instructions (Программа и методика... 1966).

Results and discussion

The object of our research was native spruce stands with trees of different age and undergrowth. The spruce age varied from 41 to 300 years (maximum 350 years). Two, more rarely three generations of spruce were present in the stands (Table 1). Table 1 Characteristics of the uneven-age blueberry spruce stands before and after rejuvenation cutting in the economic zone of NP Vodlozerski.

The older generation dominating in the canopy was 250 years and represented by few trees. The main stock was made of second generation of 170-190 years. A younger generation of 110 years was the more numerous but of lesser stock than the other ones.

Table I. Characteristics of the uneven-age blueberry spruce stands before and after rejuvenation cutting in the economic zone of NP Vodlozerski

Plot No.	Monitoring period	Composition	Number of trees per ha	Stock, cu.m/ha	Relative density	Cutting intensity, %	Damaged trees, %	Number of undergrowth, pcs/ha	Preservation of undergrowth, %
1	Before cutting in 1997	2 S 250 5 S170 1 S 110 2 P 230+ B, A	920	215	0.78			3750	
	After cutting	6S170 2S110 2P230+ B, A	799	144	0.64	33/13	3.3	2755	73
2	Before cutting in 1997	1 S 250 5 S190 3 S 110 1A100 +B, P	622	210	0.64			4550	
	After cutting	5S190 3S110 2A100+P,B	504	163	0.56	22/19	0.4	3200	70
5	Before cutting in 1999	1 S 250 6 S190 3A230+A,B	882	205	0.86			7800	
	After cutting	1S250 6S190	659	112	0.54	45/25	0.6	5600	72

Note: S – spruce, P – pine, A – aspen, B – birch.

Our report gives the results of pilot felling in the most typical for the park blueberry spruce stands of different ages. On pilot plot No.1 mature and over mature spruce trees were cut, intensity of cutting was 33 per cent by stock and 13 per cent by the number of trees. Admixture of pine, birch and aspen was preserved. The density decreased to 0.64.

Some of the remaining trees were damaged in the process of felling and transportation. According to inventory of the stand taken after the rejuvenation cutting the damaged trees made 3.3 per cent of the trees left after thinning. Breaking of the tree top and stripping of the trunk were the main damages.

Sustainability of thinned stands can be estimated by rate of mortality. During the three years of observation 4 trees with stock 2 cu.m/ha fell due to windfall. Mortality in the thinned stand does not exceed mortality in a virgin stand (3.9 cu.m/ha during 3 years).

Undergrowth plays an important role in supplementing different age groups of spruce and in reproduction of stock. Rate of survival of undergrowth after the cut-to-size method of logging was 73 per cent. At present under the canopy of the thinned stand there are 2755 trees/ha of undergrowth trees, including 525 thick young trees, which will be the reserve of stock supplement in the next decades after the thinning. Three years after the cutting 6 undergrowth trees have become inventory trees. It means that the rate of supplementing of the main stock by the undergrowth is higher than the rate of mortality, which is a proof of tolerance of un-even age spruce stands to thinning.

The stand on pilot plot No.2 before the thinning was graded as medium dense. Therefore, the thinning intensity was lower than on the previous plot – 22 per cent of the stock. The mixture of other species – pine, birch and aspen - was preserved. The density decreased to 0.56.

Inspection of the plot after 3 years showed that 2 trees with stock 3 cu.m/ha had died. Three spruce trees from undergrowth grew to inventory size. Condition of the spruce undergrowth was looking good. The rate of supplementing of the main stock from undergrowth is equal to the rate mortality, that means that the dynamic equilibrium is maintained.

There were more pine trees on pilot plot No.5. The pine was mostly faulty and was completely taken out during thinning. A purely spruce stand was formed. Intensity of cutting was 45 per cent of the stock and 25 per cent of the number of trees. The density after thinning decreased to 0.54. Observations during 2 years proved sustainability of the stand to thinning. Mortality was 2 trees with stock 0.7 cbm.

Soil cover after rejuvenation cutting in general preserved its species composition and structure. In the first year after cutting the typical shadow-tolerant (forest) species undergo certain stress which is manifest in lesser productivity and vitality of plants. In the second and third years after cutting *Rubus saxatilis, Vaccinium vitis-idaea, Calamagrostis arundinacea, Oxalis acetosella, Linnaea borealis and Lerchenfeldia flexuosa* proliferate.

It seems, that ecologically sound forest management in the native uneven age spruce stands would be characterized by the following features:

1. Natural reproduction of forest by the preserved part of the stand and undergrowth takes place in uneven age stands after rejuvenation cutting.

2. The process of natural reproduction of forest is expedited by supplementing of different age groups by the undergrowth, thus ensuring sustainability of uneven age spruce stands.

3. Rate of damage of the stand when using the cut-to-size logging technique is within the range allowed by the existing rules. On the pilot plots it was from 0.4 to 3.3 per cent.

4. According to 3-year observations the rate of mortality is equal or not more than the rate of natural supplement.

5. The above mentioned logging technique preserves the age unevenness of the spruce strands, which is a prerequisite for continuous existence of native uneven age spruce stands.

The following main measures can be recommended to ensure sustainability and biological diversity of the native stands when conducting rejuvenation cutting:

1. In absolutely uneven age stands (where 2 or 3 tree generations are present) the intensity of rejuvenation cutting can be as much as 30-35 per cent of the stock.

2. In relatively uneven age stands (with domination in stock of one generation) the intensity of cutting should not exceed 30 per cent; the mix of pine, birch and aspen should be preserved.

3. Damaged trees should not exceed 3 per cent of the trees left after thinning.

4. Fallen dead and standing dry trees should be left in place as much as possible.

5. The site of planned rejuvenation cutting should not border on forest-free ranges; strips of untouched forest of 70-100 meters width should be left as a border.

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Forest monitoring in the primaeval spruce forests in the National Park Vodlozersky

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Introduction

Monitoring value of native ecosystems within special protected areas generally depends on the rate of their preservation in natural state, their uniqueness or, on the contrary, ubiquity in a certain zone. National Park "Vodlozersky" nowadays is exceptional in the European part of Russia regarding the good state of preservation of primeval boreal forests. Spruce forests occupy 50,2% of the total forest covered area in the Park. Here they are accounted as a zonal type of vegetation and as a natural standart of biodiversity. From this point untouched or slightly disturbed primeval (climax) spruce forests are of great interest for the forest science.

The main goal of our work was to investigate biodiversity, state and structure of primeval spruce forests while having carried out forest monitoring at the series of permanent sample plots in the NP "Vodlozersky".

Objects and methods

Totally, to achive the goal mentioned above, six permanent sample plots in various forest types have been founded during last two years, including one plot (N1) in whortleberry-herbaceous type, three plots - in whortleberry type (N2, 5, 6) and two ones - in whortleberry-sphagnum type (N3, 4).

All trees thicker than 6.0 cm at a breast hight were numbered and marked on each rectangular sample plot. Precised age structure of the stands has been revealed as a result of determination of the real age of each tree by cores taken at a neckroot level. While recording all trees were sorted over species, diameter classes and spruce specimens also over age generations. Dead trees were accounted separately. Hights and diameters of 3-4 spruce trees were measured in each of 5 central diameter classes and of 1-2 trees in other ones. Concerning other species 3-4 trees within middle diameter classes and 1-2 trees in the rest ones were measured in the same manner.

In process of forest assesment all trees were depicted and classifyed over: state (sound, dead, damaged by fungi and so on), position in canopy (opened or closed tip), type of branching, colour and texture of the bark.

Assesment of self-regeneration was done within special plots with subdivision in hight and state (viable or unviable). Saplings younger than 3 years were recorded separately.

Geobotanical descriptions of ground cover were done at each permanent sample plot using common techniques (Программа и методика... 1966). For this purpose certain number of 1m² plots were established within each big plot on wich abundance (Drude) and projective cover (%), for *Sphagnum* mosses only projective cover, were recorded. Bryopsida mosses were determined by M. Boychuk (Institute of Biology Karelian Research Centre)

Soil cross-section was done at each permanent sample plot.

Results and discussion

High stocking uneven aged spruce stands of III-IV site classes were the subjects of our research (Table 1). The age of the basic (in terms of stock) generation amounted to 140-230 years. In composition of the investigated stands admixture of pine, birch and aspen amounted to 27%, dead trees - 26-76 specimens per hectar that means 9.4-28.2 m^3/ha. Volume of dead lying trees varied from 3 to 32,7 m^3/ha

Table 1 General information about permanent sample plots founded in the primaeval spruce forests in the NP "Vodlozersky"

N	Composition, %	Forest type	Age	Site class	Stock, m3/ha		Number of stems		Basal area, m2/ha
					growing	dead	growing	dead	
1	84Spr40-250 16Brch100	whortleberry-herbaceous	140	III	313,3	9,4	676	47	30,6
2	82Spr30-310 8Pn2304Brch100 6Asp110	whortleberry	230	IV	276,9	19,7	730	26	26,9
3	92Spr80-240 4Pn2204Brch80	whortleberry-sphagnum	180	IV	255,1	16,0	1065	85	29,5
4	78Spr80-350 15Asp100 6Brch901Pn200	whortleberry-sphagnum	200	IV	279,4	28,3	682	76	28,4
5	73Spr40-300 13Asp100 12Brch1002Pn200	whortleberry	180	III	319,3	18,4	697	50	29,9
6	82Spr30-300 12Asp110 2Brch1004Pn200	whortleberry	180	IV	265,8	28,2	370	28	22,4

Notes. Spr - spruce; Pn - pine; Brch - birch; Asp – aspen, 40-250 - age

Age structure of primeval stands is one of the most important parameters of their intraspecific biodiversity. It was founded that matured and overmatured spruce stands (older than 141 years) can be characterised as uneven aged phytocenosis with various types of age structures.

Comparatively uneven aged stands account for 48% of the spruce area in the Park, absolutely uneven aged ones - 36% and conditinally even aged ones - 16%, correspondently. This classification is based on the technique of Дыренков (1984).

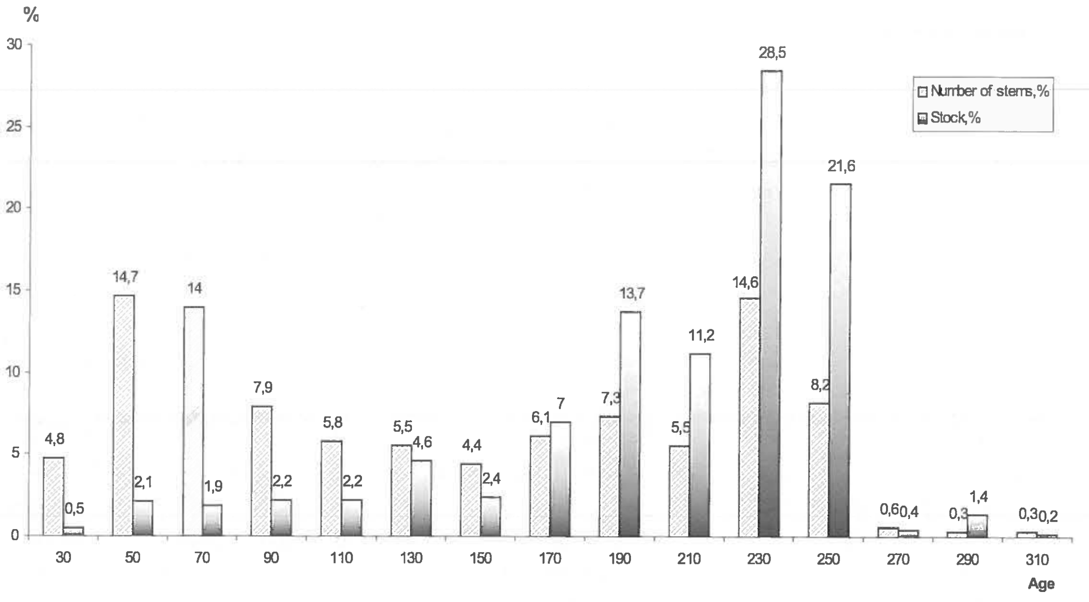

Fig. 1 Distribution of stems and stock by age classes in the whortleberry spruce stand (Plot N2)

Peculiarity of uneven aged stand is that it normally is formed by trees of various age. For example (plot N2) age of spruce specimens vary from 31 to 308 years (Fig.1). There are two maximums in the age class distribution of trees number: at the age of 50 and 230 years. The same picture we have in stock distribution with two maximums: at the age of 130 years and 230 years. In this stand three generations of spruce were distinguished. Admixture of pine, birch and aspen usually contribute to specific biodiversity of climax spruce forests.

Faultness of primeval forests is an important factor of their die off dynamics and biodiversity preservation. The quantity of spruce trees damaged by heart rot was 12-18% in number and 12-30% in stock (detected by cores). Such trees form a potential die off volume which in its turn creates microconditions for self-regeneration. Sometimes one can find up to 400 spruce seedlings growing on the upper parts of old laying trunks.

Self-regeneration (young growth) is of great value fo supplying the older spruce generations. Under the canopy of the investigated spruce stands from 1 to 9 thousand per hectar of spruce viable saplings were found with comparatively even spacing. The main role in this process belongs to large-size spruce saplings commonly amount to 0.5-1.5 thousand specimens per hectar. This is enough to provide sustainability and longevity of climax uneven aged spruce forests.

While studying biodiversity of climax spruce forests substantial attention was payed to biodiversity of ground cover. It was found that its species composition depends on the richness of growing site. The lowest level of specific diversity was found within whortleberry-sphagnum type. Its herbaceous-shrubby layer consisted of 13 species. Moss layer included 21 species with two indicators of primeval forests *(Sphagnum quinquefarium* and *S. wulfianum)* among them.

Sample plots N2,5,6 (whortleberry type) showed us a well developed moss layer where *Pleurozium schreberi, Hylocomium splendens* and 4 species of *Dicranum* prevailed. Herbaceous-shrubby layer also was well developed but not very rich in composition with prevailance of *Vaccinium myrtillus.*

Due to the fact of many big trees having been fallen by strong winds within plot N6 big spots of *Calamagrostis arundinacea* and *Vicia sylvatica,* preventing self-seeding of woody species were found. Some light demanding species such as: *Rubus idaeus, Lathyrus vernus* and indicator of primeval forests *Rhodobryum roseum* were also found.

Whortleberry-herbaceous spruce type (plot N4) appeared to be the richest one. Its herbaceous-shrubby layer was well developed and included 30 species.

Conclusions

1. Within the territory of NP "Vodlozersky" primeval spruce forests consist of stands with various age structures including two margnal positions: conditionally even aged stands and absolutelly uneven aged ones. Various intermediate age structures also could be found. The age of the basic (in terms of stock) generation amount to 140-230 years.

2. In natural conditions internal processes provide sustainability and constancy of primeval spruce stands existence and preservation of optimal level of biodiversity in such kind of ecosystems.

3. Primeval uneven aged spruce forests are not very rich in flora: 8 species of woody plants, 41 species of herbs and shrubs, 38 species of mosses

4. The most common are satellites of spruce forest such as: *Vaccinium myrtillus, Linnaea borealis, Trientalis europaea, Oxalis acetosella, Orthilia secunda* and *Maianthenum bifolium*. There found some sibirian species: *Carex globularis* and *Rosa acicularis* and the subnemoral species *Milium effusum, Paris quadrifolia* and *Convallaria majalis*. Within the moss layer a few indicators of climax forests were discovered: *Sphagnum quinquefarium, Sphagnum wulfianum* and *Rhodobryum roseum*.

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Topology-ecological classification of mire vegetation in the Republic of Karelia (Russia)

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Object

Characteristic of plant cover biodiversity at the coenotic level (β-diversity) is based on plant community classifications. The main goal of our investigations has been working out of a plant cover classification of Karelian mires and its comparison with the similar North Europe's classification.

Methods

There are several research schools and classification principles of plant communities: dominant, floristic and topology-ecological. Nowadays various statistic ordination methods analyzing both primary surveys and community groups (phytocoenon) for classification purposes are also widely used (Moen 1990, Pakarinen 1995). Topology-ecological classifications are put into practice in Scandinavian countries (Påhlsson 1994) and the North America (Jeglum 1991). We worked out a topology-ecological classification of vegetation for Karelian mires by means of the general principles of plant cover classification used in the Northern Europe (Påhlsson 1994). While distinguishing syntaxa of a different level we applied floristic and physiognomic criteria as well as ecological ones. Surveys were made in sample plots of 10-20 – 100 m², and abundance of species was evaluated upon Braun-Blanquet's 5-rank scale (Whittaker 1973). Associations are considered as the principle (the lowest) syntaxonomy unit in plant community classification of Karelian mires. Associations are distinguished according to the share of different ecological groups of species (totalling at 12) and dominating species of the main layers in community structure. The classification is three-leveled. Higher syntaxa (classes) are defined upon nutrient status: ombrotrophic, oligotrophic, mesotrophic and eutrophic. Associations are united into groups according to the degree of moisture: forested, hummock, carpet and hollow.

Results

A pool data base including 4 000 geobotany descriptions was made up and used for classification purposes. Topology-ecological plant cover classification of Karelia's mires (Kuznetsov 1998, Кузнецов 2000) including 51 associations (see Table) was worked out. Within many associations, sub-associations upon dominants of the moss layer (or its lack) and variants upon dominating species of the field layer were distinguished. Diagnostic species were determined for each association and the associations were named after 1-3 of them. In most cases they are the dominating plants of the general layers but in some multi-species eutrophic communities diagnostic species have higher occurrence and lower abundance. A general floristic composition, an average number of species in one survey (description) and a number of plants with a higher constancy (III-V classes or ranks) were identified for each association and its syntaxa. These parameters and lists of diagnostic and higher constant species allowed both to estimate a specificity of each syntaxon and to compare it with a similar group of plant communities from other regions.

Discussion

The prepared classification is fairly detailed and covers nearly the whole diversity of Karelian mire plant communities. This classification is of open structure and it is possible to add new associations and sub-associations to it or to revise the syntaxonomical status of the available species groups while new is data obtained. Data on the Karelian mire vegetation published earlier (Цинзерлинг 1932, Юрковская 1959) doesn't contain species composition tables and detailed characteristics of numerous minor associations (about 200) distinguished upon dominating species of the main layers. It impedes their usage. Similar minor associations were determined in Fennoscandia (Osvald 1923, Paasio 1941). Many of them correspond to sub-associations of our classification. At present, ecological-floristic classifications of mire communities are being rather intensively worked (Dierssen 1982, Rybnicek 1985, Moen 1990, Боч & Смагин 1993).

Distinguishing and characteristics of syntaxa in those classifications are quite complicated. We worked out a scheme of the same classification for the mire vegetation of Karelia (Kuznetsov et al. 2000). However, new associations distinguished in it are not validly published yet. A volume of many associations of our topology-ecological classification is rather close to the same associations determined by adherents of the above mentioned ecological-floristic classifications.

We compared topology-ecological classifications of Karelia and the North Europe countries (Table). Four-stepped mire vegetation classification of the North Europe includes 63 types of mire communities. All the types are distinguished according to vegetation features and they are simple communities different from mire types of Finnish classifications (Eurola et al., 1984) which include complex mire sites (ridge-hollow, flark-string etc.) with several plant communities.

Types are united into groups, which are close to ours. There are some differences in class distinguishing available. We do not distinguish the class of spring communities and include them into the eutrophic class as a group.

Type volume varies much in the North European mire plant cover classification. In the ombrotrophic class types they are very small and close to sub-associations of the Karelia's classification. On the other hand, many mesotrophic and eutrophic types (especially carpet and flark herb, grass and grass-moss) of the North European classification are very large and consist of a wide range of plant communities. According to the Karelian classification they are referred to several associations. The table clearly shows that every syntaxon of the Karelian classification is marked with a digital index corresponding to a similar syntaxon of the North European classification. Thus all the mire plant associations of Karelia have their own places in the total North Europe classification although a syntaxonomy status of them is often different.

The whole range of mire communities which is characteristic of mountain, tundra and maritime regions of the North Europe is lacking. A number of mire communities has area limits in Karelia: the eastern limits of plant communities with a dominance of *Molinia caerulea, Rhynchospora fusca, Schoenus ferrugineus, Sphagnum pulchrum*, and the western limits of *Chamaedaphne calyculata, Carex omskiana, Bistorta major* and some others.

Our classification will be further extended and enhanced by including data on the adjacent territories of the Russian North and Fennoscandia. It will allow making a more complete and unbiased assessment of diversity of mire communities in the North Europe and solving problems of their protection.

Table Classification of mire plant communities of Karelia with characteristic of species content in syntaxa (A-D) and its correspondence with classification of north Europe (E) A - number of releves, B – total number of species in syntaxa, C – average number of species in I releve, D - number of species with III-V classes of occurrence; E – code of syntaxa in classification of north Europe (after Påhlsson 1994)

CODE	SYNTAXA	A	B	C	D	E
I	**CLASS** : OMBROTROPHIC					3.I
I.I	**Group** : wood-moss					3.I.I
	Association :					
I.I.I..	Pinus sylvestris - Ledum palustre – Sphagnum angustifolium	39	60	18	20	3.I.I.2
I.I.2.	Pinus sylvestris – Chamaedaphne calyculata - Sphagnum spp.	232	55	17	15	3.I.I.3
	Subassociation :					
I.I.2.I.	P. sylvestris – C.calyculata - S.fuscum	81	55	18	20	
I.I.2.2.	P. sylvestris – C.calyculata – S.angustifol.	151	53	16	15	
I.2.	**Group** : hummock					3.I.2
I.2.I.	Chamaedaphne calyculata – Sphagnum fuscum	598	70	15	17	3.I.3.I (partly)
I.2.2.	Chamaedaphne calyculata - Sphagnum angustifolium	580	55	15	II	3.I.3.I (partly)
I.2.3.	Calluna vulgaris - Cladina spp.	135	65	19	18	3.I.2.2
I.3.	**Group** : carpet					3.I.3
I.3.I.	Eriophorum vaginatum – Sphagnum spp.	324	70	10	7	3.I.3.5, 3.I.4.I
I.3.I.I.	E.vaginatum - S. balticum	210	66	9	9	
I.3.I.2.	E.vaginatum - S.majus	22	38	9	7	
I.3.I.3.	E.vaginatum - S.papillosum	50	48	13	12	
I.3.I.4.	E.vaginatum - S.lindbergii	9	38	II	7	
I.3.I.5.	E.vaginatum - S.fallax	23	43	10	9	
I.3.I.6.	E.vaginatum - S.flexuosum	10	38	14	9	
I.4.	**Group** : hollow					3.I.4
I.4.I.	Baeothryon cespitosum – Sphagnum spp.	21	38	12	10	3.2.3.Ib
I.4.I.I.	B.cespitosum - S.balticum	12	38	12	10	
I.4.I.2.	B.cespitosum - S.majus	9	28	II	II	
I.4.2.	Scheuchzeria palustris - Sphagnum spp.	384	55	10	7	3.I.4.I-3.I.4.4
I.4.2.I.	S.palustris - S.balticum	II6	50	9	7	
I.4.2.2.	S.palustris - S.majus	153	45	7	6	
I.4.2.3.	S.palustris - S.papillosum	38	47	13	12	
I.4.2.4.	S.palustris - S.lindbergii	19	31	10	9	
I.4.2.5.	S.palustris - S.cuspidatum	18	23	8	4	
I.4.2.6.	S.palustris - S.fallax	31	45	10	10	
I.4.2.7.	S.palustris - S.jensenii	9	23	8	7	
I.4.3.	Rhynchospora alba – Sphagnum spp.	14	21	8	6	3.I.4.I-3.I.4.4
I.4.3.I.	R.alba - S.balticum	3	17	9	5	
I.4.3.2.	R.alba – S..majus	8	18	7	8	
I.4.3.3.	R.alba - S.cuspidatum	3	12	7	5	

CODE	SYNTAXA	A	B	C	D	E
1.4.4.	Scheuchzeria palustris – Hepaticae	10	24	8	8	3.1.4.5
2.	**CLASS :** OLIGOTROPHIC					3.2, 3.3
2.1.	**Group**: wood-grass-moss					3.2.1, 3.3.1
2.1.1.	Pinus sylvestris - Carex lasiocarpa - Sphagnum spp.	119	115	22	15	3.2.1.3 (partly)
2.1.1.1.	P. sylvestris – C.lasiocarpa -S.angustifol.	91	115	21	16	
2.1.1.2.	P. sylvestris – C.lasiocarpa - S.fallax	7	59	23	25	
2.1.1.3.	P. sylvestris – C.lasiocarpa - S.flexuosum	6	66	24	22	
2.1.1.4.	P. sylvestris – C.lasiocarpa - S.centrale	15	96	21	17	
2.1.2.	Betula pubescens – Carex lasiocarpa - Sphagnum spp.	35	100	18	10	3.2.1.3
2.2.2.1.	B. pubescens – C. lasiocarpa - S.angustifolium	29	97	17	10	
2.1.2.2.	B. pubescens – C. lasiocarpa - S.centrale	6	64	23	16	
2.2.	**Group** : hummock					3.2.2
2.2.1.	Carex lasiocarpa - Sphagnum fuscum	110	103	20	22	3.2.2.1
2.3.	**Group** : carpet					3.2.3, 3.3.3
2.3.1.	Molinia caerulea - Sphagnum papillosum	141	113	20	15	3.3.2.1, 3.2.3.1b
	Variant : a. Molinia caerulea	63	100	22	17	
	b. Baeothryon alpinum	15	56	15	12	
	c. Baeothryon cespitosum	63	83	20	14	
2.3.2.	Carex lasiocarpa - Sphagnum spp.	503	120	16	11	3.2.4.1a 3.2.3.1a
2.3.2.1.	C.lasiocarpa - S.angustifolium	238	108	17	11	
2.3.2.2.	C.lasiocarpa – S.papillosum	141	115	17	13	
2.3.2.3.	C.lasiocarpa – S.fallax	67	93	14	9	
2.3.2.4.	C.lasiocarpa – S.flexuosum	25	50	11	10	
2.3.2.5	C.lasiocarpa – S.centrale	23	61	16	12	
2.3.3.	Carex rostrata - Sphagnum spp.	131	68	11	10	3.2.4.1a
2.3.3.1.	C.rostrata - S.angustifolium	27	42	10	11	
2.3.3.2.	C.rostrata - S.fallax	53	65	11	11	
2.3.3.3.	C.rostrata - S.papillosum	42	59	12	11	
2.3.3.4.	C.rostrata - S. riparium	9	56	14	9	
2.4.	**Group : flark**					3.2.4 3.3.3(part)
2.4.1.	Carex lasiocarpa - Scheuchzeria palustris - Sphagnum spp.	46	58	13	15	3.2.4.1 (partly)
2.4.1.1.	C. lasiocarpa – S. palustris - S.balticum	24	57	15	17	
2.4.1.2.	C. lasiocarpa – S. palustris –S.majus	22	52	10	7	
2.4.1.3.	C. lasiocarpa – S. palustris –S.jensenii					
2.4.2.	Carex rostrata – Scheuchzeria palustris - Sphagnum spp	81	58	11	10	3.2.4.1 (partly)
2.4.2.1.	C. rostrata – S. palustris –S.balticum	30	56	11	11	
2.4.2.2.	C. rostrata – S. palustris -S.majus	33	52	10	7	
2.4.2.3.	C. rostrata - S. palustris –S.flexuosum	18	35	11	9	
2.4.3.	Rhynchospora alba – Menyanthes trifoliata – Sphagnum spp.	9	38	14	15	-
2.4.4.	Eriophorum polystachion	6	26	11	9	3.2.4.2
2.4.5.	Carex rostrata	17	69	12	8	3.3.3.1

CODE	SYNTAXA	A	B	C	D	E
3.	**CLASS :** MESOTROPHIC					3.3, 3.4
3.1.	**Group :** wood-grass					3.4.1
3.1.1.	Alnus glutinosa – Calla palustris	5	102	36	19	3.4.1.3
3.1.2.	Picea abies – Calamagrostis canescens	18	145	45	38	3.4.1.2 3.3.1.2
	a. Calamagrostis canescens	9		48		
	b. Phragmites australis	9		42		
3.1.3.	Pinus sylvestris – Calamagrostis canescens	10	124	34	23	3.4.1.1 3.3.1.1
3.1.4.	Betula pubescens – Calamagrostis canescens	13	120	26	20	3.4.1.2
3.1.5.	Salix cinerea	2				3.3.1.3
3.4.	**Group :** flark and swamp					3.3.4(par) 3.4.4(par))
3.4.1.	Phragmites australis – Menyanthes trifoliata	11	65	12	7	3.3.4.1
3.4.2.	Carex acuta	8	55	17	9	3.4.4.1
3.4.3.	Carex omskiana	10	47	16	10	-
3.4.4.	Carex cespitosa	14	90	16	7	3.4.4.1
3.4.5.	Carex diandra	8	56	23	20	3.4.4.1
3.4.6.	Carex chordorrhiza	24	52	11	9	3.3.3.1
3.4.6.1	C.chordorrhiza – Menyanthes trifoliata	17	48	11	8	
3.4.6.2	C.chordorrhiza – Sphagnum obtusum	7	23	11	11	
3.4.7.	Carex lasiocarpa – Menyanthes trifoliata	211	150	16	5	3.3.3.1
3.4.7.1.	C.lasiocarpa – M.trifoliata	147	150	15	5	
3.4.7.2.	C.lasiocarpa – Comarum palustre	13	100	21	12	
3.4.7.3	C.lasiocarpa – Sphagnum obtusum	9	46	15	12	
3.4.7.4	C.lasiocarpa – S.riparium	8	70	19	10	
3.4.7.5.	C.lasiocarpa – S. subsecundum	19	75	16	9	
3.4.7.6.	C.lasiocarpa – Warnstorfia exannulata	8	71	21	14	
3.4.7.7.	C.lasiocarpa – Hamatocaulis vernicosus	7	73	16	10	
3.4.8.	Carex limosa – Menyanthes trifoliata	163	80	12		3.3.3.1
3.4.8.1.	C. limosa – M.trifoliata	121	77	12	8	
3.4.8.2	C. limosa – Sphagnum obtusum	15	52	14	12	
3.4.8.3.	C.limosa –S. subsecundum	18	52	14	12	
3.4.8.4.	C.limosa – Warnstorfia exannulata	8	33	10	6	
3.4.9.	Rhynchospora fusca	21	28	12	13	3.3.3.4
3.4.10.	Calamagrostis neglecta	5	52	13	2	3.3.4.1
3.4.11.	Equisetum fluviatile	22	87	12	6	3.3.4.1
3.4.12.	Menyanthes trifoliata	9	63	17	14	3.3.4.1
3.4.13.	Comarum palustre	9	67	18	15	3.3.4.1
4.	**CLASS :** EUTROPHIC					3.4
4.1.	**Group :** wood-moss					3.4.1(par)
4.1.1.	Pinus sylvestris – Sphagnum warnstorfii	41	178	32	25	3.4.1.1
	a. Phragmites australis	14	149	39	28	
	b. Carex lasiocarpa	12	96	26	19	
	c. Molinia caerulea	15	117	30	27	
4.2.	**Group :** hummock					3.4.2
4.2.1.	Equisetum palustre - Sphagnum warnstorfii	58	186	33	19	3.4.2.1a

CODE	SYNTAXA	A	B	C	D	E
4.2.1.1.	E.palustre – S. warnstorfii	51	186	34	19	
	a. Equisetum palustre	26	147	29	21	
	b. Polygonum bistorta	25	145	39	19	
4.2.1.2.	E.palustre - Tomenhypnum nitens	7	77	21	16	
4.2.2.	Molinia caerulea - Sphagnum warnstorfii	71	120	21		3.4.2.1a
4.2.2.1.	M.caerulea – S. warnstorfii	48	120	22	16	
	a. Molinia caerulea	30	116	24	16	
	b. Baeothryon cespitosum	6	50	21	18	
	c. Baeothryon alpinum	12	74	21	19	
4.2.2.2.	M.caerulea – S.subfulvum	23	68	20	21	
4.2.3.	Carex lasiocarpa - Sphagnum warnstorfii	89	130	18		3.4.2.1a
4.2.3.1.	C.lasiocarpa – S.warnstorfii	70	129	18	16	
	a. Carex lasiocarpa	54	121	19	13	
	b. Phragmites australis	16	65	16	13	
4.2.3.2.	C.lasiocarpa – S.teres	9	62	18	15	
4.2.3.3.	C.lasiocarpa - S.subfulvum	10	30	14	13	
4.3.	**Group :** carpet					3.4.2
4.3.1.	Carex lasiocarpa - Campylium stellatum	29	105	21	14	3.4,2,1b
4.3.2.	Schoenus ferrugineus - Campylium stellatum	22	58	17	13	3.4.2.1c
4.4.	**Group :** flark					3.4.3
4.4.1.	Carex lasiocarpa - Scorpidium scorpioides	20	68	15	9	3.4.3.3
4.4.2.	Carex limosa - Scorpidium scorpioides	12	50	14	14	3.4.3.3
4.4.3.	Carex livida – Menyanthes trifoliata	70	75	11	11	3.4.3.3
4.4.3.1.	C.livida – M. trifoliata	60	75	11	12	
4.4.3.2.	C.livida – S.scorpioides	10	35	13	9	
4.5.	**Group :** spring					3.5.1, 3.5.2
4.5.1.	Epilobium hornemannii - Montia fontana - Philonotis fontana					3.5.1.2
4.5.2.	Cratoneuron spp.					3.5.2.2
4.5.3.	Paludella squarrosa					3.5.2.3

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Biodiversity of dystrophic bogs in Russian taiga

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Introduction

Dystrophic raised bogs are widely distributed mainly in the north of taiga zone and in its suboceanic regions. The term "dystrophic" has been proposed by V.D. Lopatin in order to emphasize the extreme deficiency in nutritions in this group of bogs, to distinguish them from oligotrophic bogs.

Objectives

The task of the present communication is the analysis of biodiversity and revealing the specificity of regional mire types of this group.

Methods and materials

In the effort to analyse the vegetation cover of mires the traditional methods have been used: geobotanical releves, peat analysis, aerial and space photographs, as well as the results of compiling and analysing the vegetation maps. The cartographical method is an irreplaceable source of biodiversity analysis since only this method gives an idea of the location of various syntaxonomical and chorological units in space. Faunistic samples have been obtained by filtering samples of water (in most cases 25 l) through a plancton net (gauze N 65). The samples were treated by the traditional methods common in fresh-water hydrobiology. The detailed study of diversity was carried out on mires of the Arkhangelsk District (the North-east European type) and in Karelia (the South White Sea type). The species composition, structure of phytocoenoses, quantitative characteristics (abundance/coverage) of species, ground-water table and values of PH were studied. For microfauna the species composition and stages of ontogenesis were studied, and the numbers per $1m^3$ were calculated. Distribution areas of all types of mire massifs were assigned according to Растительность СССР (1990), the section "Mires" of which was compiled by Юрковская (1989).

Results and discussion

According to their vegetation we unite dystrophic bogs into the group of liverwort-lichen-*Sphagnum* bogs. They are widespread throughout Russia from the Gulf of Finland coast in the west up to the sea shore of Western Kamchatka in the east. Some regional types of dystrophic bogs are distinguished: the East Baltic Sea, South White Sea, North-east European, North Middle Ob', Sakhalin, and West Kamtchatka.

They always form large mire massifs. Their development is connected with extensive drainage areas (Fig.1). The slowing-down of exchange processes is characteristic of bogs in general, and especially in this group of bogs, peat formation almost ceases. *Sphagnum* mosses, that not long ago made up the main biomass of these bogs, are replaced by lichens, liverworts and algae.

Species composition in dystrophic habitats is the most conservative. There are 18-20 species of vascular plants, 20 species of *Sphagnum* mosses and some other species of Bryidae, 15 species of liverworts, and 15-20 of lichens (Table 1). Among them only few species are widely distributed. There are still less to be edificator species.

Fig. 1 Aerial photo of a bog of the South White Sea type

Table 1. Plant species of dystrophic bogs. Studied sites: 1 White Sea coast, 2 Arkhangelsk District; Species distributed: r rarely; + sparsely; ++ frequently; * dominants; " - " absence of species. Liverworts have been studied only in 1.

District; Species distributed: r rarely; + sparsely; ++ frequently; * dominants; " - " absence of species. Liverworts have been studied only in 1.

Species	1	2
Pinus sylvestris	+	+
Andromeda polifolia	++	++
Betula nana	+	+
Calluna vulgaris	++*	-
Chamaedaphne calyculata	+	++*
Empetrum nigrum	++*	++
Ledum palustre	+	++
Oxycoccus microcarpa	++	++
O. palustre	++	++
Vaccinium myrtillus	r	+
V. uliginosum	+	++
V. vitis-idaea	+	+
Rubus chamaemorus	++*	++*
Drosera anglica	++	++
D. rotundifolia	++	++
Carex limosa	+	++*
C. pauciflora	+	+
C. rariflora	++*	-
Eriophorum russeolum	-	++*
E. vaginatum	++*	++*
Rhynchospora alba	+	-
Trichophorum cespitosum	++*	++*

District; Species distributed: r rarely; + sparsely; ++ frequently; * dominants; “ - “ absence of species. Liverworts have been studied only in I.

Species	I	2
MOSSES		
Sphagnum angustifolium	++	++
S. aongstroemii	+	+
S. balticum	++*	++*
S. capillifolium (S. nemoreum)	++	++
S. compactum	+	+
S. cuspidatum	r	-
S. fallax +	+	
S. fuscum	++*	++*
S. lindbergii	++*	++*
S. magellanicum	+	+
S. majus ++*	++*	
S. russowii	+	+
S. papillosum	+	+
Aulacomnium palustre	++	+
Dicranum bergeri	++	++
D. elongatum	+	-
Pleurozium schreberi	++	++
Pohlia nutans	++	++
Polytrichum strictum	++	+
Warnstorfia fluitans (Drepanocladus fluitans)	+	+
Aneura pinguis	+	
Calypogeia neesiana	+	
C. sphagnicola	+	
Cephalozia bicuspidata	++	
C. connivens	+	
Cephaloziella sp.	++	
Cladopodiella fluitans	++*	++*
Gymnocolea inflata	++*	++*
Kurzia pauciflora	+	
Lophozia ventricosa	+	
Mylia anomala	++*	++*
Odontoschisma denudatum	+	
LICHENES		
Cladonia arbuscula	++*	++*
C. botrytes	+	-
C. cornuta	+	+
C. crispata	+	+
C. deformis	+	+
C. digitata	+	+
C. furcata	+	+
C.pyxidata	+	+
C. rangiferina	++*	++*
C. stellaris	++*	++*
Cetraria ericetorum (C.tenuifolia)	+	+
C. islandica	++	+
C. nivalis	+	-
Cetrariella delisei	++	++
Icmadophila ericetorum	++	-

The analysis of the biodiversity of the invertebrate fauna, carried out in the bogs on the White Sea coast, has given analogous results. 1-2 guiding species are dominants and make up the main body of the mass in biocoenoses. In highly dystrophic water bodies (pools, hollows) the specific acidophilous species and species of wide ecological range are distributed. The latter are highly decreased in size as compared with common species of lakes. Inhabitants of poorly watered hollows are acidophilous or sphagnophilous species. The microfauna of such hollows is extremely poor in species, but rich in number at the cost of guiding species (often monoforms). In the last case there is a full analogy with vegetation. For instance, in hollows (association *Trichophorum cespitosum - Sphagnum balticum*) the microfauna is represented by only two species of Crustacea: *Alonella excisa* (Fisch.) and *Acanthocyclops longuidoides* Lill. (Table 2), but their population density is very high, especially that of the first species (350 thousand individuals/m^3). Identical density is characteristic of two dominants of the vegetation cover, especially of *Sphagnum*. Its coverage is almost 100% and it prevails in phytomass.

The connections in the distribution of invertebrates were observed not with concrete phytocoenoses but with their ecological groups. The number of invertebrates increases with the increase of moistening of hollows and loosening of *Sphagnum* cover. Their maximal diversity was observed not in pool but in hollows of *Scheuchzeria palustris-Sphagnum* communities (more than 25 species). As to biomass, Crustacea prevail everywhere, but as to species number, their quantity is equal or gives up place to other groups (Rotatoria, Insecta, Vermes) in pools and hollows with loose cover. In the studied habitats 51 taxa are recorded in total (Table 2), which considerably exceeds the diversity of vascular plants and mosses in corresponding phytocoenoses, which achieves as little as 25 species.

Table 2. List of microfauna species

Name of taxon	2	3	4	5	6
VERMES					
Nematoda	-	+	+	-	-
Oligochaeta	-	-	+	-	-
ROTATORIA					
Bdelloidea	-	+	-	+	+
Keratella paludosa (Lucks)	-	+	+	-	-
Euchlanis triquetra Ehrb.	-	-	+	-	-
Euchlanis sp.	-	-	+	-	-
Trichotria truncata (Whit.)	-	+	+	-	-
Lecane (Lecane) luna (O.F.Muell.)	-	-	-	+	-
L. (Monostyla) lunaris (Ehrb.)	-	+	-	-	+
Lecane sp.	-	-	+	-	-
Notommata allantois Wulf.	-	+	-	-	-
Monommata grandis Tessin	-	+	+	-	-
Trichocerca parvula Carlin	-	-	-	+	+
T. longiseta (Schr.)	-	-	+	-	-
Trichocerca sp.	-	-	-	-	+
Ploesoma triacanthum (Berg.)	-	-	-	+	+
P. truncatum (Lev.)	-	-	+	-	+
INSECTA					
Collembola	-	+	-	-	-
Odonata larvae	-	-	+	-	-
Hemiptera (Rhynchota)	-	-	-	-	+
Diptera larvae	-	-	-	-	-
Trichoptera larvae	-	-	-	-	-
Tendipedidae larvae	-	+	+	+	+

Name of taxon	2	3	4	5	6
Orthocladiinae	-	-	-	-	+
Psectrocladius gr.dilatatus v.d. Wulp.	-	-	-	-	+
P. gr. medium Tshernovskij sp. n.	-	-	-	-	+
Corynoneura sp.	-	-	+	-	-
Ablabesmyia fulva Kieff	-	-	+	-	-
Terdigradae	-	+	+	-	-
CRUSTACEA					
Cladocera					
Holopedium gibberum Zaddach	-	-	-	-	+
Scapholeberis microcephala Lill.	-	-	+	-	-
Bosmina obtusirostris Sars.	-	-	-	-	+
Streblocerus serricaudatus (Fisch.)	-	-	+	-	-
Acantholeberis curvirostris (O.F.Muell.)	-	-	+	-	-
Acroperus harpae (Baird)	-	-	-	+	+
Alonopsis elongata (Sars)	-	-	-	-	+
Rhynchotalona rostrata (Koch)	-	-	+	-	-
Alona costata Sars	-	-	+	-	-
Alonella excisa (Fisch.)	+	+	+	-	+
Chydorus sphaericus (O.F.Muell.)	-	-	-	+	+
Ch. sphaericus var. caelatus Schoedler	-	-	-	+	-
Ch. ovalis Kurz	-	+	+	-	+
Chydorus sp.	-	-	+	-	-
Polyphemus pediculus (Linne)	-	-	+	+	+
Cyclopoida					
Acanthocyclops longuidoides Lill.	+	+	-	-	-
A. longuidoides var. eriophori Gurney	-	-	+	-	-
Cop. st. Cyclopoida	-	+	+	+	-
Nauplii Cyclopoida	-	+	-	+	+
Harpacticoida					
Arcticocamptus arcticus (Lill.)	-	+	+	+	-

Note. Hollows: 2 - with dense moss cover; 3,4 - with loose moss cover. Pools - 5,6.

Vegetation diversity increases on the phytocoenotical and supraphytocoenotical levels. The diversity of vegetation cover of dystrophic bogs is accounted for their pattern (frequent alternation of the community fragments within restricted area), complexity phenomena, complicated by denudation processes. Sometimes 8-9 communities and their fragments, belonging to different syntaxonomical categories, are presented within the area of 100 m^2. A characteristic feature of the vegetation structure of a dystrophic bog and its surface is the presence of significant areas free of vegetation, e. g. pools, erosion hollows, funnels, spots of bare peat, etc.

It is also remarkable that on ridges microdepressions appear with plants alien to the vegetation of the ridges themselves. We have observed different developmental stages of such microcoenoses - future hollows in their infancy. A part of them is revegetated again by lichens and *Sphagnum fuscum,* the other part is being separated from ridges and joining to neighbouring hollows; otherwise the ridge may divide to pieces, and thus new hollows appears. In such a way the area of hollows increases and that of ridges decreases.

Let's pay attention also to another phenomenon, characteristic of tops in such bogs. The tops are usually flat or even a bit concave. Their vegetation has a composition unusual to a normal raised bog, being composed by meso-oligotrophic or even eutrophic species. So, according to our observations in the Arkhangelsk District, moss cover on tops is formed by *Sphagnum papillosum* and the grass layer is dominated by

Drosera anglica, Carex limosa and *Menyanthes trifoliata.* The upper layer of peat deposit under such vegetation (up to 1 m depth) is composed of *Sphagnum* transitional peat overlying the raised bog peats. These data point to the fact of regeneration of destroyed vegetation cover. Григялите & Сейбутис (1969) described such kind of deposit in Lithuania for the first time and named it as "regressive" one. In contrast, I believe that in the above phenomenon we deal with regeneration or restoration of oligotrophic state after eutrophic "indignation", caused by a long dystrophic stage of bog development.

Despite the complicated structure of the vegetation cover, diverse habitats, a great number of various complexes and combinations of plant communities, the regional types of mire massifs differ from each other by only a few differential species of different geographical range. For instance, *Calluna vulgaris, Rhynchospora alba, Sphagnum magellanicum, S. rubellum* and *S. cuspidatum* are typical in the East Baltic Sea bogs, *Calluna vulgaris, Carex rariflora* and *Sphagnum lindbergii* in the South White Sea bogs, *Chamaedaphne calyculata* and *Eriophorum russeolum* in the North-east European bogs, *S. lenense* in Sakhalin, *Carex middendorfii* in the West Kamtchatka and *Pinus sibirica* in West Siberia (North Middle Ob type of mire massif).

Conclusions

The analysis of dystrophic bogs of Russia showed the low level of species diversity, which is true both for flora and microfauna. The high population density of a few species is recorded. Diversity increases at the syntaxonomical and especially at the supraphytocoenotical levels due to the peculiarities of the vegetation cover composition. Regional types of dystrophic raised bogs differ from each other only in few species of different geographical range. The significance of cartographic methods for the biodiversity analysis is emphasized.

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Application of cartographic approach to the study of the vegetation of Polisto-Lovat mire system

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Introduction

As a result of work on the project " Investigation of biodiversity of protected mire systems of the north-west of Russia ", grant №1516/1999 RSS the territory of Polistovsky reserve (Pskov region, Russia) was studied. The reserve is located 300 km to the south from St. Petersburg. It is created in 1994/95 for protection of the western part of Polisto-Lovat mire system, which is a unique natural object. Its eastern part was taken under protection earlier, when the Rdejsky reserve was created (Novgorod region).

Polisto-Lovat mire system is the largest one in the North-West of the European Russia. It is situated in the southern part of the Priilmen Lowland on the watershed of the Polist and Lovat Rivers. The total area of the mire system is estimated to be 93 000 hectares. The mire system consists of several mire massifs. It has been formed by the overgrowth of shallow lakes on a place of a huge post-glacial reservoir. The process of mire development accelerated during the Subatlantic period of the Holocene. The geological and geomorphologic factors as well as humid climate promoted this process.

The maximum depth of the mire system is more than 8 metres. The average depth is 3,3 m. The peat deposits are mainly composed of *Sphagnum* peat. *Sphagnum magellanicum* peat prevails all over the mire.

The mire system gives a start to some rivers. There are underground watercourses too. The Polisto-Lovat mire system has more than 20 lakes located in groups. They are shallow with a peat bottom. There are numerous sand islets, which are scattered on mire territory.

Polisto-Lovat mire is a typical raised bog system. Its margin parts are transitional mires. Юрковская (1992) considers the Polisto-Lovat mire system to belong to the Western-Russian type of bogs of taiga zone. The mire system consists of many bog structures in various stages of development, with a number of local convex centers and outlet streams. Hummock-hollow complexes are situated on mire slopes, surrounding local centers. About half of the mire system is occupied by pool bog sites.

Located on the border of southern taiga subzone and coniferous-broad-leaved forest subzone, the system contains western elements of vegetation cover (*Calluna vulgaris* (L.) Hull, *Sphagnum tenellum* (Brid.) Perss. ex Brid., *S. rubellum* Wils. and *S. cuspidatum* Ehrh. ex Hoffm.) as well as eastern ones (*Chamaedaphne calyculata* (L.) Moench and *Sphagnum majus* (Russ.) C.Jens). Besides, there are northern elements like *Betula nana* L., *Sphagnum jensenii* H.Lindb. and *S. lindbergii* Schimp. ex Lindb (Богдановская-Гиенэф 1933). *Betula nana* and *Sphagnum lindbergii* are on the southern border of their distribution here.

The Polisto-Lovat mire system is on the Ramsar Shadow List of the Russian Federation.

Methodology

The territory of Polistovsky reserve was investigated during two field seasons using the method of geobotanical profiles. Each profile consisted of plots. The full geobotanical descriptions of communities were carried out for all plots. They had exact geographical coordinates (GIS, topographic maps).

The creation of a legend to the vegetation map of Polistovsky reserve was preceded by classification. The dominant approach traditionally used by Russian geobotanical school was applied to the description of vegetation. The abundance and covering of species of vegetation cover were recorded. The geobotanical descriptions of mire vegetation were put into tables, then they were grouped on the basis of the similarity of floristic composition and structure dominant species. The classification of the descriptions was carried out with the use of the dominant approach. The floristic classification of the Braun-Blanquet school was tested on the same descriptions.

Remote sensing methods are applied to study mire massifs and mire systems. Black and white aerial photographs of different scales and a colour satellite image were used. The aerial photographs were interpreted in laboratory, and the directions of field study routes were planned using them. Vegetation patterns were delimited using the aerial photographs as a sketch map, and checked during the field work. The method of aerial photo interpretation is usually used for vegetation mapping. It is a necessary tool for compiling of maps in different scales. The application of computer technologies considerably facilitates this process. GeoDraw 1.14 and Geograph 1.5 for Windows programs, created by the Moscow Institute of Geo information Researches, were used.

The geobotanical profiles were made with the principle to visit a maximum number of diverse patterns for one route. The geobotanical descriptions were carried out repeatedly in different communities for the subsequent classification. Herbarium of *Sphagnum* mosses, lichens and liverworts were collected for each plot. In the course of the work, the preliminary map was covered by a network of point-keys, which were used for extrapolation of their contents in patterns.

Results and discussion

The western part of Polisto-Lovat mire system contains a number of microlandscapes: lagg, sedge-sphagnum zone, hummock-hollow complex; dwarf shrub-cottongrass-*Sphagnum* bog with rare pine and a hollow-pool complex (Fig. 1).

The vegetation of the western part of Polisto-Lovat mire system has a complex character. Ombro-oligotrophic sites with hummock-hollow and hummock-pool complexes are widely distributed. Dwarf shrub-cottongrass-*Sphagnum* communities with pine occupy the hypsometric tops of the bog. The bog is forested by *Pinus sylvestris* f. *litwnowii* and f. *wilkomii*. Wooded sites alternate with open sites or sites with dead trees.

The marginal parts are occupied by mesotrophic communities. Lagg is well-developed in the western border of the mire system. Being rather wide along Ratcha elevation, it is gradually narrowed to the south. Lagg (margin fen) has a width up to 100 m. It is characterized by herb-sedge vegetation (*Comarum palustre* L., *Carex nigra* (L.) Reichard and *Equisetum fluviatile* L.) with sparse black alder (*Alnus glutinosa* (L.) Gaertn). This site is the richest with nutrient conditions. The following site is the mesotrophic sedge-*Sphagnum* zone (*Carex rostrata* Stokes and *Sphagnum fallax* (Klinggr.) Klinggr). It is changed into dwarf shrub (*Calluna vulgaris*, *Oxyccocus palustris* Pers., *Rubus chamaemorus* L. and *Andromeda polifolia* L.), cottongrass (*Eriophorum vaginatum* L.), *Sphagnum* (*S. magellanicum* Brid., *S. angustifolium* (Russ. ex Russ.) C.Jens. and *S. fuscum* (Schimp.) Klinggr.) communities with sparse pine stands. In the mire centre there is an oligotrophic bog.

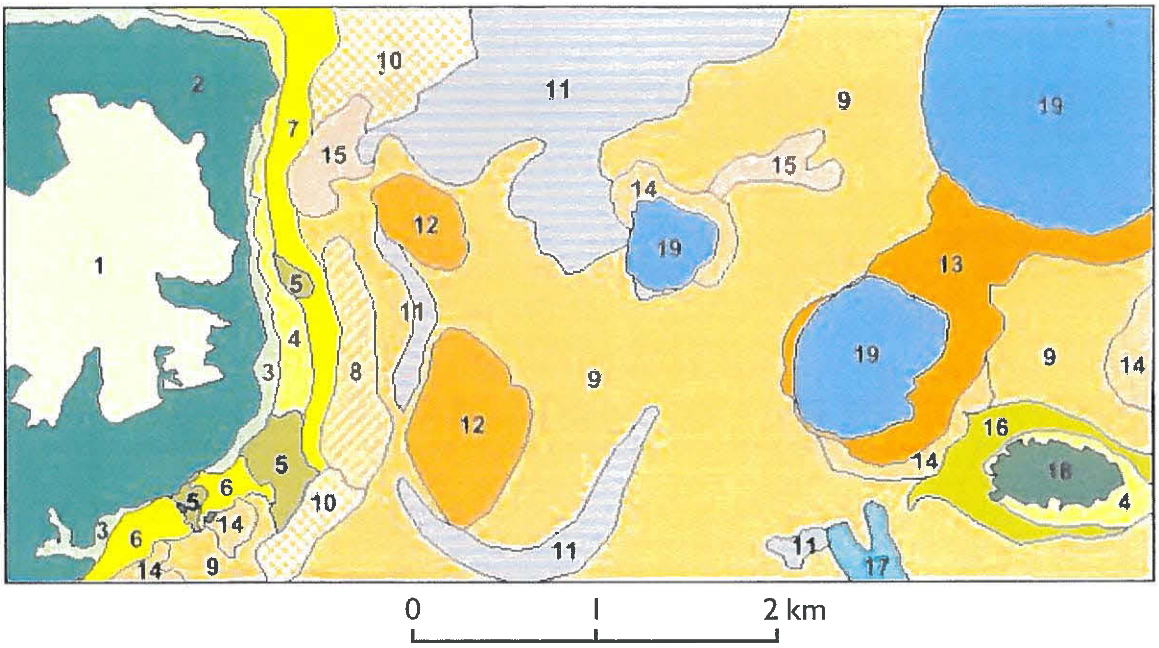

Fig. 1. A fragment of the Vegetation map of Polistovsky Reserve. 1. Agricultural fields; 2. Birch-aspen forests and shrubs; 3. Lagg; 4. Sedge fen; 5. Herb-sedge fen; 6. Treeless cottongrass bog; 7. Hummock-hollow complex being formed; 8. Hollow complex with sparse hummocks; 9-10. Hummock-hollow complexes; 11. Ridge-hollow-pool complexes; 12. Wooded raised bog; 13. Bog pine forest; 14. Pine bog; 15. Bog with sparse pines; 16. Wet bog hollow complex; 17. Overgrown bog stream; 18. Mineral soil islands; 19. Relic lakes.

Hummock-hollow complex is allocated in a narrow strip on the slope to the Ratcha.

The local centre is a wooded raised bog, where *Chamaedaphne calyculata* and *Ledum palustre* L. prevail. Lichens *Cladonia arbuscula* (Wallr). Flot. ssp. *mitis* (Sandst). and *Cladonia fimbriata* (L). Fr. are common. I found *Cladonia glauca* Flörke, a new species for the Pskov region, on the bogs (determined by Olga Katenina).

To the north from Ratcha the mire can be characterized as oligomesotrophic: there grow dwarf shrubs (*Chamaedaphne calyculata* and *Betula nana*), sedges (*Carex lasiocarpa* Erhr.), *Sphagna* (*Sphagnum fallax*) with birch (*Betula pubescens* Ehrh.).

Lagg is occupied by *Alnus glutinosa*, *Equisetum fluviatile* and *Calla palustris* L. A zone of shrubs (*Salix myrtilloides* L., *S. lapponum* L. and *S. rosmarinifolia* L.), sedges (*Carex lasiocarpa* Ehrh.) and *Sphagnum* spp. follows further. A small orchid *Hammarbya paludosa* (L). O. Kuntze was met several times in this site.

To the north-east from the strip of mineral islets, the bog has more oligotrophic features. There are the first pine trees, and the vegetation gets a complex character.

Hummock-hollow complexes occupy a large part of the area of the Polisto-Lovat mire system. In the course of analysing the vegetation cover of hummock-hollow complexes, the following regularity was revealed.

Dwarf shrub (*Calluna vulgaris*)-cotton grass (*Eriophorum vaginatum*)-*Sphagnum* communities with pine are widely distributed on hummocks. The height of Pinus sylvestris is 0,5-3 m. It is represented by f. *litwinowii* and f. *wilkomii*. The hummocks are flat and low. They are covered with *Sphagnum fuscum* as a dominant species. *Sphagnum angustifolium*, *S. rubellum* and *Polytrichum strictum* are also common species. *Cladonia stygia* (Fr). Ruoss. can be found very often on these sites. This lichen grows like a *Sphagnum* moss. Its length can reach up to 0,3-0,5 m. *Rhynchospora alba* (L.) Vahl with *Sphagnum balticum* (Russ.) Russ. ex C.Jens. or *S. majus*, sometimes *Scheuchzeria palustris* L. grows in hollows. *Sphagnum cuspidatum* Ehrh. ex Hoffm. occupies the most wet hollows.

The hummocks of another type of complexes are characterized by cottongrass-*Sphagnum* communities. *Sphagnum magellanicum* is the dominant species of moss cover. *S. angustifolium* and *Polytrichum strictum* are present as well. The hollows are covered with *Rhynchospora alba, Scheuchzeria palustris* and *Sphagnum balticum.*

The pool bog complexes with sparse ridges extend to the northeast to Novgorod region. The character of vegetation cover is still the same on ridges: dwarf shrub (*Calluna vulgaris*)-cottongrass (*Eriophorum vaginatum*)-*Sphagnum* (*Sphagnum fuscum*) communities with *Pinus sylvestris* f. *pumila*. *Sphagnum angustifolium, S. magellanicum, S. rubellum, Polytrichum strictum, Cladonia stygia* and *Cladonia stellaris* (Opiz) Brodo. are present as well. *Sphagnum fallax* occupies the transitional microsites between hummocks and hollows.

The plant communities with *Rhynhospora alba* and *Sphagnum balticum* are distrubuted on the margins of pools, in which they are replaced by liverworts and *S. majus*. The hollows have a black colour due to the presence of liverworts and algae. *Rhynchospora alba* groups and individual plants of *Carex limosa* L. are scattered on the surface. *Nymphaea tetragona* Georgi. grows in the open water of bog pools.

Table 1. Oligotrophic bog vegetation.

Number of relèves			
11		7	
Associations			
1		2	
Sphagnum magellanicum	$V_{3\text{-}4}$	Sphagnum fuscum	$V_{4\text{-}5}$
Eriophorum vaginatum	V_{+4}	Andromeda polifolia	V_{+2}
Andromeda polifolia	V_{+2}	Eriophorum vaginatum	$V_{1\text{-}4}$
Oxyccocus palustris	V_{+2}	Drosera rotundifolia	V_{+}
Pinus sylvestris	III_{+3}	Ledum palustre	$III_{+\text{-}2}$
Drosera rotundifolia	V_{+}	Oxyccocus microcarpus	I
Polytrichum strictum	$V_{1\text{-}3}$	Empetrum nigrum	I
Chamaedaphne calyculata	V_{+3}	Sphagnum angustifolium	$V_{2\text{-}3}$
Sphagnum angustifolium	$V_{2\text{-}3}$	Oxyccocus palustris	V_{+2}
		Chamaedaphne calyculata	IV_{+2}
Sphagnum fuscum	IV_{+2}	Sphagnum magellanicum	$IV_{1\text{-}2}$
Ledum palustre	III_{+3}	Polytrichum strictum	$III_{1\text{-}2}$
Empetrum nigrum	II		
Calluna vulgaris	II	Pinus sylvestris	V_{+2}
Scheuchzeria palustris	II	Calluna vulgaris	$III_{1\text{-}2}$
Oxyccocus microcarpus	II	Sphagnum rubellum	III_{+2}
Sphagnum rubellum	I	Scheuchzeria palustris	II
Menyanthes trifoliata	I	Menyanthes trifoliata	I
Rhynchospora alba	I	Rhynchospora alba	I
Betula pubescens	I	Betula pubescens	-
Carex limosa	I	Carex limosa	-
Aulacomnium palustre	I	Aulacomnium palustre	-
Sphagnum balticum	-	Sphagnum balticum	I

1- Ass. Chamaedaphne-Sphagnetum magellanici subass. typicum;
2- Ass. Ledo-Sphagnetum fusci

Oligotrophic homogeneous vegetation of bogs, which is represented by pine-cotton-grass-dwarf shrub communities, is found as well (Fig. 1). *Chamaedaphne calyculata* and *Rubus chamaemorus* prevail. *Sphagnum magellanicum* and *S. angustifolium* co-dominate in moss layer.

The application of the floristic approach to the analysis of geobotanical descriptions has allowed to compare the studied vegetation of Polisto-Lovat mire system with the Prodromus of syntaxons, compiled by Боч & Смагин (1993). After grouping the vegetation complexes into types, it is possible to consider the types as mapping units for the purpose of large-scale mapping.

Oligotrophic bog vegetation belongs to the following associations (Tab. 1):

Ass. *Chamaedaphne-Sphagnetum magellanici* Bogdanowskaya-Guiheneuf 28 em. Boc 90 Subass. typicum;

Ass. *Ledo-Sphagnetum fusci* Du-Rietz 21;

Àss. *Caricetum limosae* Osvald 23 (Tab.3):

Fac. *Eriophorum vaginatum*

Subass. *sphagnetosum angustifolii*

Vegetation of mesotrophic herb-sedge-*Sphagnum* communities of marginal parts of the mire system (Tab.2):

Ass. *Caricetum rostratae* Osvald 23

Subass. *sphagnetosum fallacis;*

Ass. *Caricetum lasiocarpae* Osvald 23

Fac. *Menyanthes trifoliata*

Subass. *sphagnetosum fallacis;*

The vegetation of hollows belongs to the association Caricetum limosae Osvald 23.

Table 2. Vegetation of herb-sedge-Sphagnum mesotrophic communities of the marginal parts of the mire system.

Number of relèves			
8		7	
Associations			
1		2	
Carex rostrata	$V_{2\text{-}3}$	Carex lasiocarpa	V_{+2}
Scheuchzeria palustris	I	Carex rostrata	II
Carex limosa	III_{+1}	Eriophorum polystachion	-
Rhynchospora alba	-	Menyanthes trifoliata	$V_{2\text{-}3}$
Drosera anglica	-	Equisetum fluviatile	II
		Comarum palustre	I
Carex lasiocarpa	-		
Eriophorum polystachion	-	Scheuchzeria palustris	II
Menyanthes trifoliata	II	Carex limosa	IV_{+1}
Equisetum fluviatile	-		
Comarum palustre	I		
Oxyccocus palustris	V_{+2}	Oxyccocus palustris	V_{+2}
Eriophorum vaginatum	I	Eriophorum vaginatum	I
Chamaedaphne calyculata	II	Chamaedaphne calyculata	II
Andromeda polifolia	I	Andromeda polifolia	III_{+1}
Drosera rotundifolia	-	Drosera rotundifolia	II
Sphagnum magellanicum	-	Sphagnum magellanicum	-
Sphagnum fallax	V_5	Sphagnum fallax	V_5

1 – Ass. Caricetum rostratae, subass. sphagnetosum fallacis;

2 - Ass. Caricetum lasiocarpae, subass. sphagnetosum fallacis.

The associations are subdivided into some subassociations (Tab. 3). Most widespread subassociation of the investigated part of Polisto-Lovat mire system is the subassociation *sphagnetosum cuspidatii*. It is diagnosed by *Sphagnum cuspidatum*. *Andromeda polifolia* and, particularly, *Oxyccocus palustris* are common for this subassociation. It occupies the swampy sites of oligotrophic bogs and is characterized mainly by *Carex limosa* and*Scheuchzeria palustris*. There are also subassociations: *sphagnetosum baltici* (in the western part), *sphagnetosum maji* (everywhere), and rare ones: *sphagnetosum papillosi* and *sphagnetum jensenii* (in the southern part).

Table 3. Vegetation of the subassociations of Ass. Caricetum limosae.

Species	Number of relèves			
	3	4	3	6
	Subassociations			
	1	2	3	4
Carex limosa	IV_{1-2}	III_{1-2}	II	I
Scheuchzeria palustris	V_{+2}	IV_{+2}	III_2	II
Eriophorum vaginatum	II	II	IV_{+1}	V_{+4}
Oxycoccus palustris	III_+	V_+	III_+	V_{+2}
Andromeda polifolia	V_{+1}	IV_{+1}	IV_{+1}	V_{+2}
Chamaedaphne calyculata	-	I	II	V_{+3}
Drosera rotundifolia	I	I	-	IV_+
Sphagnum magellanicum	-	-	-	V_{2-3}
S. majus	V_5	I	-	-
S. cuspidatum	-	V_5	I	-
S. balticum	I	-	V_5	-
S. angustifolium	-	-	-	V_{4-5}
Rhynchospora alba	IV_2	IV_{+2}	III_2	-
Drosera anglica	III	II	I	-

Ass. Caricetum limosae:
1- subass. sphagnetosum maji;
2- subass. sphagnetosum cuspidatii;
3- subass. sphagnetosum baltici;
4- subass. sphagnetosum angustifolii.

In the north-eastern part of the reserve, where hummock-pool complexes are distributed, the association *Hepatico-Rhynchosporetum albae* Bogdanovskaja-Guiheneuf 28 em. Botch 92 was described. Its diagnostic species are *Hepaticae* (*Cladopodiella fluitans*, (Nees) Buch, *Gymnocolea inflata* (Huds.) Dum. and *Mylia anomala* (Hook.) S.Gray). This association indicates a regress of bog vegetation and its destruction under the influence of water stagnation and allocation of CH_4 and H_2S (Боч & Смагин 1993). Богдановская-Гиенэф (1928) believed that these sites will be developed into small pools, or a restoration of *Sphagnum* cover will take place.

According to Боч & Смагин (1993) the processes of regeneration of *Sphagnum* cover occur regularly by *Sphagnum lindbergii* or *S. tenellum*. Богдановская-Гиенэф (1969) emphasized the important role of *Sphagnum papillosum* in the restoration of *Sphagnum* cover of black hollows and bare peat. This question attracts my attention in connection with the interest to the geography and ecology of *Sphagnum* mosses. Species like *Sphagnum jensenii*, *S. lindbergii*, *S. pulchrum* and *S. tenellum* are rare in North-West Russia. During my research I found and confirmed the presence of two rare species on the bogs of Polisto-Lovat mire system: *Sphagnum jensenii* (the definition is checked up by Ekaterina Kuzmina) and *S. tenellum*. Also S. lindbergii could grow in hummock-pool sites, but it has not been found so far.

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Flora and vegetation of the mire ecosystems of National park Vodlozersky

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Introduction

Mires are an integral part of the nature landscapes of the National Park Vodlozerski and occupy 191 thousand hectares. Such high degree of paludification of the territory (more than 40 %) is the result of climatic and hydrological conditions, as well as geological and geomorphological peculiarities of the landscapes. The present report presents new information about the flora and vegetation of the mires in the park. It was collected in the course of field studies conducted in 1997-2000 in the southern (area of Pilmasozero and Kelkozero), northwestern (near Kirich lake) and northern (near Kerazhozero and Njuhchozero) areas of the park. The research work was financed by Tacis project "Forest resources management in the northwest Russia" and two grants of the Global Ecological Fund of Russia: No.11 B/15-98 and 11 B/18-99.

Results

Flora

We have discovered 97 new plant species growing in the park's mires. *Calluna vulgaris* is growing in abundance in the northern areas on dystrophic ridge-hollow-pool bogs. Besides, *Poa pratensis, Carex echinata, C. aquatilis, Crepis paludosa, Galium trifidium, Stellaria crassifolia, Viola epipsila, Utricularia minor* and *Calliergon cordifolium* have been found in the northern part of the park on meso-eutrophic herb-moss mires. Flora of the meso-eutrophic mires in the southern part of the park is most diverse. Here one can find *Thelypteris palustris, Selaginella selaginoides, Trisetum sibiricum, Calamagrostis phragmitoides, Carex heleonastes, C. appropinquata, Gymnadenia conopsea, Hammarbya paludosa, Corallorhiza trifida, Listera ovata, Platantera bifolia, Bistorta major, Saxifraga hirculus, Parnassia palustris, Moneses uniflora, Ligularia sibirica, Cinclidium stygium, Paludella squarrosa* and *Calliergon richardsonii*. At present the park's mire flora includes 203 plant species: 112 vascular plants and 91 mosses.

Vegetation of mires

For the first time the dystrophic ridge-hollow-pool Southern White Sea mire types were recorded in National Park Vodlozerski. Meso-eutrophic and eutrophic mires which are rather rare in the park have been studied, new data on the flora and vegetation of the park's aapa type of mires has been collected.

Dystrophic ridge-hollow-pool southern White Sea mires are located in the northern part of the park, mostly near Njuhchozero. The larger mires of this type are on the watershed of Njuhcha river and Ileksa river. It should be noted that the southern White Sea type mires are the northernmost European sub-oceanic mires. This group includes the mires with developed processes of erosion and denudation. Therefore, the role of *Sphagnum* mosses there is weakened since liverworts and lichens replace them. Large number of pools free of *Sphagnum* cover and small lakes of secondary origin give evidence to the processes of erosion and denudation. *Calluna vulgaris* is a typical species of European sub-oceanic mires. Mires of southern White Sea type are common on the Pomorski shore of Kola peninsula along the White Sea shore and to the east up to Kanin peninsula. The largest of them are located on the White Sea lowlands, where they take up to 70-80% of the territory (Юрковская, 1992).

Dystrophic mires in the park have a slightly convex surface. Their central parts are taken up by dystrophic Cladineto-fusci sphagneta + Jungermannieta and Cladineto-fusci Sphagneta + Sphagneta baltici + pools mire sites, which can occupy as much as 70% of the mire area. The flora of such mire sites is poor. Dwarf shrubs *Calluna vulgaris, Empetrum nigrum, Andromeda polifolia* and *Ledum palustre* dominate in the field layer. Very often one can meet there *Baeothryon caespitosum, Rhynchospora alba* and *Eriophorum vaginatum*, more rarely *Carex limosa* and *C. pauciflora. Sphagnum fuscum, S.balticum, Cladina rangiferina* and *C. stellaris* are common in the moss-lichen layer. Ridges take up about 20-30% of the mire sites area. The vegetation cover there is represented by communities typical for such type of mires: *Pinus sylvestris - Calluna vulgaris - Sphagnum fuscum + Cladina* sp. and *Calluna vulgaris – Cladina rangiferina + C. stellaris.* Vegetation of the *Sphagnum* hollows, which occupy about 40% of the mire, is formed of communities *Baeothryon caespitosum – Sphagnum balticum*, and *Scheuchzeria palustris – S. balticum.* Hummocks with *Rhynchospora alba* and *S. balticum* are common in the hollows with degraded *Sphagnum* cover. *Scheuchzeria palustris* and *Carex limosa* grow in the pools with depth over 30 cm.

Oligotrophic Sphagnum ridge-hollow and pine- dwarf shrub-*Sphagnum* mire sites form fringes of dystrophic mires. Communities of *Pinus sylvestris – Calluna vulgaris – Sphagnum fuscum* form vegetation cover of such ridges and hummocks. Plant communities of *Scheuchzeria palustris – S. balticum* and *Rhynchospora alba – S. balticum* are typical for the *Sphagnum* hollows. Communities of *Eriophorum vaginatum – Sphagnum angustifolium*, occupy carpet parts of the pine- dwarf shrub-*Sphagnum* mire sites.

Oligotrophic pine-dwarf shrub-Sphagnum and oligotrophic ridge-hollow Pechora-Onega mire ranges dominate in the northwest part of the park (near Kirich lake).

Meso-oligotrophic cottongrass - *Sphagnum* mires are very common to the east and northeast of Kerazhozero lake. They have a flat surface with rare small hummocks. The mire flora there is poor. It consists of 25 species of vascular plants and mosses. The most typical species are: *Andromeda polifolia, Oxycoccus palustris, Chamaedaphne calyculata, Eriophorum vaginatum, Scheuchzeria palustris, Carex limosa, C.pauciflora, Drosera rotundifolia, Sphagnum angustifolium, S.balticum, S.papillosum, S.magellanicum* and *S. majus. Carex rostrata* and *Menyanthes trifoliata* grow in the sites with high ground water level. Low-flow waterlogged *Sphagnum* mire sites take up the larger part of the mires with vegetation cover made of communities of *Eriophorum vaginatum – Sphagnum balticum* with some *S. papillosum.* The mire fringes are made of oligotrophic pine- dwarf shrub-*Sphagnum* mire sites with hummock - carpet microrelief. Communities of *Pinus sylvestris – Empetrum nigrum + Rubus chamaemorus – Sphagnum fuscum + S. angustifolium* dominate on the hummocks. Communities of *Eriophorum vaginatum – S. angustifolium* occupy the carpets.

Mesotrophic herb-*Sphagnum* mires are abundant in the park. In the northern part of it they are also quite common. They are formed in depressions with water flow and high level of ground water. *Sphagnum* carpets are dominating with communities of

Carex rostrata – Sphagnum fallax. Sometimes such mire sites are intersected by transition fens with proliferation of *Comarum palustre, Menyathes trifoliata, Eriophorum polystachion, Carex paupercula, C.diandra* and *Sphagnum fallax*. The underground water springs often form small rivulets and secondary lakes. Communities of *Carex rostrata – Sphagnum riparium* occupy their banks. *Sphagnum* fens with slow water flow are formed after the lakes. Fringes of mesotrophic herb-*Sphagnum* mire sites are taken up by oligotrophic pine *Sphagnum* sites.

We have studied a meso-eutrophic herb-Sphagnum mire 1.5-km to the north-east of Kerazhozero lake. It is a part of a complex mire system consisting of mesotrophic herb-Sphagnum and dystrophic ridge-hollow-pool mires. The mire was formed in a depression with water runoff and numerous springs of ground water. Therefore the area is excessively waterlogged with open ponds in some spring locations or low (about 1 m high) spring mounds. The mire flora consists of 49 plant species: 35 vascular plants and 14 mosses. *Comarum palustre, Menyathes trifoliata, Carex lasiocarpa, Equisetum fluviatile, Sphagnum warnstorfii, S.subsecundum* and *S. fallax* are growing in abundance there, *Rumex acetosa, Galium trifidum, G.palustre, Stellaria crassifolia* and *Cicuta virosa* can be found there, as well as *Juncus stygius*, which is protected in Archangelsk district.

Excessively waterlogged meso-eutrophic Herbeta + Sphagneta fallaxi mire sites with hummocks and flarks take up the central parts of the mire. The 5-8 cm mounds occupy 59% of the area. They host communities of *Menyanthes trifoliata - Sphagnum fallax* and *Betula nana - Menyanthes trifoliata - Sphagnum teres + S. subsecundum*. Communities of *Carex lasiocarpa + Equisetum fluviatile* and *Equisetum fluviatile - Calliergon giganteum* fill the flarks. Eutrophic Betuleto – Sphagneta warnstorfii + Herbeto-Sphagneta teresi mire site lies to the west of the central part of mire. Communities of *Betula pubescens - Carex lasiocarpa + Sphagnum warnstorfii* take up the hummocks around tree trunks. *Carex lasiocarpa* and *Sphagnum teres* are dominating on the flarks.

At the junction of the above mentioned sites in the northern part of the mire there is a small spring mound about 4 m wide. It is covered with *Calamagrostis neglecta + Rumex acetosa - Calliergon stramineum + S. teres*.

We have studied a meso-eutrophic mire Saimoh in the area of tectonic displacement 1.5 km to the east of Kirich lake. By its geographic location it can be classified Onega-Pechora aapa type. Plants, which are typical for Karelian aapa mires, have been found there: *Molinia caerulea, Juncus srygius, Baeothryon alpinum, Rhynchospora alba, Selaginella selaginoides, Trientalis europaea* and *Dactylorhiza maculata*. Meso-eutrophic Herbero - Sphagneta warnstorfii + Herbeta and Sphagneta papillosi + Herbeta + pools mire sites dominate in the central part of the mire. *Carex lasiocarpa + Molinia caerulea - Sphagnum papillosum, Carex lasiocarpa + Molinia caerulea - Sphagnum papillosum* and *Rhynchospora alba + Juncus stygius - S. papillosum*, which are typical for Karelian aapa mires are common on the *Sphagnum* ridges there. Communities of *Menyanthes trifoliata + Carex limosa* occupy the pools and grassy hollows. Communities of *Pinus sylvestris - Molinia caerulea + Carex lasiocarpa + Menyanthes trifoliata - Sphagnum fallax* are quite common in the pine-wooded northern mire fringe. We assume that the western boundary of the occurrence of Onega-Pechora aapa mires should be, obviously, not on Vyg river, but along Ileksa river – Vodlozero lake – Vodla river. Taking into account the peculiar features of the structure of vegetation cover of aapa mires in National Park Vodlozerski they can be classified as a new Ileksa-Vodlozero geographic variant.

Eutrophic herb-moss mires are rare in Karelia and unique in National Park Vodlozerski. One of such mires was found in the southern part of the park on Kelka river. The mire flora consists of more than 100 species. Small spring mounds are formed at the sites of calcium-rich ground water outflow, which are covered with mosses: *Hamatocaulis vernicosus, Calliergon giganteum, C.richardsonii, Bryum pseudotriquetrum* and *Cinclidium stygium*. Rare plant communities can be observed there with *Epipactis palustris, Thelypteris palustris* and *Eriophorum latifolium*.

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Edward Wainio — a pioneer of floristic research on the borderland between Northern Finland and Russian Karelia

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Edvard August Vainio (1850–1929, until 1877 Lang, 1877–1919 Wainio) was a world-renowned lichenologist. In his youth, however, he worked mainly with vascular plants and the subject of his doctoral dissertation (1878) was on plant geography.

Between 1875 and 1877 he studied the then poorly known regions in the borderland between the Grand Duchy of Finland and Russian North Karelia, an area between 63°18′–65°25′N lat and 29°01′–31°42′E long. In this area, only Kuusamo and the Paanajärvi regions were floristically somewhat known, while the rest was almost totally unexplored "terra incognita". In spring 1875, before Wainio started out on his first excursion to North Karelia, prof. W. Nylander wrote in a letter from Paris: "It is pleasing, but ... truly it must be one of the poorest parts of the country, so even with his excellent capacity, it may be difficult to find many curiosities in such an area. He should go further, make a leap to the northwestern corner of the Onega region" (free translation from the quotation in Vitikainen 1999: 136). Later, in the autumn of the same year, Nylander, however, had to confess that he had misjudged the situation and he wrote: "It is good that Cand. Lang has found many novelties, even in Nurmes which, when I was travelling there, seemed to be a piece of the Sahara in Finland" (Vitikainen 1999: 136).

Field excursions in the remote backwoods of the Finnish-Karelian borderlands were at that time strenuous indeed. Against this background the list of sites visited by Vainio is very impressive.

Soon after his second excursion (in summer 1877) Wainio defended his academic dissertation in 1878. It was the first dissertation in biology written in the Finnish language. It contained a mass of information on physical geography, vegetation and flora from this scientifically largely unknown region. In his obituary of Vainio, Prof. Kaarlo Linkola wrote about this and another of Vainio's phytogeographical works: "The descriptions of the localities and their vegetation are thorough and consistent, they are certainly among the best that have been written in Finland on these subjects. Both these papers hold a prominent position in the history of Finnish botany, being the first publications on plant geography in the Finnish language, and as such the fundament of the Finnish terminology on plant geography" (Linkola 1934: 6).

Mainly on the basis of floristic characteristics and also with due consideration to the phytogeographical features, Wainio (1878) distinguished altogether ten regions in his study area. He then grouped these minor regions into six provinces. Prior to that time all of northern Finland north of 64°N lat had been divided into three provinces only: part of *Ostrobottnia australis* (Oa.), northern Ostrobottnia (O.) and *Lapponia fennica* (L.). In the Russian part of Eastern Fennoscandia only two regions were distinguished: *Karelia rossica* (Kr.) and *Lapponia rossica* (Lr.) (Nylander & Sælan 1859; Fig. 1).

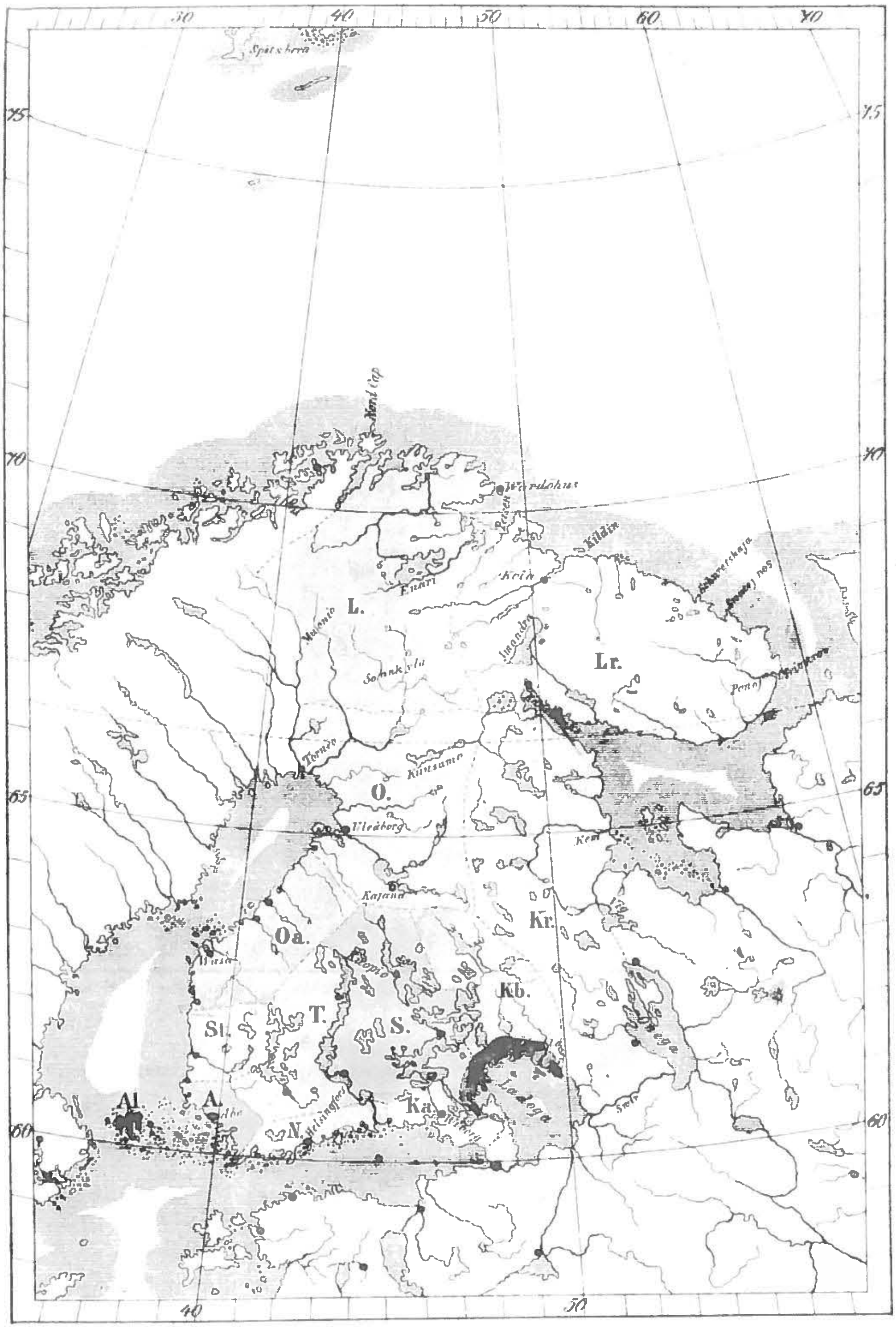

Fig. 1. The first biogeographical division of Eastern Fennoscandia (Nylander & Sælan 1859).

Wainio's division was as follows (Wainio's terms *kunta* and *maakunta* have in the following been translated as *county* and *province*):

I The province of North Karelia (Pohjais-Karjalan maakunta)
1. The county of Pielisjärvi (Pielisjärven kunta)
2. The county of Lieksa (Lieksan kunta)
II The province of Olonets Karelia (Aunuksen-Karjalan maakunta)
3. The county of East Repola (Itä-Repolan kunta)

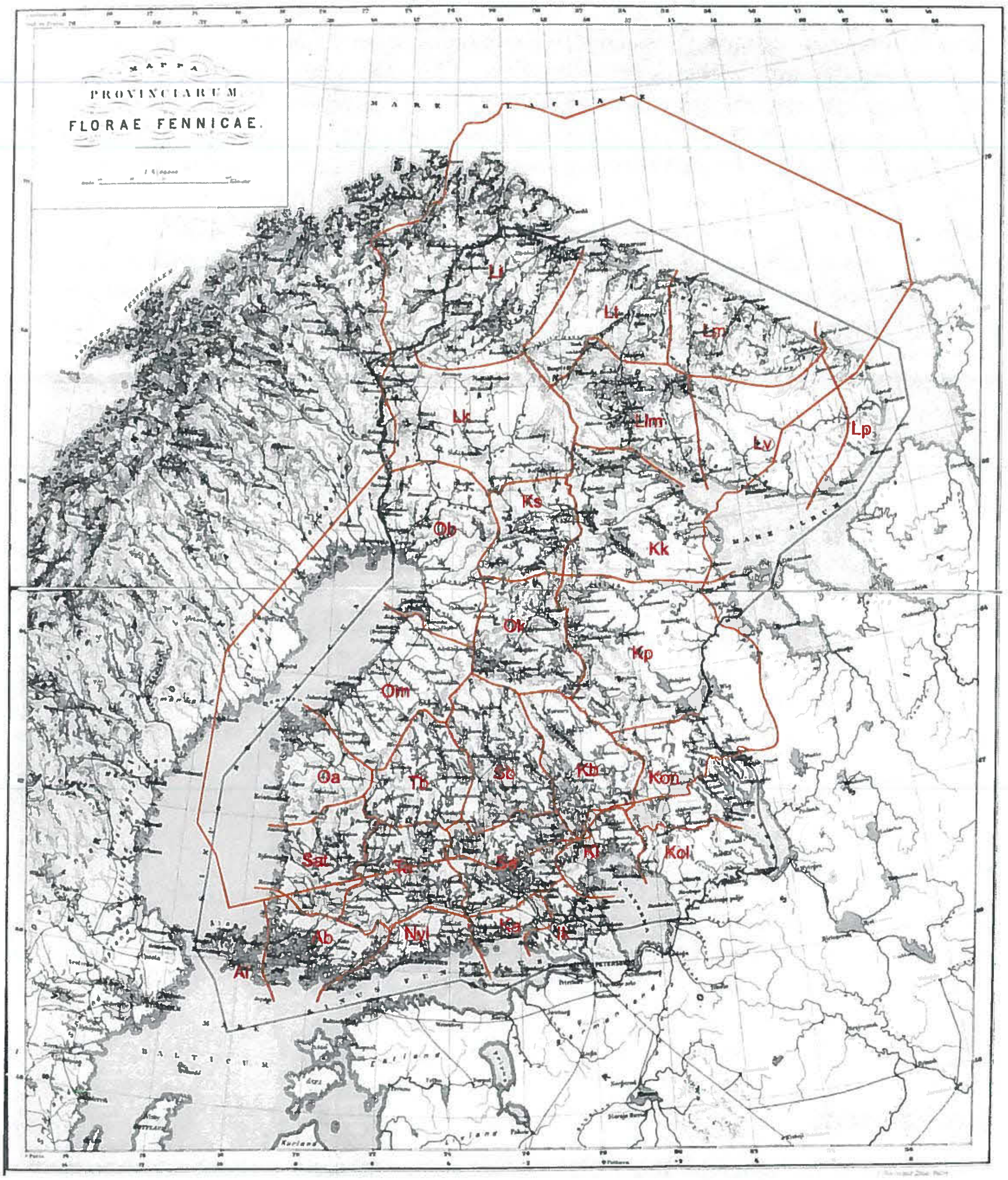

Fig. 2. The biogeographical division of Eastern Fennoscandia according to Hjelt (1882).

III	The province of Kianta (Kiannan maakunta)
4.	The county of Kuhmo (Kuhmon kunta)
5.	The county of Kianta (Kiannan kunta)
IV	Central Russian Karelia (Keskinen Venäjän-Karjala)
6.	The county of Kiimasjärvi (Kiimasjärven kunta)
7.	The county of Kuitti Lakes (Kuittijärvien kunta)
V	The province of Tuoppajärvi (Tuoppajärven maakunta)
8.	The county of Kiestinki (Kiestingin kunta)
9.	The county of Paanajärvi (Paanajärven kunta)
VI	The province of Kuusamo (Kuusamon maakunta)
10.	The county of Kuusamo (Kuusamon kunta)

Wainio was scrupulous in his treatment of the floristic characteristics of each of these regions on the basis of both his own observations and other available information.

He also devoted a special chapter to the question of the eastern boundary of the Finnish flora area bordering Russian Karelia. In his opinion it mainly followed the state boundary of that time with one interesting exception. He came to the conclusion that the county of Paanajärvi floristically resembled Russian Karelia to such a degree that it had to be combined with Russian Karelia (Wainio 1878: 138).

It is amazing to see how Wainio already then, on the basis of his relatively limited material, understood so clearly the essential features of the different regions; the similarities and dissimilarities between them. In 1882, when Hjelt first presented the basis of the present biogeographical division of Eastern Fennoscandia, the mutual boundaries of the then new provinces *Karelia borealis* (Kb, North Karelia), *Karelia onegensis* (Kon), *Ostrobottnia kajanensis* (Ok, Kainuu), *Karelia pomorica* (Kp), *Regio kuusamoënsis* (Ks, Kuusamo) and *Karelia keretina* (Kk) correspond in the main with the suggestions of Wainio (with the exception of the boundary between *Regio kuusamoënsis* and *Karelia keretina*) (Fig. 2). They have also continued to be valid until the present time (e.g. Hylander 1953; Heikinheimo & Raatikainen 1971). The only major alteration since Hjelt's map was published (1882) is that the province *Karelia pomorica* of that time has now been specified as *Karelia pomorica occidentalis* (Kpoc).

In Russian Karelia a rather similar division was also suggested by Раменская (1960) for the northern area, with, however, different names for the regions. Recently, Кравченко *et al.* (2000) have recommended the use of Finnish nomenclature for the provinces in the Russian part of Fennoscandia as well.

The pioneering work of Wainio more than a hundred years ago has formed a solid basis for biogeographical studies in a large area of the remote Finnish–Russian borderland. It is with admiration that we acknowledge his important achievements in the field of phytogeography as well as in lichenology.

Acknowledgements

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Diversity of Karelian local floras along the Finnish-Russian border

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Introduction

In view of the plans to establish the Green Belt of Fennoscandia the existing and planned protected areas along the Finnish-Russian border have lately been intensively studied. The present publication offers a brief account of the results of floral research in some of the areas and their comparative analysis.

Study areas and methods

Analyzed were the floras of the national park (NP) Paanajarvi (PAA), Kostomukshskii strict nature reserve (KOS), planned NP's Kalevalskii (KAL), Tulos (TUL) and Koitajoki (KOI), Tolvajarvi landscape reserve (TOL), Pälkjärvi (PIA) and Island Valamo (VAL) areas (see Fig. 1). The listed territories fit well into the notion of local flora (LF), widely used in Russian floristic science. Local floras are floras of test plots established to find out the floristic situation (floral sample) in a certain geographic point. Experience suggests that these areas for the taiga zone should be 300-500 (up to 1000) km^2. Species lists are based on our field research, critical analysis of herbarium collections and data from the literature. PIA flora was reconstructed using data from the literature (Huuskonen 1945). Only indigenous species were taken into account in comparative analysis of LF.

LF species compositions were compared using Jaccard similarity coefficient and Simpson's similarity coefficient - the greatest of the two measures of inclusion (Юрцев & Семкин 1980) that illustrates the part-whole relations, and is most applicable for comparing floras of unequal area. LF taxonomic structures, as shown by the sequence of the 20 families leading in the number of species, were compared using GAMMA rank correlation coefficient (in STATISTICA 4.5 for Windows). To analyze the geographic structure we used the «degree of importance» of a geographic element in the LF composition, describing the relative share of species with similar types of distribution range, rather than specific species. All indigenous species were combined into 40 groups geographical elements, combination of 10 latitudinal zones (arctic, arctoalpine, subarctic, subarctoalpine, arctoboreal, subarctoboreal, boreal, boreonemoral, nemoral, plurizonal) and 5 longitudinal sections (amphi-atlantic, european, euro-siberian, euro-asian, circumpolar). Endemics were considered separately. Similarity of the LF geographic structure was analyzed using GAMMA rank correlation coefficient and Smirnov's taxonomic analysis. In accordance with Smirnov's method the greatest "degree of importance" belongs to rare features (in our case rare geographic elements of the flora). The calculated values of Smirnov's taxonomic relations show how strong the relationship is and help to identify negative relations between the LF compared (Шмидт 1984).

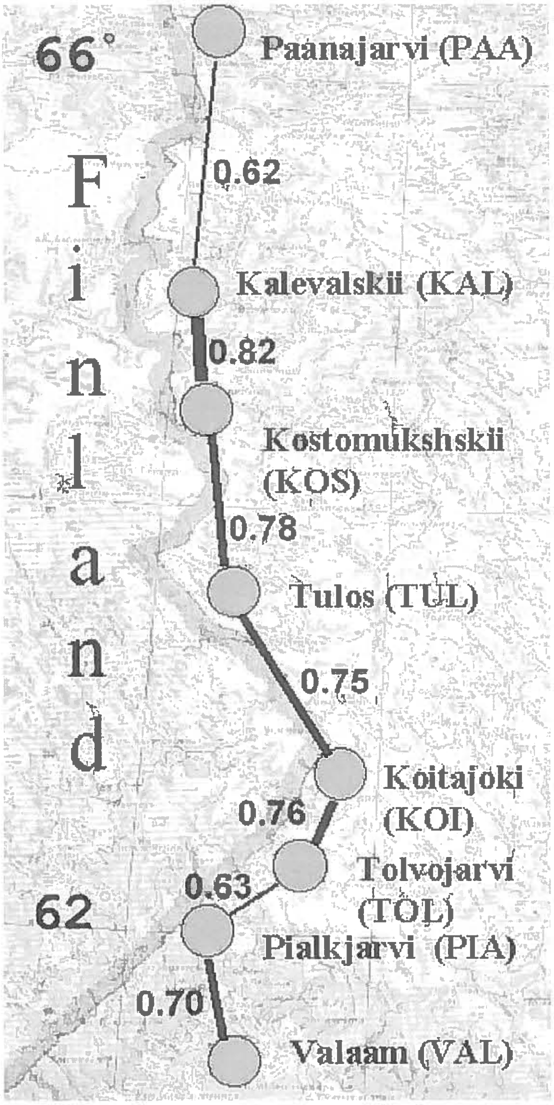

Fig. 1. Maximum similarity dendrogram for LF species compositions (Jaccard coefficient) placed on the schematic map of Karelian territories bordering on Finland. Line width indicates the coefficient value. Abbreviations of LF names used in the text are given in brackets.

Results

There is a lot of variation in the floristic richness of the study areas (Table 1). The number of vascular plant species was the lowest in TOL, KOI and TUL, geographically located in the centre of the series. At the same time, the role of the indigenous fraction grows towards the north, which is a reflection of the degree of human impact on the environment. The number of specific (found only in one of the compared LF) species was the greatest in PAA, markedly lower in VAL and lower yet in PIA. LF in the central part of the area are represented by practically the same species.

Comparison of the species lists using Jaccard coefficient (Fig. 1) and cluster analysis has demonstrated PAA and the two southernmost LF of PIA and VAL to be unique. All other LF's form a cluster with about the same level of relation, the strongest relationship observed between KAL and KOS. Application of Simpson's measure of similarity (Fig. 2) enabled identification of two groups of floras – northern and southern, as well as of the intermediate position of KOI, and, to a lesser degree also TOL, that are equally included in the northern and southern groups.

Comparison of geographic structures with GAMMA rank correlation coefficient demonstrated the exclusiveness of PAA, and some isolation of PIA and VAL from all other southern LF (Fig. 3). Absolute dominance of the boreal element smoothes down the differences between LF, so we decided to apply Smirnov's taxonomic method, which gives more weight to rare elements, reveals negative relations, and is thus noted for a much higher differentiating capacity that the GAMMA coefficient. Application of Smirnov's method yielded the following results (Fig. 4):

Table 1. Diversity of local floras.

Local floras	Number of species: Total	Indigenous	%	Specific
Paanajarvi (PAA)	545	443	81	89
Kalevalskii (KAL)	391	311	80	2
Kostomukshskii (KOS)	378	299	79	2
Tulos (TUL)	339	270	80	1
Koitajoki (KOI)	330	261	79	0
Tolvajarvi (TOL)	355	273	77	0
Pälkjärvi (PIA)	515	386	75	18
Valamo (VAL)	564	412	73	55

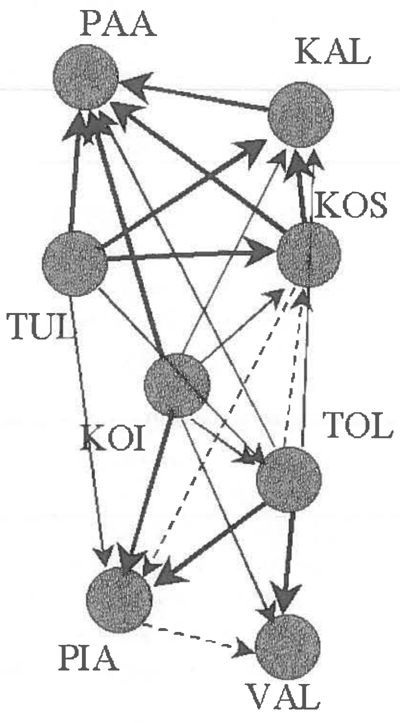

Fig.2. Directed graph of LF inclusion (Simpson's measure). Note: bold line denotes LF inclusion by 91-93%, fine line – by 88-90%, dotted line – by 85-87%; arrows shows inclusion direction.

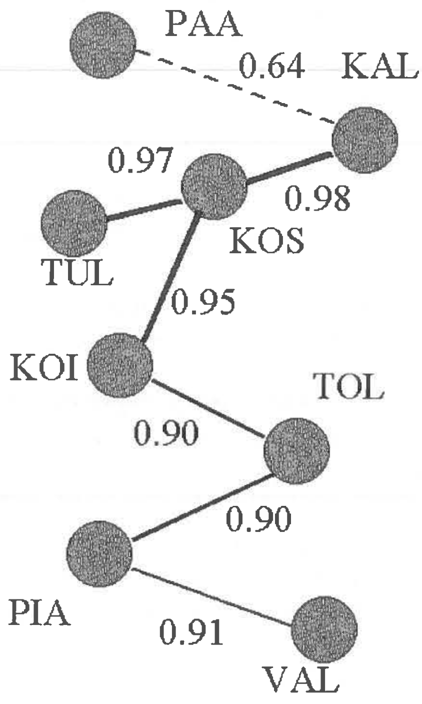

Fig.3. Maximum similarity dendrogram for LF geographic structures (GAMMA coefficient).

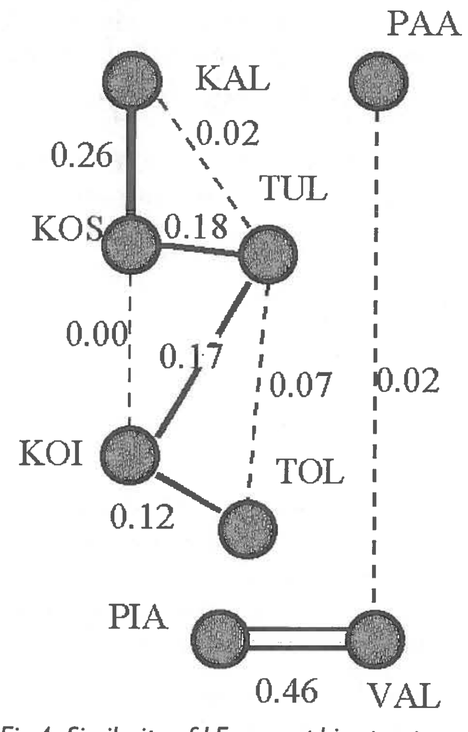

Fig.4. Similarity of LF geographic structures calculated following Smirnov's method. Only positive relations are marked, degree of relation is indicated by the number near the line and the line type.

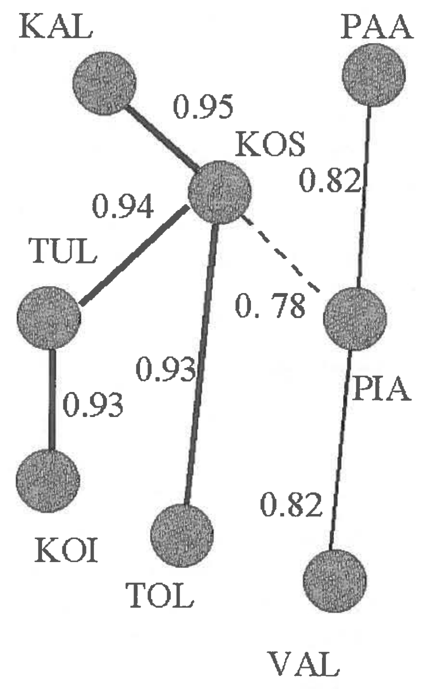

Fig. 5. Maximum similarity dendrogram for LF taxonomic structures (GAMMA coefficient).

1) Three groups of LF are clearly distinguished: 1) PAA, 2) KAL-KOS-TUL-KOI-TOL, 3) PIA-VAL;
2) Group KAL-KOS stands out from the second groups, that comprises central Karelian floras;
3) The central LF in group 2 is TUL, which has the greatest number of positive relations.
4) PAA is the most original LF with only one positive, though very weak, relation to VAL LF, which geographically is the furthest from the former. The common feature in the geographic structure of these LF is the presence of arctic and arctoalpine, as well as nemoral and boreonemoral elements. Species of the arctic, arctoalpine and nemoral LF complexes in PAA, PIA-VAL are Holocene relicts.

Quantitative analysis of the leading families' distribution patterns indicated that the top part of the family-species spectra is constituted by a total of 14 families, of which seven are among the top ten in all LF. A distinguishing feature of the family spectrum in VAL is that its leading group of families does not include *Salicaceae*, but has *Lamiaceae* and *Brassicaceae*, as well as a different order of the top three families. Only in PIA and VAL the top ten inlcudes the family *Fabaceae* and does not include *Ericaceae*. Common characteristics of the family spectra of the northernmost (PAA) and southernmost (PIA and VAL) LF are they both have *Caryophyllaceae* and lack *Juncaceae* among the top ten families.

Comparative analysis of the LF taxonomic structure (Fig. 5) using GAMMA rank correlation coefficient once more evidenced a very close relationship between LF within central Karelia and their relationship to LF in KOI and TOL. The most interesting result in our opinion is however PAA-PIA-VAL grouping, despite the fact that the relations are much weaker here. Similarity of the family-species structures suggests that in the most ancient times the floristic complexes of the northernmost and southernmost LF formed under the same conditions. Two pathways of eastern (Siberian) species migration: along the White Sea southern coast, through lake Piaozero, Olanga river, lake Paanajarvi and further west (Söyrinki 1956), and via lakes Onego and Ladoga to the Gulf of Bothnia and Gulf of Finland coasts (Hiitonen 1946, Миняев 1965), as well as availability of rich parent rock, including marble and dolomite outcrops, facilitated the presence of species from the Siberian floristic complex in LF.

KAL-KOS-TUL-KOI-TOL group also appeared owing to similar conditions of the flora genesis. The flora was completely destroyed by glaciation and sea transgressions. Parent rocks are almost exclusively acidic, which barred the spreading of many species and influenced on the flora richness.

Conclusion

The research enabled us to make some conclusions concerning spatial differentiation of the flora along the Finnish-Russian border.
1) There is a group of LF from KAL in the north to TOL in the south, with depauperate and homogeneous species composition and absolute predominance of the boreal group of species. The central LF in the group is TUL.
2) PAA is obviously divided from KAL by a boundary of, at least, a floristic province. Further research into 2-3 LF in the border zone between vil. Voinitsa and lake Paanajarvi is necessary to draw an accurate borderline.
3) Quite clearly differentiated is the KAL-KOS group, noted for a higher contribution of northern (subarctic and subarctoalpine) species, as compared to central Karelian LF located further south.

4) PIA and VAL are little related to other LF and with each other. If, however, the geographic structures are compared using Smirnov's taxonomic method, they are found to form a cluster with a high degree of relation. This fact indicates the presence of a clear floristic boundary between PIA and TOL. Юрковская & Паянская-Гвоздева (1993), while recognizing the boundary of Цинзерлинг (1932) between north- and mid-taiga subzones, drew the boundary between mid- and south-taiga in Karelia, and delineated buffer strips in the subzones. In accordance with this division PIA and VAL belong to the northern strip of southern taiga, KOI and TOL to the southern strip of middle taiga, and all other LF are located in the southern (TUL), middle (KOS-KAL) and northern (PAA) strips of northern taiga. It is known that the boundaries of geobotanical and floristic regions may coincide at the lowest levels of zonation. Some concurrence is observed in our case as well. The exception is KOI and TOL, which occupy an intermediate position between the south- and north-taiga floras, but in most cases are closer related to the north-taiga LF. The "northern" appearance of this part of western Karelia is confirmed also by the analysis of faunistic data. The so-called "north-taiga peninsula" within the mid-taiga subzone has been identified in the area (Кравченко & Сазонов 2000).

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Vanishing of vascular plants in Karelia: myths and reality

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Special focus in the research of Karelian flora carried out in the last two decades, including preparation of Red Data Books of Karelia (Ивантер & Кузнецов 1995) and Eastern Fennoscandia (Kotiranta et al. 1998), was placed on rare species including those in need of protection. This approach enabled researchers to assess the contribution of different anthropogenic factors to species extinction and make some conclusions about the actual threats to particular species.

One of the principal mechanisms for conservation of the regional biota diversity is protection of rare and vulnerable species. The Red Data Book of Karelia (Ивантер & Кузнецов 1995) now lists 205 vascular plant species, 62 of which (30%) are classified as extinct, endangered or vulnerable (Table 1).

Table 1. Number of protected species in various categories

Category	Number of species	%
Extinct	13	6,3
Endangered	15	7,8
Vulnerable	34	16,1
Rare (lower risk)	102	49,8
Indeterminate	41	20,0
Total	205	100,0

The studies of the last decade suggest however that the negative role of these factors in our region has been somewhat overstated.

Human activities producing the worst effect on vascular plants are bank and shore destruction and reclamation, logging and mire drainage. Each activity is the main risk factor for 15-20% of the species (Table 2).

Until lately, mire drainage in southern Karelia was an almost all-embracing activity. In the last years, however, it practically ceased. Furthermore, drainage efficiency is often rather low, ditch clogging being very common. So far, there are no reliable data about extinction or a clear decline of a certain species due to mire drainage. Bank and shore destruction is supposed to be a threat to a numerous group of aquatic and submerged species. In reality, however, the process in Karelia is limited to small areas, and reduced notably after drift timber floating stopped. Moreover, local bank and shore destruction favours the spread of many species that prefer newly vacated substrates, including protected species. Many plant species benefit also from seasonal or long-term changes in water levels. Thus, the species *Isoetes setacea*, that is considered vulneterm changes in water levels. Thus, the species *Isoetes setacea,* that is considered vulnerable, is quite abundant both in Karelian water storage reservoirs after water rises by several meters (e.g. lake Vodlozero) and in lakes after emptying to obtain new arable lands (e.g. lakes, Konchozero, Iso- and Pieni-Iijärvi).

Table 2. Protected species classified according to the factors responsible for their existence

Factors responsible for endangering of threatened species	Primary reason	Secondary reason
Gathering of flowers	2	23
Picking as edible or medicinal plants	5	7
Mining and quarrying	16	6
Changes in farm landuse	1	
Closure of meadows	15	5
Logging	32	10
Mire and wet forest reclamation	30	4
Pollution of waterbodies	20	4
Shore destruction	39	19
Other causes	16	9
Cause unknown	29	
Total	205	87

Other human activities such as water pollution, mining and quarrying, collecting food and medicinal plants, closure of meadows are the major threats to 3-10% of Karelian Red Data Book species. Mining and quarrying are detrimental for the most numerous group of Red Book species – rock-inhabiting species (Table 3). Plentiful rock-inhabiting species are a distinguishing feature of flora in Fennoscandia, where outcrops of bedrock of various compositions are abundant. It is actually because of the lack of suitable substrate that many of the species are rare in Karelia. There is no reliable evidence that rock-inhabiting species have gone extinct due to mining and quarrying. On the contrary, it is marble debris in the quarry on mount Belaya Gora that red listed species such as *Asplenium ruta-muraria, A. viride, Gymnocarpium robertianum, Epipactis atrorubens* and *Arabis hirsuta* grow on. Closure of meadows is undoubtedly the most deteriorating factor that presumably caused the extinction or apparent decline of a large number of formerly more or less common species.

Table 3. Number of protected species according to habitat

	Main habitat		Secondary habitat
	№	%	№
Forests	35	17	15
Rocks	47	23	6
Mires	28	14	3
Freshwaters	19	9	
Freshwater shores	40	20	12
Marine waters & coasts	4	2	
Bushes, edges	2	1	
Oroarctic, oroboreal	13	6	2
Meadows	10	5	12
Other	7	3	
Total	205	100	50

In the past years much attention was paid to decorative species the flowers of which were gathered by local people. For this reason many regional Red Data Books abound in common enough species, which can be said e.g. about the first edition of the Red Data Book of Karelia. At present, gathering of flowers is considered the main risk factor only for two species, including *Pulsatilla vernalis*.

A lot of vascular plants are considered as threatened or negatively affected by forestry especially forest cutting and listed in Red Data Books. For example, in Sweden forestry practices resulted in decline of 73 vascular plant species (Ingelög et al. 1987). Among Finnish threatened plants, about 14% are negatively affected by forestry practices (Rassi & Väisänen 1987). In the Red Data Book of Russia (Красная книга РСФСР 1988) logging is mentioned as the cause of decline for about 10% of vascular plant species. Near 17% of vascular plants listed in the Red Data Book of Karelia (Ивантер & Кузнецов 1995) are also considered vulnerable to cutting.

We have studied the effect of clear-cuttings on "Kirich" local floras ("Vodlozersky" National Park, Arkhangel'sk region) and projected "Atleka" landscape reserve, Vologda region, both located in the White Sea - Baltic Sea watershed (Kravchenko 1998). The absolute dominants in both cases are spruce forests. 20-25 % of the studied areas was clear-cut.

Both floras are quite poor with 255 and 316 vascular plant species recorded, respectively. According to the occurrence and abundance all species in undisturbed and secondary habitats were divided into three main groups: hemerophobes, hemerophiles and hemeradiaphores. Various degrees of the negative effect of the cuttings were recorded for 40-50% of vascular species. Naturally, hemerophobes are dominated by the typical taiga sciophilous species. Hemerophobes are especially widespread among pteridophytes, orchids, violets and tall herbs. On the other hand, an almost equal number of species (around 40%) benefit from logging and belong to hemerophiles. Such species included a lot of grasses (forming wood-reed, hair-grass, and bent-grass felling sites) as well as aquatic and submerged species, which spread to numerous roadside pools and ditches. In both cases the research revealed 13% of indifferent species (hemeradiaphores). The group comprised chiefly species with non-forest habitats like water bodies and mires.

Analysis of the growth patterns of protected forest species suggests that the major pre-requisite for their survival is remnant, uncut forests (Kravchenko 1999). A longstanding logging practice in Karelia was to leave forest fragments with sparse stock, low marketability, overmoistened, hardly accessible and so on, uncut. As a result, uncut fragments in boreal forests felled in the past occupy considerable areas. In Karelia, e.g., they make up 20-25% of total felled area. Uncut fragments serve as refugia for many vulnerable boreal organisms, such as aphyllophorous fungi, wood-inhabiting lichens and bryophytes, xylophagous insects and dendrophilous birds. Uncut fragments can be regarded as a spontaneously developed network of unprotected forest micro-reserves. Along with protected areas it plays a leading part in the conservation of many rare and protected boreal plant and animal species including old-growth forest indicator-species. Particularly important are overmoistened streamside habitats, which have highly varied microbiotopes, large amounts of dead wood and the generally higher level of biodiversity. Such elongated uncut fragments, which may reach an area of 30 or more ha with a length of 4 or more km, act as ecological corridors in vast clear-cut areas.

A more or less fair idea of the ongoing processes can be obtained by studying the flora in a given area once in a certain period of time and comparing the results. An ad hoc survey of local floras in different parts of Karelia carried out after a 50-year pause indicated that the aboriginal component of floras is substantially stable. Most species, including red listed species, were recorded again despite logging and mire drainage. We studied the long-term dynamics of flora in several localities in Karelia surveyed earlier – in the 1930's – 40's, namely: Olanga river valley (now included in the Paanajärvi National Park), Azhepnavolok peninsula (Zaonezhje), area near village Selga (central Karelia) and lake Hiisjärvi area (southern Karelia). The similarity of the species lists obtained 50 and more years later was very high – 0.82-0.9, the distinctions being related primarily to the dynamics of the adventive component of the floras (Кравченко et al. 1999). Some forest and mire species might have vanished owing to clear-cutting in the post-war period (e.g., a rare orchid *Epipogium aphyllum*, which in undisturbed habitats, however, also makes prolonged pauses in flowering during which it lives under the ground) and mire drainage (such species as *Schoenus ferrugineus* was not found). We believe though that it would be more correct to speak of not finding the species again.

Re-examined were also many localities in the northwestern shore of Lake Ladoga (Heikkilä et al. 1999; Savola 1999) and the Zaonezhje Peninsula (Кравченко et al. 2000) – territories with original flora, a large number of relic species (their very nature making them most sensitive to unfavourable anthropogenic impacts) and widely represented red listed species. Furthermore, these areas are the most intensely managed parts of Karelia with many centuries of economic activities.

The species that used to be more or less widespread, but were not found for the second time even in the exact points of their previous finds, are obviously dominated by the species related to human activities. Simultaneously, in fairly natural habitats (in the region the habitats richest in rare species are various bedrock outcrops, especially sheer cliffs) most protected species, including super-rare species, known in Karelia from 1-2 points only (e.g., *Minuartia verna, Draba cinerea, Potentilla pennsylvanica*) were found for the second time, usually as thriving populations (Heikkilä et al. 1999).

Such species as *Cypripedium calceolus*, which in many countries is considered a most typical example of endangered species and is protected everywhere, was found again in its classic habitats. It grows successfully even within the city of Petrozavodsk.

It is therefore safe to say that most vascular plant species in the boreal zone are quite tolerant of various anthropogenic factors that are not accompanied by fundamental transformation of landscapes (such as e.g. transformation of forest landscapes into agricultural or urban landscapes). Since forest fires that used to destroy everything in huge areas have always been the main natural factor affecting the natural dynamics in boreal ecosystems, it is this factor that the species composition of boreal biota is adapted to. Hence, felling that bring about consequences for vascular plants similar to those caused by catastrophic fires (or even less deteriorating, since e.g. the soil litter and humic layer are not destroyed as in the case with fires) do not result in impoverishment of the vascular plant flora, which is rather poor and not so original (endemic species practically absent) in the area, owing largely to the numerous fires in the past.

Generally speaking, the composition of the native component (including most species considered endangered or in need of protection) in local boreal floras proved to be quite conservative through long-term dynamics, despite substantial human impact in the areas occupied by some floras. Logging and mire drainage resulted in local extinction or decline only of the most hemerophobic species (mostly pteridophytes, orchids and boreal tall herbs).

The adventive fraction of the floras is, on the contrary, noted for high lability. Some introduced species, principally buckwheat and, especially, flax weeds (*Lolium remotum, Camelina* spp., *Vicia angustifolia, Cuscuta epilinum*, etc.) disappeared from the territory completely after cultivation of the crops had ceased. Wide use of herbicides and improved purification of seeds in combination with reduction of the area of land under rye and other cereals resulted in a pronounced decrease or total disappearance of formerly rather common weeds such as *Apera spica-venti, Bromus secalinus, Vicia villosa, Centaurea cyanus*, etc. We find this process to be absolutely natural however. Furthermore, the Russian tradition is that introduced species are next to never included in Red Data Books, and no special measures for their conservation are called for or implemented.

Thus, the vanishing of native vascular plant species from the regions with the economy dominated by the forest industry, as is the case with Karelia (farmland, communities, roads, etc. occupy just about 2% of the total area), is not so explicit.

This however does not at all reduce the significance of conservation measures for the most rare and vulnerable plant species including such activities as Red Data Book compilation, and most importantly – designation of new protected areas in territories with the highest conservation value.

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Bryoflora of the Finnish-Russian Nature Reserve Friendship

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Introduction

The Nature Reserve Friendship (70500 ha) is situated in the north taiga sub-zone (64°10'-64°40' N - 29°30'-30°30' E) on the both sides of Russian-Finnish state (Fig. 1). It consists of Kostomuksha Strict Nature Reserve (KSNR) on the Russian side and five Nature Reserves on the Finnish side (FNR): Ulvinsalo, Elimyssalo, Lentua, Iso-Palonen - Maariansärkät and Juortanansalo.

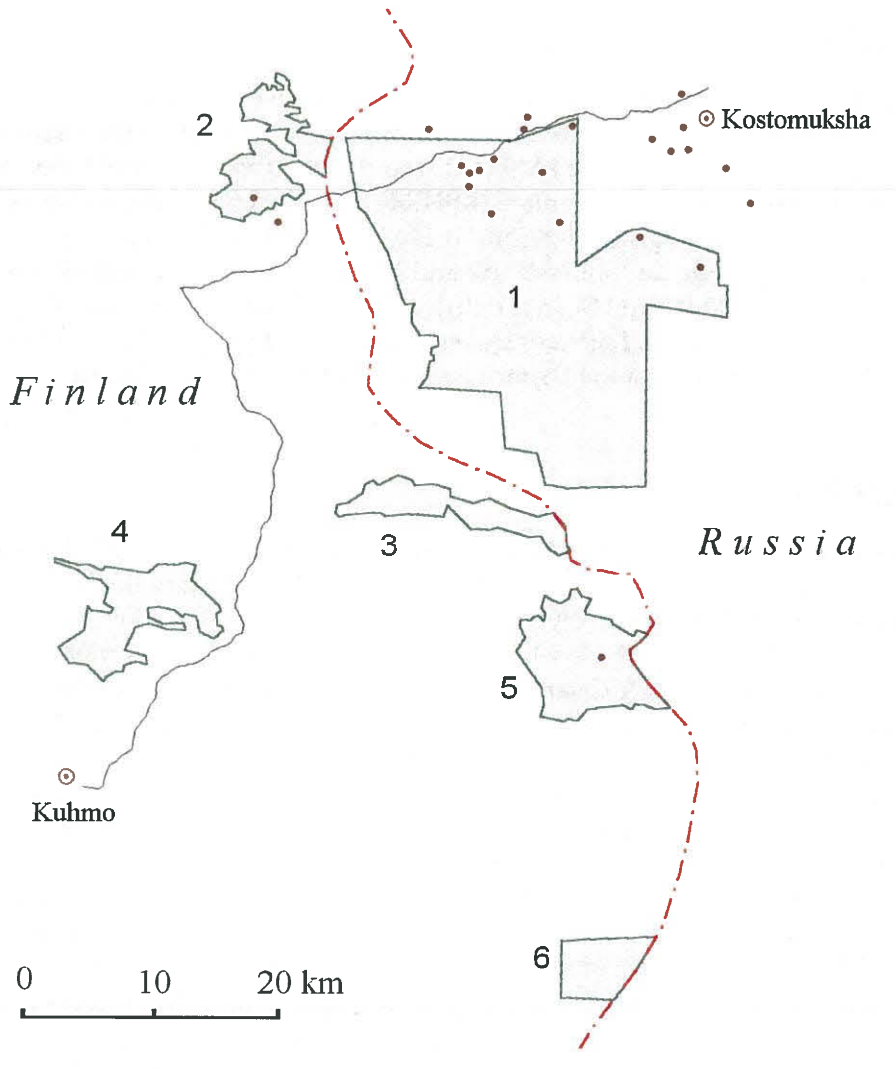

Fig. 1. Outline map of the Nature Reserve Friendship and bryology investigation plots. 1.Kostomuksha Strict Nature Reserve (48000 ha) 2.Juortanansalo-Lapinsuo Mire Reserve (3700 ha) 3.Iso-Palonen and Maariansärkät Nature Reserve (3900 ha) 4.Lentua Nature Reserve (5100 ha) 5.Elimyssalo Nature Reserve (7300 ha) 6.Ulvinsalo Strict Nature Reserve (2500 ha)

Bryoflora of the Nature Reserve Friendship has not been studied earlier. A few data on mosses of the park and vicinities of the Kostomuksha town is available in a number of publications (Wainio 1878, Brotherus 1923, Юрковская 1974, Елина & Кузнецов 1977, Mäkirinta et al. 1997, Heikkilä et al. 1997).

Materials and methods

During 1995-1998 bryofloristic investigations were carried out in the territory of Nature Reserve Friendship (Fig. 1): in KSNR and in two FNR's (Juortanansalo-Lapinsuo and Elimyssalo). In the same period, bryophyte flora in the surroundings of Kostomuksha was studied. Field investigations were conducted by a route method. 1016 moss samples were collected. Field materials were analyzed at the Laboratory of mire ecosystems of the Karelian Research Centre of the Russian Academy of Sciences. Moss samples are kept in the Herbarium of the Laboratory. The taxonomy in the text follows Ignatov & Afonina (1992). To make the geographical analysis of the bryoflora, the classification of flora elements for the northern regions (Шляков 1961) has been used. Some parts of the data obtained have been already published (Бойчук 1999, Kuznetsov et al. 2000).

Results

According to our data the bryoflora of Nature Reserve Friendship includes 172 moss species (KSNR 159; FNR 112: Juortanansalo 94; Elimyssalo 70). In the vicinities of the town of Kostomuksha, outside KSNR, 123 moss species were recorded. Boreal species are dominating in the Park bryoflora (KSNR 62%, FNR 70%). In the forests of the Park 76 moss species were registered (KSNR 70, FNR 49), in mires 87 (75 and 83), on meadows 26 (26 and 0), on banks and shores 90 (88 and 20), on stones and rocks 63 (63 and 20), and in damaged sites 17 (16 and 5). In the Park territory (KSNR) 4 moss species (*Sphagnum subnitens, S. denticulatum, Fontinalis squamosa* and *Warnstorfia pseudostraminea)* included into the Red Data Book of the Eastern Fennoscandia (1998) were found.

Discussion

Bryoflora of the Russian part of the Nature Reserve Friendship (KSNR) includes 159 moss species of 67 genera and 28 families (Table 1). According to the floristic regional distribution, KSNR is involved into Kuitozersko-Leksozersky floristic region (Раменская 1960), which is closely similar to the biogeographical province *Karelia pomorica occidentalis* (Mela & Cajander 1906). While not eminent for diversified natural conditions (acid bedrocks and soils), this region (*Kpoc)* still holds the fourth place in Karelia in bryophytes diversity, after *Karelia ladogensis, Karelia onegensis* and *Kuusamo* (Волкова & Максимов 1993). As regards to the quantitative composition, the moss flora of the KSNR amounts to 67% of the *Kpoc* bryoflora and 36% of the Karelian bryoflora. In KSNR 12 new moss species for *Kpoc* (*Cnestrum schistii, Dicranella palustris, Drepanocladus aduncus, Hygrohypnum smithii, Limprichia cossoni, Plagiomnium medium, Pohlia andalusica, Racomitrium affine, Schistostega pennata, Sphagnum subnitens, Ulota crispa* and *Brachythecium plumosum)* were revealed. For the first time 3 new species *(Dicranella palustris, Hygrohypnum smithii* and *Ulota crispa)* from KSNR, recorded in Finland (Koponen et al. 1998), have been registered in the bryoflora of Karelia. Outside KSNR, in the vicinities of Kostomuksha town, 123 moss species belonging to 57 genera and 23 families were recorded (Table 1), 6 of which *(Bryum argenteum, B. creberimum, B. imbricatum, Calliergonella cuspidata, Pseudoleskea radicosa* and *Hylocomiastrum pyrenaicum)* are new for *Kpoc*. Generally, the bryoflora in KSNR and the surroundings of Kostomuksha totals 174 moss species (71 genera and 28 families).

Table 1.Dominating families of the compared bryofloras (n = number of species; % = share of the total number of species; N = position within flora)

Families	KSNR			Kostomuksha			FNR			Kpoc		
	n	%	N	n	%	N	n	%	N	n	%	N
Sphagnaceae	33	20.8	1	31	25.2	1	29	25.9	1	35	14.8	1
Amblystegiaceae	23	14.5	2	20	16.3	2	18	16.1	2	30	12.7	3
Dicranaceae	19	11.9	3	14	11.4	3	14	12.5	3	31	13.1	2
Bryaceae	10	6.3	4-5	9	7.3	4	4	3.6	8-9	17	7.2	4
Polytrichaceae	10	6.3	4-5	7	5.7	5	8	7.1	4	14	5.9	6
Brachytheciaceae	9	5.7	6	6	4.9	6-7	6	5.4	5	16	6.8	5
Mniaceae	7	4.4	7	4	3.3	9	5	4.5	6-7	11	4.7	7
Hylocomiaceae	5	3.1	8-10	6	4.9	6-7	5	4.5	6-7	7	3.0	10-11
Grimmiaceae	5	3.1	8-10	5	4.1	8	3	2.7	10	9	3.8	9
Splachnaceae	5	3.1	8-10	3	2.4	10	4	3.6	8-9	7	3.0	10-11
Hypnaceae	(4)			(2)			(2)			10	4.2	8
n in 10 families	126			105			96			180		
% of bryoflora	79.2			85.4			85.7			76.3		
Total n	159			123			112			236		
Number of genera	67			57			49			99		
Number of families	28			23			23			35		

In the Finnish part of the Park (FNR) 112 moss species belonging to 49 genera and 23 families were found (Table. 1) (Juortanansalo 94 species, 41 genera and 22 families; and Elimyssalo 70, 34 and 17, respectively). Thus, according to our data the bryoflora of Nature Reserve Friendship includes 172 moss species, referring to 71 genera, 28 families, 3 sub-classes (*Sphagnidae, Andreidae, Bryidae*).

Comparison of the floristic lists showed that 99 species are found in both parts of the Park (KSNR, FNR), 24 of which are *Sphagnum* mosses. The number of common mosses for Juortanansalo and Elimyssalo is 52. 13 specific mosses (*Sphagnum quinquefarium, Pogonatum dentatum, Schistidium apocarpum, Dicranella cerviculata, Dicranum bonjeanii, Calliergonalla cuspidata, Cinclidium stygium, Dicranum elongatum, Hypnum cupressiforme, Hylocomiastrum umbratum, Splachnum vasculosum, Pseudocalliergon trifarium* and *Dicranum leioneuron)* have been recorded only in FNR. They have not been found in KSNR. First 6 species were found in the vicinities of Kostomuksha town and the next 4 in *Kpoc* (Волкова & Максимов 1993). 2 mosses (*Splachnum vasculosum, Pseudocalliergon trifarium)* have not been registered in *Kpoc.* 1 moss (*Dicranum leioneuron)* is missing in the bryoflora of Karelia. In the vicinities of Kostomuksha town 9 moss species *(Sphagnum contortum, Dicranum spurium, Bryum argenteum, B. creberrimum, B. imbricatum, Meesia triquetra, Pseudoleskea radicosa, Amblystegium serpens* and *Hylocomiastrum pyrenaicum),* which are missing in KSNR and FNR, were revealed. Generally, bryofloristic investigations in those territories (KSNR, FNR, Kostomuksha) made it possible to reveal 182 moss species belonging to 74 genera, 28 families, 3 sub-classes.

The most widely represented families (1 place) of bryoflora studied were *Sphagnaceae, Amblystegiaceae* and *Dicranaceae* (2-3 positions respectively) (Table 1). It could be explained by a zonal (north taiga) location of the region, i.e. the wider spreading of forest and mire communities and volumes of families (the most numerous ones). *Polytrichaceae* and *Brachytheciaceae* have also a higher position. *Bryaceae, Mniaceae, Grimmiaceae, Splachnaceae, Hylocomiaceae* are dominating as well. *Hypnaceae,* having a higher occurrence in *Kpoc* province (8 position), was not dominated in the investigated bryofloras and it was represented by 4 (KSNR) or 2 (FNR, Kostomuksha) species. Ten dominating families unify more than 3/4 of moss species revealed (Table 1). Species of 23 (from 28) families were common for both parts of the Park (KSNR, FNR). I did not find 5 families

(*Fissidentaceae, Leskeaceae, Neckeraceae, Pterigynandraceae, Schistostegaceae)* in FNR due to both a little number of suitable habitats and substrates (craggy ground, lake shores, fallen spruce trunks) and poor studies of these territories. *Sphagnum* is dominating in all the investigated bryofloras. All Sphagnum mosses characteristic to *Kpoc* (35 species) were revealed in the bryofloras of KSNR and Kostomuksha surroundings. A large share of *Polytrichum, Dicranum, Brachythecium. Calliergon* and *Warnstorfia* species in the Park bryoflora pertains its boreal features.

Geographical analysis showed that boreal moss species dominated in the bryoflora of the Nature Reserve Friendship (KSNR 62%; FNR 70%). Species of the north latitude groups (arctic-mountain, hypo-arctic, hypo-arctic-mountain) consist of one fifth of the total bryoflora (KSNR 21%; FNR 20%); southern (nemoral) 6% and 2%, respectively. Most species (KSNR 93%; FNR 95%) have circumpolar distribution.

Mosses of the Nature Reserve Friendship were found in various habitats. According to the data above the highest moss biodiversity of KSNR is pertaining to aquatic or littoral habitats (90 moss species), and in FNR to mire habitats (83). In fact, there is a great number of lakes, rivers and brooks in the territory of KSNR, and their bryoflora has been studied well. Bryological investigations in FNR were concentrated on mires (Isosuo, Härkösuo) and their forested margins. Eutrophic mire sites are found more often in mires in FNR than in KSNR. This was where *Cinclidium stygium, Pseudocalliergon trifarium, Dicranum bonjeanii and Calliergonella cuspidata* were found. These mosses were not recorded in KSNR mires. Higher biodiversity of mosses in KSNR forests is caused by a wide variety of forest types and substrates within the huge territory. The number of mosses of stony-rocky substrates in FNR is much smaller than in KSNR due to the lack of bedrock outcrops in the former. There are not enough data to compare habitat bryofloras of meadows and damaged sites (especially in FNR) yet.

The bryophyte inventory made was the first but yet not complete. Bryoflora of the southern part of KSNR (southwards Kamennaya river) and 3 FNR (Ulvinsalo, Lentua, Iso-Palonen) is entirely unknown. Bryology studies in the Park should be urgently continued.

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Bryophyte diversity of mature spruce forests in North Karelia Biosphere Reserve (Finland)

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Introduction

Bryophytes are an integral constituent of old-growth forests. They are involved in the formation of forest floor and vegetation of specific microhabitats. They overgrow the rotting trunks and exposed roots of fallen trees, etc. The bryofloristic literature from Finnish protected areas contains data from only a few areas where old growth forests may have survived (Tuomikoski 1939, 1941, Koponen 1967, Kujala et al. 1979, Söyrinki 1988, Haapasaari & Fagersten 1987, Laaka 1993, Halonen & Ulvinen 1996).

Special studies on bryophyte diversity of old-growth forests were carried out in coniferous south taiga forests growing predominantly under suboceanic climate conditions in Sweden and Norway (Gustafsson & Hallingbäck 1988, Söderström 1988, Hallingbäck 1991, Frisvoll 1997, Frisvoll & Prestø 1997). Frisvoll & Prestø (1997) found out that there is a significantly higher bryophyte diversity in old-growth forests as compared with ordinary mature forests or managed forests. On the Russian side of the Finnish-Russian state border the bryophyte diversity has been studied in Tolvajärvi reserve (Maksimov et al. 1999)

Bryophyta are an obligatory constituent of old-growth forest ecosystems but relevant information about diversity of bryophytes is very scanty. The goal of this paper is to discuss preliminary results of the detailed study of bryophytes in the mature spruce forests of North Karelia Biosphere Reserve.

Material and methods

The bryophyte biodiversity of mature spruce forests was studied in 1996-1997 at 23 protected sites from northeastern part of North Karelia province (Finland). Most of the sites were in the first list of Finnish old growth forests proposed for protection (Rassi et al. 1992). From Ilomantsi municipality twelve sites, Tapionaho, Pieni Kotavaara, Hoikka (east side), Syväjärvi (Hoikan puro), Lahnavaara, Pyötinkönkosket, Koitajoki (Koitajoen varsi), Lakonjärvi, Pampalo, Pampalo (slope) and Raiskionaho were studied. From Lieksa town we studied the sites Haapahaasianvaara, Päävaara, Pahkavaara, Ukonsärkkä Särkilammenkangas (Särkipuro) and Suolamminvaara. From Nurmes and Valtimo five sites Murtovaara, Piilopirtinaho, Alimmainen Verkkojärvi, Paistinvaara and Salmivaara, were studied.

The studied mature spruce forests were dominated by Myrtillus type (MT) sites according to the Finnish classification of forests types (Cajander 1926). Both spruce (*Picea abies* (L.) Karsten) and birch (*Betula pendula* Roth, *B. pubescens* Ehrh.) were common. Willow (*Salix caprea* L.) and aspen (*Populus tremula* L.) were encountered occasionally. Most of the examined aspen trees were dead due to the ring cutting practice used commonly in Finland. The age of the forests was 120-160 years.

Most of the studied sites are in the North Karelia Biosphere Reserve which lies in the eastern corner of the biogeographic province of *Karelia borealis* (Kb) in Eastern Fennoscandia (Mela & Cajander 1906) or slightly north of the boundary between mid- and south boreal forest zones (Ahti et al. 1968).

A list of bryophytes at each of the 23 investigated sites was compiled from the information about species composition at 25-30 arbitrarily chosen locations. Bryophyta were collected from different substrates, such as forest floor, rotting wood, the base of trunks to heigth of 0.5 m from soil surface, bare soil on soil-covered roots of overturned trees, tree trunks at height of 0.6 to 2.0 - 2.5 m, big boulders and bedrock exposures. A herbarium consisting of about 1000 samples of bryophyta was collected and identified. The nomenclature of mosses follows Ignatov & Afonina (1992), and that of liverworts Konstantinova et al. (1992).

Results

Altogether, 158 species of bryophytes (107 mosses and 51 liverworts) were found.

Thirty-eight mosses and seven liverworts were found from forest floor samples. *Pleurozium schreberi, Hylocomium splendens, Dicranum polysetum, D. scoparium*, and *D. majus* are the dominant bryophytes. *Sphagnum girgensohnii, S. russowii, S. capillifolium, and S. angustifolium* grow in microdepressions. *Sphagnum quinquefarium* and *S.wulfianum*, which are old-growth forest indicator species, were also common.

Rotten wood was occupied by a versatile set of thirty-three mosses and nineteen liverworts. *Pleurozium schreberi, Sanionia uncinata, Dicranum fuscescens, Tetraphis pellucida, Ptilidium pulcherrimum, Lepidozia reptans, Blepharastoma trichophyllum*, and *Orthocaulis attenuatus* were the dominant species and several of them also grow on other substrates. Species growing mainly on rotten wood were *Tetraphis pellucida, Cephalozia lunulifolia, Lophozia longidens, L. longiflora s.l., L. longiflora var. guttulata, Crossocalyx hellerianus* and *Calypogeia suecica*. Three of the last species are old-growth forest indicators.

Bare soil and soil cover roots of overturned trees were occupied by twenty-one mosses and eleven liverworts. *Pogonatum urnigerum, Pohlia nutans, Dicranella cerviculata, Polytrichum juniperinum, P.commune, Plagiothecium laetum*, and *Callipogeia integristipula* were the dominant species, *Schistostega pennata* was the only old growth forest indicator species found on this substrate.

The base of tree trunks and protruding roots are many sided substrates for bryophytes. *Populus tremula* trunks were favoured by 25 mosses and 5 liverworts. *Sanionia uncinata, Plagiothecium laetum, Ptilidium pulcherrimum, Brachythecium salebrosum* and *B. starkei* were the most common species. *Rhytidiadelphus triquetrus, Plagiomnium cuspidatum, Campylium sommerfeltii* and *Eurhynchium pulchellum* were found occasionally.

Salix caprea trunkbases were inhabited by fifteen mosses and 5 liverworts, and only nine mosses and 5 liverworts were found on *Picea abies*. *Callicladium haldanianum* was found only on base of the roots of *Betula pendula*, which was favoured by fifteen mosses and 6 liverworts.

Aspen epiphytes were represented by *Ortotrichum speciosum, O. obtusifolium, Ptilidium pulcherrimum, Pylaisiella polyantha* and *Sanionia uncinata*. The liverwort *Radula complanata* was encountered occasionally.

Big boulders and rocks were a suitable habitat for twenty three mosses and 10 liverworts. These habitats are characterised by *Andreae rupestris, Paraleucobryum longifolium, Dicranum scoparium, Anastrophyllum minutum, Blepharostoma trichophyllum,* and *Orthocaulis attenuatus. Homalia trichomanoides, Mnium stellare* and *Neckera oligocarpa* are old growth forest indicator species.

Dung of elk is a less common substrate. *Splachnum luteum, S. rubrum, Tetraplodon angustatus* and *T. mnioides* usually grow on it.

Old growth forests indicator species such as *Crossocalyx hellerianus, Lophozia longiflora* var. *guttulata, Sphagnum quinquefarium, Sph. wulfianum,* and *Schistostega pennata* were fairly common in the studied sites. Of the indicator species *Calypogeia suecica, Lophozia ascendens, Rhytidiadelphus subpinnatus, Homalia trichomanoides,* and *Orthodicranum flagellare* were very scarce.

Discussion

Bryophyte substrate distribution in the Biosphere Reserve shows that species on rotten wood and trunks of alive trees are the most specific and apparently endangered. Ecology of the bryophytes occupying forest floor is mostly more flexible and these species are less endangered. The following species are most remarkable among the rare bryophytes in Finland: *Calypogeia suecica, Cephalozia macounii, Lophozia ascendens, Plagiomnium drummondii and Polytrichastrum pallidisetum.* These species are also included in the Red Data Book of East Fennoscandia (1998). Findings of them as well as bryophytes specific for old growth forests of Fennoscandia (see Hallingbäck 1991 and Söderström 1988), i.e., *Rhodobryum roseum, Sphagnum quinquefarium, S. wulfianum, Calypogeia suecica, Crossocalyx hellerianus, Lophozia longiflora var. guttulata, L. ascendens,* are a sign of virgin nature of the mature spruce forests of North Karelia Biosphere Reserve.

The highest species diversity of Bryophytes was reported from Pieni Kotavaara (71 species), Pampalo (70 species) and Ukonsärkkä (68 species). Of these sites Pampalo is the most interesting because six old growth forest indicator species - *Calypogeia suecica, Homalia trichomanoides, Lophozia longiflora, Mnium stellare, Rhytidiadelphus subpinnatus* and *Sphagnum quinquefarium* - were found there.

A comparative analysis of bryophyte diversity in mature forests in Tolvajärvi Landscape Reserve (Suojärvi District, Republic of Karelia, Russian Federation) and in Pieni Kotavaara (Ilomantsi, Finland), shows a significant difference between the sites. Epiphytic species as well as species growing on trunk base of aspen are almost missing in Pieni Kotavaara because large *Populus tremula* trees are missing. On the other hand, there are no windthrows in Tolvajärvi site, and thus the species specialised on these habitats are missing.

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Aphyllophorous fungi in pine forests in the Kostomuksha area, Republic of Karelia

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Introduction

Some consequences of human activities, such as industrial pollution, adversely affect the state of natural ecosystems and their constituents. A standard ecological assessment is made only for an autotrophic block, whereas heterotrophic organisms remain beyond the scope of study. It should be noted, however, that because their response to environmental changes is manifested within a shorter time, such factors as a decline in abundance, breeding fluctuations and variations in species composition often indicate unfavourable changes. Therefore, in assessment of the state of natural ecosystems, a special study of their heterotrophic and other constituents is highly important for a better understanding of mechanisms of resistance to anthropogenic impacts.

Aphyllophorous fungi are one of the main components of the heterotrophic block in forest ecosystems. This group of organisms responds to environmental changes in its own way: the most sensitive species are eliminated and vacant ecological niches are occupied by eurytopic species (Бондарцева & Свищ 1991; Бондарцева *et al.* 1994). To compare the species composition of this group of fungi, mature crowberry-blueberry pine stands growing in the Kostomuksha Nature Reserve were also studied. The most significant parameters, used to assess the state of natural and anthropogenically damaged forest ecosystems, are the species diversity and occurrence of some indicator-species of aphyllophorous fungi.

The effect of industrial emission on forest ecosystems in the vicinity of the Kostomuksha ore-dressing plant (now Karelsky Okatysh Joint-Stock Company) has been studied by the Forest Research Institute of the Karelian Research Centre, RAS, since 1987. The plant, which was put into operation in 1982, is located in the northwestern Republic of Karelia in the north-taiga subzone. It is considered the biggest source of airborne environmental pollution in Karelia. The main pollutants emitted are sulphur dioxide (SO_2), dust which contains iron, nickel and other heavy metals, as well as carbon monoxide (CO) and nitrogen oxides (NO_2). Their total annual volume varied from 71-52 thousand tonnes in 1992-1995 to 56-47 thousand tonnes (Государственный доклад... 1993-1999).

Materials and methods

In the study region, forest ecosystems are dominated by pine stands (about 70%) that chiefly belong to a green-moss group of forest types (crowberry-bilberry and crowberry-lingonberry associations). The aftereffect of airborne emission from the Kostomuksha plant was studied at sampling sites, 0.24 ha in size, located at a distance of 0.5-23 km from the source of pollution (Fig. 1). The sampling sites were laid out in medium-aged (65-68 years) mature (105-130- year-old) crowberry-blueberry pine stands that grow on sandy podzols, the most common type of forest in this area, and extend along the dominant (southwest-northeast) wind line (Table 1). Most sites have a second storey formed by spruce; individual birch- and aspen-trees are also encountered. Sampling sites 1, 2 and 17 are located at the boundary of the Kostomuksha State Nature Reserve which is 20 km southwest of the plant. In August 1997 and in September 1999, aphyllophorous fungi were collected at the above sampling sites.

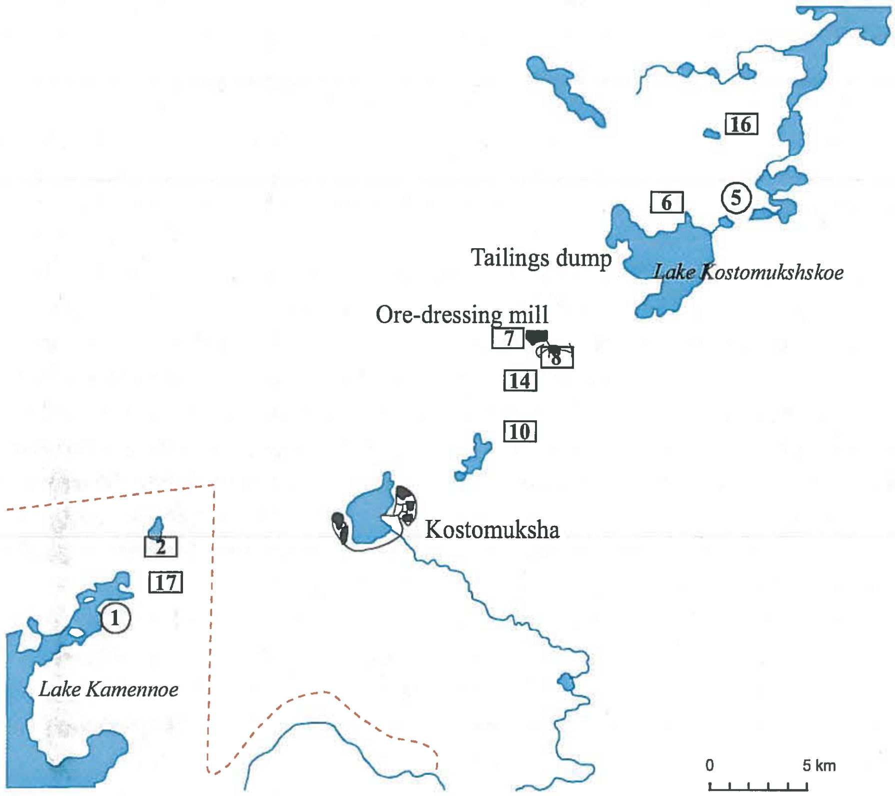

Fig. 1. Map of sample plot distribution

Table 1. Characteristics of sampling sites

Sampling site no.	Composition of stand	Age of stand, years	Distance from plant, km
1	9P1B *S	65	23
2	9P1B +S	130	21
5	10P *S,B	68	12
6	9P1S *B	105	9
7	8P1S1B *A	105	0.5
8	7P2S1B	105	0.5
10	8P2S +B	105	5
14	8P1B1S,A	105	2
16	9P1B +S	105	13
17	9P1B +S	110	23

Symbols

·Pinus sylvestris (P- pine), Picea spp. (S -spruce), Populus tremula (A - aspen), Betula spp. (B - birch)

·+ 2-5 %

·* less than 2 %

Results and discussion

A total of 114 species of 64 genera is now known in blueberry pine stands in the study area (Table 2), as compared to 84 species in 1997 and 73 species in 1999. Eight of these, namely *Chaetoderma luna, Junghuhnia luteoalba, Phellinus pini, Ph. viticola, Phlebia cornea, Ph. cretacea, Postia hibernica, Pseudomerulius aureus* and *Sistotremastrum suecicum*, are identified as indicator-species (Kotiranta & Niemelä 1996) for old-growth pine forests. Besides, three spruce-restricted indicator-species, viz. *Amylocystis lapponica, Phellinus chrysoloma* and *Ph. ferrugineofuscus*, were found. Forty-two species, five of which are indicator-species, were revealed in the reserve. Twenty-one to thirty-eight species were reported from the sampling sites laid out in the industrial zone of Kostomuksha, the number of indicator-species varying from 1 to 6. In studying the species composition of wood-attacking macromycetes, special attention was given to mycorrhiza-forming fungi because these basidial fungi are known to be most susceptible to environmental changes (Шкараба *et al.* 1991, Петров 1992, Селиванов *et al.* 1994). Examples of such aphyllophorous fungi reported are: *Aphinema byssoides, Piloderma croceum* and some ground and telephorous macromycetes, e.g. *Albatrellus confluens, Hydnellum ferrugineum, Sarcodon imbricatus* and *Tomentella spp.* The studies conducted at the sampling sites in 1997 showed that the harmful effect of airborne emission from the Kostomuksha plant was most apparent at site 16 which lies 13 km northeast of the plant near a tailingspile. The results of our observations agreed with those of forest-pathological monitoring (Лазарева *et al.* 1992). The 1999 study showed that the situation had slightly improved. Twenty-two aphyllophorous fungus species were identified at site 16, two species being mycorrhiza-forming fungi. The total number of species known at site 16 is 28 – an average value for the sites studied. The state of heterotrophic organisms in these forest ecosystems has improved presumably because the amount of pollutants emitted by the Kostomuksha plant has decreased in the past few years.

The results of 1997 and 1999 monitoring show that the degradation of these pine stands has not become irreversible yet. If the amount of pollutants is diminished, the surrounding forest ecosystems are likely to restore their natural state. It is desirable, therefore, to continue the study of the species composition of aphyllophorous fungi in these habitats.

Table 2. Aphyllophorous fungi in pine stands in the industrial zone of Kostomuksha

Fungus species	Sampling site nos.										
	0	1	2	5	6	7	8	10	14	16	17
Albatrellus confluens (Alb. et Schwein.: Fr.)											
Kotl. et Pouzar	+										
Amphinema byssoides (Pers.: Fr.) J. Erikss.		*		*	*	*	+*		*	*	*
··Amylocystis lapponica (Romell) Singer						*					
Amyloporia xantha (Fr.: Fr.) Bondartsev et Singer	+	*	+		+*	+*			*	*	+*
Antrodia serialis (Fr.) Donk	+*	+	+		+	+	*	+	+	*	+
A. sinuosa (Fr.) P. Karst.				+*	+*	+	+	+	*	*	+
Antrodiella semisupina (Berk.et Curtis) Ryvarden	+	+									
Asterodon ferruginosus Pat.	+										
Athelia bombacina (Pers.) Jülich									+	*	
Botryobasidium botryosum (Bres.) J. Erikss.	+	*			+*	+	+*		*	*	
B. candicans J. Erikss.								+	*		
B. obtusisporum J. Erikss.				*			*			*	
B. subcoronatum (Höhn. et Litsch.) Donk		*		+		+*					+
Ceraceomyces serpens (Tode : Fr.) Ginns						+			+		
C. sublaevis (Bres.) Jülich		*			*				*		*
C. violascens (Fr. : Fr) Jülich											+*
Ceriporiopsis pannocincta (Romell) Gilb. et Ryvarden	+										

Fungus species	Sampling site nos. 0	1	2	5	6	7	8	10	14	16	17
Cerrena unicolor (Bull.: Fr.) Murrill										*	
·Chaetoderma luna (Romell ex Rogers et H. S. Jacks.) Parmasto						+					
Climacocystis borealis (Fr.) Kotl. et Pouzar	+										
Coltricia perennis (L.: Fr.) Murrill	+			+		+					
Columnocystis abietina (Pers.: Fr.) Pouzar								+			
Conferticium ochraceum (Fr.: Fr.) Hallenb.							+				
Coniophora arida (Fr.) P. Karst.						+					
C. fusispora (Cooke et Ellis) Sacc.				+							+
C. olivacea (Pers.: Fr.) P. Karst.		+					+*		+	+	+
Daedaleopsis confragosa (Bolton: Fr.) Schröt.										+	
D. septentrionalis (P. Karst.) Niemelä										*	
Dacryobolus karstenii (Bres.) Oberw. ex Parmasto		*		+	+	+				*	+*
D. sudans (Alb. et Schwein.: Fr.) Fr.					*						
Fomes fomentarius (L.: Fr.) Fr.	+*	+*	+*	+*	+*	+*	+*	+*	+*	+*	+*
Fomitopsis pinicola (Alb.et Schwein.) P. Karst.	+*	+*	+*	+*	+*	+*	+*	+*	+*	+*	+*
Gloeophyllum sepiarium (Wulfen : Fr.) P. Karst.	+		+		+*		*	+			
Gloeoporus dichrous (Fr.: Fr.) Bres.											*
Henningsomyces candidus (Pers.: Fr.) Kuntze			*								
Hydnellum ferrugineum (Fr.: Fr.) P. Karst.	+										
H. scrobiculatum (Fr.) P. Karst.		*									
Hyphoderma praetermissum (P. Karst.) J. Erikss. et A. Strid	+	+*		+					+*		
H. setigerum (Fr.) Donk	+									*	+
Hyphodontia alutacea (Fr.) J. Erikss.									+		
H. aspera (Fr.) J.Erikss.	*				+						
barba-jovis (Fr.) J. Erikss.									*		
H. breviseta (P. Karst.) J. Erikss.	+	+		*			*	+	*		+
H. subalutacea (P. Karst.) J. Erikss.				+					*		
Hypochnicium geogenium (Bres.) J. Erikss.									+		
Inonotus obliquus (Pers.: Fr.) Pilát	+	+		+		+	+		+		+
I. radiatus (Sow.: Fr.) P. Karst.	+										
I. rheades (Pers.) P. Karst.	*										
·Junghuhnia luteoalba (P. Karst.) Ryvarden		*								*	
Laxitextum bicolor (Fr.) Lentz							+				
Leucogyrophana romellii (Fr.) Ginns					*						
L. sororia (Burt.) Ginns						*					
Merulius tremellosus Schrad.: Fr.							*				
Onnia triqueter (Lentz : Fr.) Imazeki	+										
Oxyporus corticola (Fr.) Ryvarden		*	+								
Peniophora polygonia (Pers.: Fr.) Bourdot et Galzin						+					
Phanerochaete laevis (Pers.: Fr.) J. Erikss. et Ryvarden	+	+			+	+		+	+		+*
Ph. sanguinea (Fr.) Pouzar	+	+*	+	+		+*	+*		+	+	
Ph. sordida (P. Karst.) J. Erikss. et Ryvarden	+						*	+	+	+	
·Phellinus chrysoloma (Fr.) Donk	+	+			+	+	+		+		
Ph. conchatus (Pers.: Fr.) Pat.	+										
·Ph. ferrugineofuscus (P. Karst.) Bourdot	*										
Ph. igniarius (L.: Fr.) Quél.	+			*		+	+	+	+		
Ph. laevigatus (Fr.) Bourdot et Galzin	+										
·Ph. lundelii Niemelä	+		+	+		+					+
·Ph. pini (Brot.: Fr.) A. Ames	+		+		+	+	+	+	+		+

Fungus species	Sampling site nos.										
	0	1	2	5	6	7	8	10	14	16	17
Ph. tremulae (Bondartsev) Bondartsev et Borisov			+			+		+			+
·Ph. viticola (Schwein.: Fr.) Donk	+				+		*				
Phellodon tomentosus (Fr.) Banker				+			+	+			
··Phlebia cornea (Bourdot et Galzin) J. Erikss.						*					
·Ph. cretacea (Bourdot et Galzin) J. Erikss. et Hjortstam	*		+*			*					
Ph. radiata Fr.			*							*	
Phlebiella borealis K.H. Larss. et Hjortstam									+		
Ph. pseudotsugae (Burt.) K.H. Larss. et Hjortstam					+				+		*
Phlebiopsis gigantea (Fr.: Fr.) Jülich	*										
Piloderma byssinum (P. Karst.) Jülich										*	*
P. croceum J. Erikss. et Hjorstam	+	+*	+	+*	+	+*	+		+*	*	+
Piptoporus betulinus (Bull.: Fr.) P. Karst.	+		+		+	+	+		+		+*
Polyporus varius Fr.								+			
Postia fragilis (Fr.) Jülich					+*	+					
··P. hibernica (Berk. et Broome) Jülich				+					*		
·P. lateritia Renvall					*						
·Pseudomerulius aureus (Fr.: Fr.) Jülich	+										
Resinicium bicolor (Alb. et Schwein.: Fr.) Parmasto						+*		+			
R. furfuraceum (Bres.) Parmasto	+	+*	*	+*		+*	*	+	*	*	+*
Sarcodon imbricatus (L.: Fr.) P. Karst.				*							
Schizopora paradoxa (Schrad.: Fr.) Donk						*					
Scytinostroma galactinum (Fr.) Donk									+		
Serpula himantioides (Fr.: Fr.) P. Karst.										*	
Sistotrema raduloides (P. Karst.) Donk	+										
S. sernanderi (Litsch.) Donk		*							*		
·Sistotremastrum suecicum Litsch. ex J. Erikss.										+	
Skeletocutis amorpha (Fr.) Kotl. et Pouz.		+		+	*						
S. bigutullata (Romell) Niemelä,		*									*
·S. odora (Sacc.) Ginns	+										
S. subincarnata (Peck) Jean Keller		*									
Stereum hirsutum (Willd.: Fr.) Gray					+		+*	+			
S. rugosum Pers.: Fr.						*					
S. sanguinolentum (Alb.et Schw.: Fr.) Fr.		*		+	+	+					
Tomentella bryophila (Pers.) M.J. Larsen						*					
T. lapida (Pers.) Stalpers								+			
T. stuposa (Link) Stalpers									+		
Tomentellopsis submollis (Svrcek) Hjortstam					*				*	*	*
Trametes hirsuta (Wulfen : Fr.) Pilát			+								
T. ochracea (Pers.) Gilb.et Ryvarden			+			*		+			
T. pubescens (Schumach.: Fr.) Pilát	+					+					
Trechispora vaga (Fr.) Liberta		*	*	+						*	+*
Trichaptum abietinum (Pers.: Fr.) Ryvarden	+	+*	+	+*	+	+	+*	+	+*		+*
T. hollii (J.C. Schmidt: Fr.) Kreisel				+							+
T. pargamenum (Fr.) G. Cunn.							+*			+*	
Tubulicrinis effugiens (Bourdot et Galzin) Liberta									+		
T. gracillimus (D.P. Rogers et H.S. Jacks.) G. Cunn.										+	
T. subulatus (Bourdot et Galzin) Donk		*		+	*						+
Vararia investiens (Schwein.) P. Karst.			+	+*							
Total number of species	42	30	21	28	28	38	27	21	37	28	31
Number of indicator-species	7	2	2	2	4	6	3	1	3	2	2

Note. Sampling sites. 0 – reserve area. Symbols: before the name of a species · - indicator-species for old and ·· - very old forests (Kotiranta ja Niemelä, 1996); in columns: + - based on 1997 collections, * - based on 1999 collections.

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Algae censors biodiversity formation in the North Russian rivers

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Introduction

Lists of species provide the basis for the study of the biota structure and the factors that affect it. It is important to make systematic analysis more complete, but it is equally important to improve diagnoses, to revise classifications and phylogenetic schemes, and to change the concept of a species. Besides, one should bear in mind that species are not equivalent in their "contribution" to biota structure. They can differ in evolution status, the extent of phylogenetic isolation, and functional role in ecosystems. Therefore, assessment of diversity solely as an arithmetic sum of species without considering the fact that they are not equivalent is hardly acceptable, and does not reflect changes in a coenoses.

Changes in the species number and its relatively abundance in periphyton communities can be used to survey water quality. Many richness, evenness and diversity indices have been developed to characterize communities. But more often have been suggested that the best means for detecting shift in the environment is Shannon-Weaver diversity index, which is an integral characteristic of assemblages.

The purpose of this paper is to summarize and discuss, with specific examples, the variations in species diversity not only after changes in abiotic factors, but also in watercourses that differ in geographic position. The hypothesis that changes in species diversity can be used as an indicator of changes in water quality was tested

Material and methods

Attached communities have been studied at 49 streams located within north-western Russia from Ladoga Lake to Barents Sea. It allows to estimate the climatic and the hydrological regime influence on phytoperiphyton communities structure and abundance.

Biodiversity indices have been tested with materials collected from natural and artificial substrata. In all the rivers studied, samples were collected during a short summer low-water period. In some rivers characteristic of each region observation was conducted during an open water period (April-October) or rivers were studied througout the season.

The sample form of Shannon-Wiever formula

$$\overline{H} = -\sum (N_i / N)\ln(N_i / N)$$

was used as an index of species diversity. It was calculated separately for diatoms and for communities in whole, for rivers and separate locations and communities. The diatom database software "OMNIDIA" (Lecointe et al. 1993) was used to calculate trophic diatom index (TDI), the values of which varied more at low concentrations (Eloranta 1999).

Results and discussion

The most important characteristics of the phytoperiphyton in studied rivers is underline its belonging to the flora of boreal type, as true high latitude elements even in the rivers of the Barents Sea Basin occupy, as a rule, a subordinate position (Komulainen 2002). Taxonomic structure of periphyton displays a tendency for the concentration of inter- and intraspecies taxons in a small number of genera and families while at the same time forming a considerable amount of genera and families comprised of few species which reflects the complexity of florogenetic processes. This trend suggests that a significant role in the formation of periphyton, in studied rivers is played by the allochthonous way of development.

Taxonomical structure of algal communities is formed either due to the introduction of new taxons into them or at the expense of combinatorial change within the same species. The first is determined for periphyton by entering of allochthonic species from plankton and bottom algae communities. Floristic diversity is also maintained due to the succession asynchronism in various sites of the river system and algal drift explains simultaneous presence of spring, summer and autumn species in algocenosis at that, the formation rate is mainly regulated by light conditions.

Some "northern" traits, characteristic of algal periphyton flora, are apparent at the different levels of taxonomic analysis (Komulainen 1998). With predominance of diatoms, blue-green algae become less diverse northwards than green algae. Species that show a high phosphorus and nitrogen demand are the first to drop out of algal coenoses. Forms that are accidental for the periphyton are less common than true attached forms. *Nostocales/Oscillatoriales* ratio increases from 1.6 for the rivers of the Ladoga Lake basin to 4.0 for those of the Barents Sea basin.

Assessing the impact of climate changes on biodiversity is difficult due to the spatial and temporal scale and the complexity of the problem, and its interactions with other environmental factors. In spite of marked north-south variations in taxonomic composition of phytoperiphyton in study rivers, the diversity indices values remain practically the same ranged from 2.0 to 3.0 for most rivers (Fig. 1). This shows that the algal coenoses of periphyton are highly developed in the rivers studied that have high vital activity, self-regulation and stability.

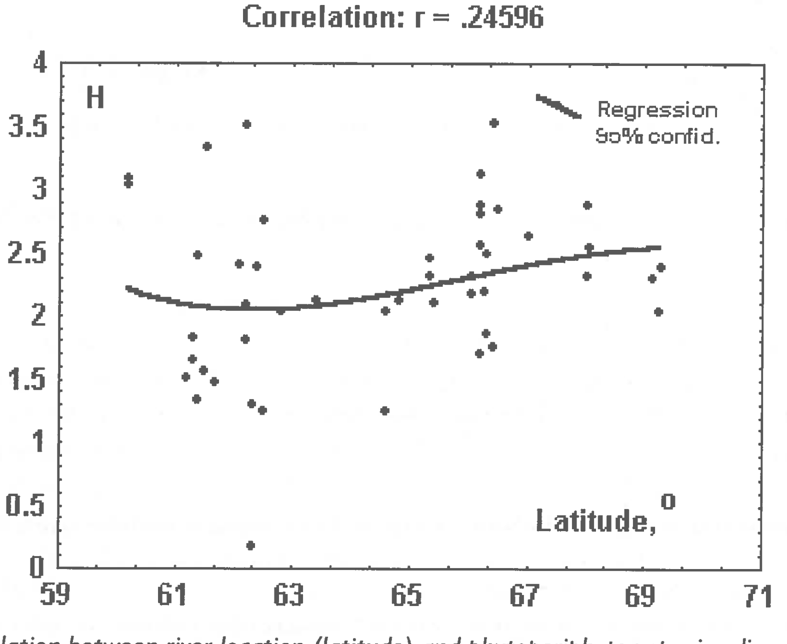

Fig. 1. Correlation between river location (latitude) and phytoperiphyton species diversity indices (H).

At the same time the heterogeneity of habitat in each river is very high and significant for the formation of periphyton diversity. Firstly differences in species composition have been observed between pool, run and riffle habitats. Current is the main "taking" factor determining mosaic character of the periphyton communities distribution and regulating the periphyton succession. It is noted that during floods, a large quantity of attached material is irretrievably removed from the ecosystem, and the formation of biodiversity begins from the very beginning.

Species diversity peaked quickly during colonisation and decreased as the length of exposure increased. Pool zone showed greater diversity indices during the first few days exposure than did slides exposed in riffle zones. After week diversity of algae-coenoses was significantly ($p<0.05$) greater at 0.1 m c^{-2} than at 1.0 m c^{-2}. Later on this brief conditioning period, however, the riffle slides showed more rapid cell growth and accommodation rates, particularly. That is why in the rapids with poorly sorted moss-covered rocky substrates diversity values were generally greater than at the pools. But for both cases the negative relations of an index Shannon-Wiever with phytoperiphyton biomass was very weak ($r = 0.30$, $F = 3.50$, $P < 007$).

Besides, phytoperiphyton diversity was observed to increase in rivers with large basin areas (Fig.2) and decreased in communities were filamentous algae have become very abundant.

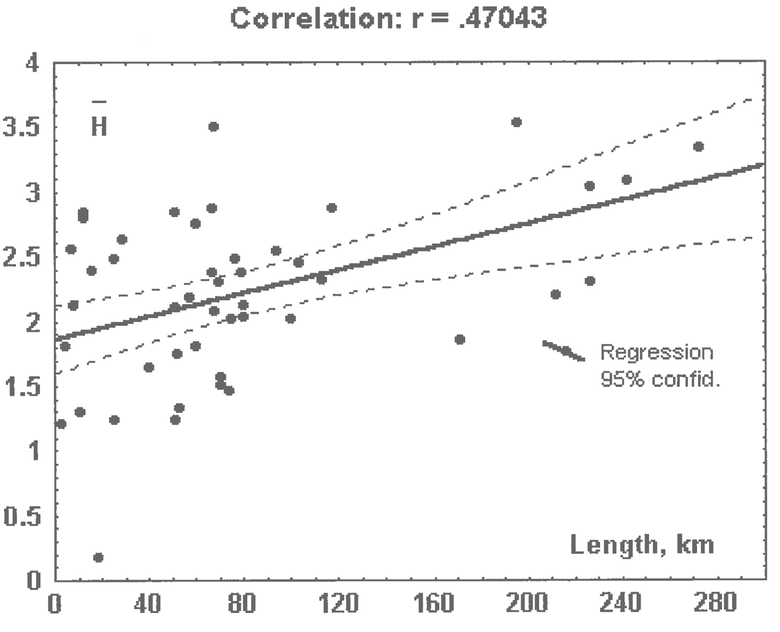

Fig. 2. Correlation between river size (length, km) and phytoperiphyton species diversity indices (H).

Variations in diversity are caused not only by the variability of hydrological regime. Lake factor is of great importance, by the removal of allochthonous species from swamps and running-water lakes (Komulainen 1999). Structure and abundance of allochthonic algae flora changes in dependence on the number of lake their morphometry, trophic status and seasons. In attached communities, in addition to euperiphytonic forms, which have adjusted to the attached mode of life and are scarce in other algocenotic types, periphyton was found to include planktonic and benthic algae. Allochthonous forms are clearly dominated by colony-forming planktonic diatoms, such as *Aulacosira* spp, *Melosira* spp, *Fragilaria* spp. and *Tabellaria fenestrata* (Lyngb.) Kütz. A particularly substantial contribution to the formation of periphyton in large lakes is sometimes made by planktonic green (*Palmodictyon viride* Kütz., *Hyalotheca mucosa* (Merth.) Ehr.)

and the blue-green (*Gloeotrichia echinulata* (J. S. Smith.) P. Richt., *Microcystis aeruginosa* Kütz., *Aphanizomenon flos-aquae* (L.) Ralfs, *Anabaena* spp., *Woronichinia naegeliana* (Ung.) Elenk., and *Oscillatoria agardhii* (Gom.)) algae, that cause waters "blooming".

Migration of a large number of algae from one assemblage to another and from lakes to rivers leads to significant indices of diversity changes, which constant fluctuations indicate the low organization and stability of algal communities in these locations. As a result of such "mutual enrichment" the classical continuum has been interrupted and local increase/decrease changes in phytoperiphyton communities diversity constantly observed .

Most of the rivers are not affected by human activities. The impact of man on the water bodies is basically caused by the discharge of domestic and agricultural waste water rich in nutrients. The increase of anthropogenic effect leads to slightly increased bottom species diversity and structural trivialization, followed by a decline in the number of dominant species. The halophobic-acidophilic-indifferent composition of diatoms is enriched in alkaliphilic and halophilic species. Leading oxiphilic xenosaprobic diatoms of the genera are observed to drop out, and the role of *Tabellaria* becomes less important. TDI values calculated for river in which same human impact was observed varied rather widely but correlation between the TDI and index of biodiversity was significant ($r=0.46$; $F=19.0$; $P<00004$).

There are problems with using species diversity indices to indicate pollution trend to be related to predicting decrease in diversity in response to decrease in water quality. But in our experiments with artificial substrates it has been found that at the initial stages of contamination, the structure changes by introduction of new species and the large-scale reproduction of the species that were earlier scarce in phytocenosis. Fig. There are changes in diversity index for periphyton communities in Lizma River developed on slides which were placed to points where there was sewage water input in river, after three months exposure in clear water (Fig. 3). With an increase in anthropogenic impact an oligodominant complex of species is formed and structural trivialization followed by a decline in the number of dominant species and the communities become less diverse and structurally more simple.

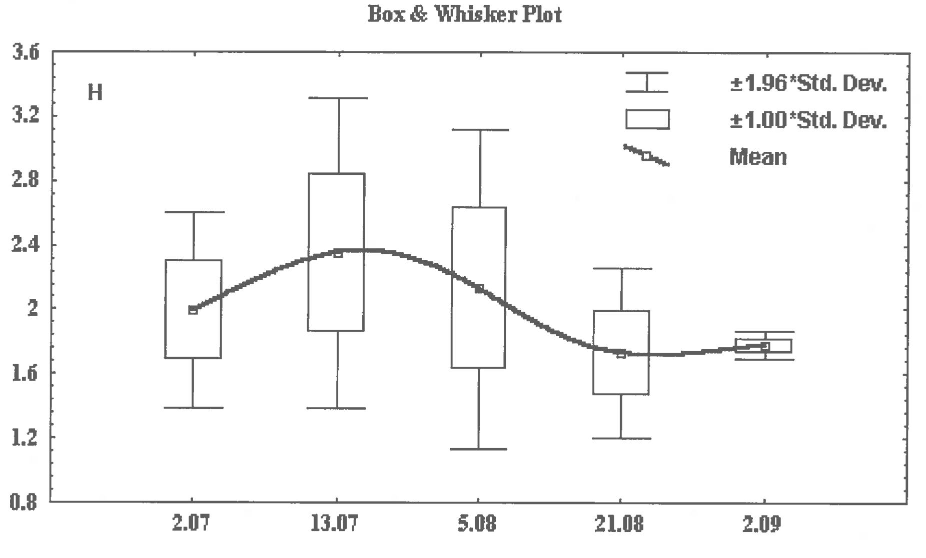

Fig. 3. Box plot of species diversity indices (H) for phytoperiphyton developed in point of sewage water input.

The minimisation of anthropogenic effect and the stabilization of hydrological regime lead to the rapid reconstruction of the natural structure of algal cenosis. It has often been noticed that algal flora has a natural structure even at a short distance from the place of wastewater discharge. This is favoured by alternation of zones differing in hydrological regime, when a riffle-pool complex acts as "a natural water treatment facility".

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Changes in the fauna and distribution dynamics of terrestrial vertebrates in the European North of Russia

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Introduction

Changes in the fauna composition and boundaries of the range of species in the European North are affected by a number of factors. The leading role is now played by human-induced transformations of animal habitats. Rapid alteration of the ecological situation in extensive areas results in fragmentation or destruction of primary and establishment of secondary ecosystems, where native species may fail to find a suitable habitat. On the other hand, the emergence of new conditions in secondary types of ecosystems facilitates their colonization by new species.

Other important factors influencing the changes in distribution are annual and multiannual natural abundance variations, particularly accumulation of the so-called population «potential». Another one is artificial support of the high density of some hunted animal populations in certain areas, as well as introduction of new species and wildlife conservation activities.

The Karelian landscapes changed notably in the last century. Vast areas of primeval forests were replaced by clearcuts, and then covered primarily by deciduous and mixed stands of varying age. Agricultural area increased mainly at the expense of large drained mires. Bogged forests in large areas were considerably transformed by forest drainage, as well. All these changes had a tangible effect on the general appearance of the terrestrial vertebrate fauna and the distribution of its representatives.

Results and discussion

The limits of the distribution range of sand lizard (*Lacerta agilis*), water snake (*Natrix natrix*), crested newt (*Triturus cristatus*) and common toad (*Bufo bufo*) have moved much to the north within a short enough period of time.

The bird species for which a distribution shift further to the north was observed are blackbird (*Turdus merula*), balld-coot (*Fulica atra*), white and black storks (*Ciconia ciconia* and *Ciconia nigra*), black-headed gull (*Larus ridibundus*), and many passerines. Some bird species are expanding their range quite rapidly. Thus, Eurasian blackbird, for which no reliable reports of nesting could be found before 1965, colonized the southern part of the republic in the last 10-12 years, and now nests regularly up to as far as 63° N (Зимин 1988).

The mammals that demonstrated a high expansion rate are: mole (*Talpa europea*), European hedgehog (*Erinaceus europeus*), Northern birchmouse (*Sicista betulina*), common vole (*Microtus agrestis*), Eurasian harvest mouse (*Apodemus agrarius*), European polecat (*Mustela putorius*), Eurasian badger (*Meles meles*), Midrussian wolf (*Canis lupus*) and roe deer (*Capreolus capreolus*) (Fig. 1).

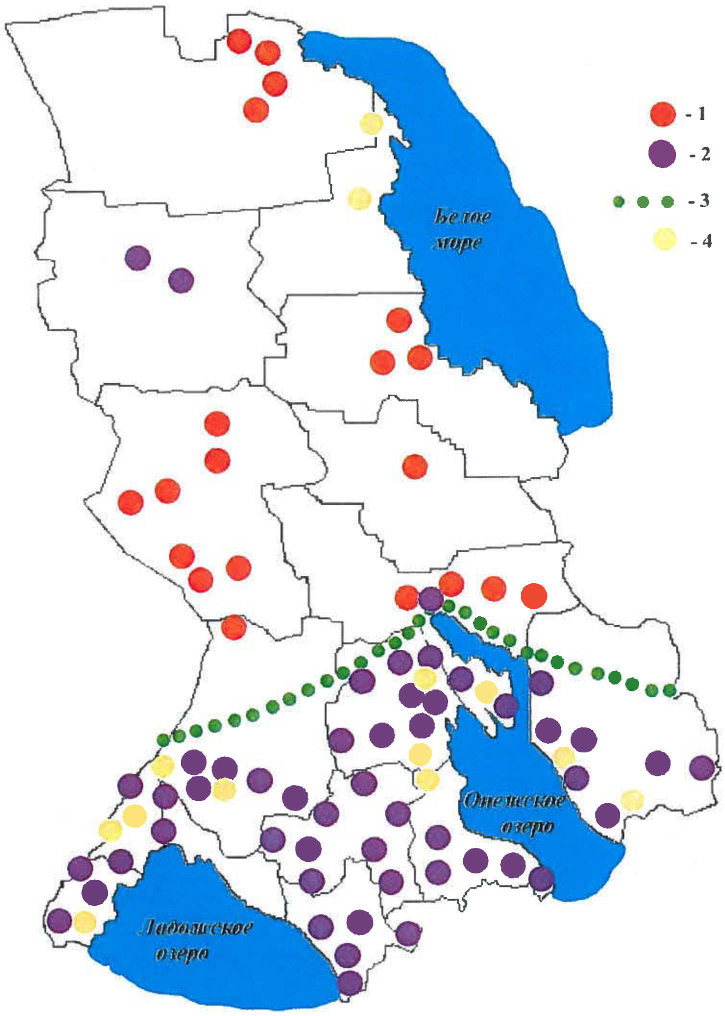

Fig. 1. Distribution of the wild boar and roe deer in Karelia (according to Danilov 1979, with additions) 1 – places of wild boar registration, 2 – wild boar breeding and staying over winter, 3 – the border of the regular registration and breeding of the wild boar, 4 – places of the roe deer registration

However, an absolutely fantastic phenomenon for which no clear explanations have been found yet is the speedy expansion of the European wild boar to the north observed in the 1960's - 80's throughout the European part of Russia. This phenomenon deserves a more detailed discussion.

In the very remote past, some 2-3 millennia B.P., and in the period covered by history, i.e. 2-3 centuries ago, wild boar could be found neither in Karelia, nor even in most of the area now included in the Leningrad region. The northernmost finds of wild boar bones amongst fauna remnants from Neolithic sites are: the southern shore of Lake Ladoga (Иностранцев 1882) and the southern coast of Finland Bay (Поляков 1879).

At the beginning of the 20th century, wild boar could not be found in most of the Russian Northwest territory either (Русаков 1979). Moreover, it was believed that the species could not live further to the north than the mean maximum snow cover depth isoline of 40 cm and snow-covered period duration over 160 days (Формозов 1946, Насимович 1955, Фадеев 1973). The closest to Karelia area where wild boar was a permanent resident was the Baltic states.

The first wild boar individuals in the Leningrad region were encountered in 1947-1948. It only took the species 20 years to colonize the whole of the region and show up in Karelia, and 15 more years to reach the Arctic circle (Иванов 1962, Данилов 1979, Русаков 1979, Русаков & Тимофеева 1984) (Fig. 1).

We do not however consider extra distant occurrences of individuals or small groups of animals with no reproduction in the area as actual expansion of the range, be it wild boar or any other terrestrial vertebrate species. With this principle in view, the modern northern limit of the wild boar permanent residency range in Karelia can be depicted as an abstract line joining the settlements Tolvajarvi – Karhumäki – Pjalma – Kolodozero (Fig. 1).

The visible reason for wild boar expansion to the north is first of all the situation with high population densities in the adjacent areas where the animals came from. In our case these were the Baltic states and Belorussia. Another reason was the series warm winters with little snow in the late 1960's – early 1970's. On the third place is the high moving activity of the animals. Therefore their arrival in areas quite far from the residential habitats, surely contributed to the expansion. Such behavior is pre-determined not only by the species ecology, but also by the scarcity of natural feeding resources for wild boar in the Russian European North and the difficulties with obtaining food owing to the early and deep freezing of the soil.

A tendency towards expansion northwards has been lately demonstrated by many representatives of the broad-leaved forest fauna complex, which is mainly due to the primeval coniferous forests in the north- and mid-taiga being replaced by deciduous and mixed stands, and the emergence of large clear-cut and young stand areas.

Most representatives of the north-taiga fauna show no visible trends for southwards expansion of the range. On the contrary, the above reasons forces many of them to shift the southern limits of the distribution range to the north. For example Siberian chikadee (*Parus cinctus*), pine grosbeak (*Pinicola enucleator*), three-toed woodpecker (*Picoides tridactylus*), smew (*Mergus albellus*) and willow grouse (*Lagopus lagopus*) are such species. Retreat of game animals to the north was caused both by direct human pursuit (wolverine, forest reindeer), and the growing disturbance factor.

Our data shows that the major reasons for the shrinkage of wolverine range and abundance were the application of poison in the so-called wolf-fighting from 50-s to the early 1980's, and direct pursuit of the animals using snowmobiles nowadays.

Some noteworthy changes were observed also in the situation with forest reindeer. After the time when semidomestic reindeer husbandry in Karelia was over and the pursuit and killings of wild animals by reindeer breeders was stopped, wild forest reindeer started recovering its former abundance and distribution range quite rapidly. As a result, as soon as in the mid-1970's the population abundance reached over 6000 individuals, and the southern distribution limit shifted down to the abstract line joining the communities Kuolismaa – Porajärvi – Maselgskaya, and then along Lake Onego shore to the administrative border with the Vologda region (Данилов 1975a, Данилов et al. 1973, 1986) (Fig. 2).

Dramatic transformations in the society in the late 1980's-early 1990's however brought by a poaching «bloom» in Karelia, as well as in other parts of Russia. As a consequence, there are now just a little over 3,500 reindeers in Karelia, the southern distribution limit retreated almost as far north as Segezha. The southern part of the range became fragmented again.

Sometimes, drastic ecological changes are the results for a retreat of the species from the positions conquered in the course of prolonged expansion in one direction. Thus, as a result of the northwards expansion of gray partridge in the 19th – beginning of the 20th century, the species settled in Karelia up to the latitude of Segezha (63°30′N). After the form of the agricultural activities in the region changed, i.e. grain crop cultiva-

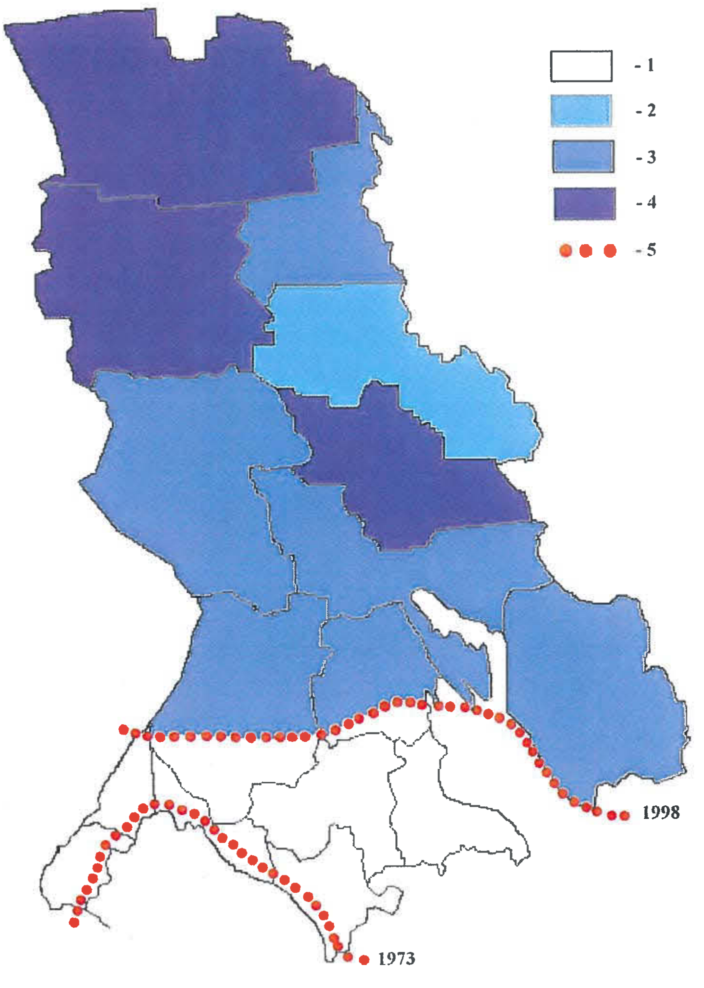

Fig. 2. Distribution and number (average for many years) of the wolverine in Karelia, tracks per 10 km. 1 – no tracks, 2 – 0.01 and less, 3 – 0.02-0.09, 4 – 0.10 and more, 5 – southern border of spreading

tion stopped, gray partridge completely disappeared from the republic (the last find was reported in 1961). About the same happened to European hare, small number of which have stayed only in the southernmost agricultural districts of the republic.

A vivid example of rapid colonization of northern areas followed however by a gradual retreat is demonstrated by starling. In the first half of the 20th century it spread into the Kola peninsula, nesting there steadily and abundantly. Starting with the mid-1970s however, its abundance in the northern regions of the Northwest Russia, as well as in the North of Scandinavia, rapidly decreased. By now the process reached Central Russia (Зимин 1988).

Finally, the human activity that is the last one to be considered here, but produces an exceptionally powerful impact on the fauna, is the introduction of new animal species. In Karelia the process started in 1932 with the release of muskrat in the Pudozh district.

In 1934 muskrat introduction was followed by the release of a small group of American mink near Petrozavodsk. At present the species is quite common and even numerous throughout Karelia. Our investigations (Данилов 1963, 1969, 1972, Danilov 1992) showed that mink acclimatization succeeded owing to the continuous adding of farm-bred animals escaped into the wild (Fig. 3).

The introduction of this predator in Karelia lead to tragic consequences for the native species European mink. The latter disappeared from Karelia, now only presumably occurring in the north-east of the Pudozh district. (Fig. 3). The same reason caused the extinction of European mink from the Leningrad region, and most parts of the Novgorod, Pskov, Vologda and Tver regions (Данилов & Туманов 1976).

In the early 1950s another representative of the North American fauna appeared in Karelia. Canadian beaver immigrated from Finland, where the species had been released earlier (Данилов 1962, 1975b, Danilov 1992, 1995). Expanding their range both independently and with human help, the animals colonized most of Karelian territory (Fig. 4). Their abundance is now a little over 3000 individuals.

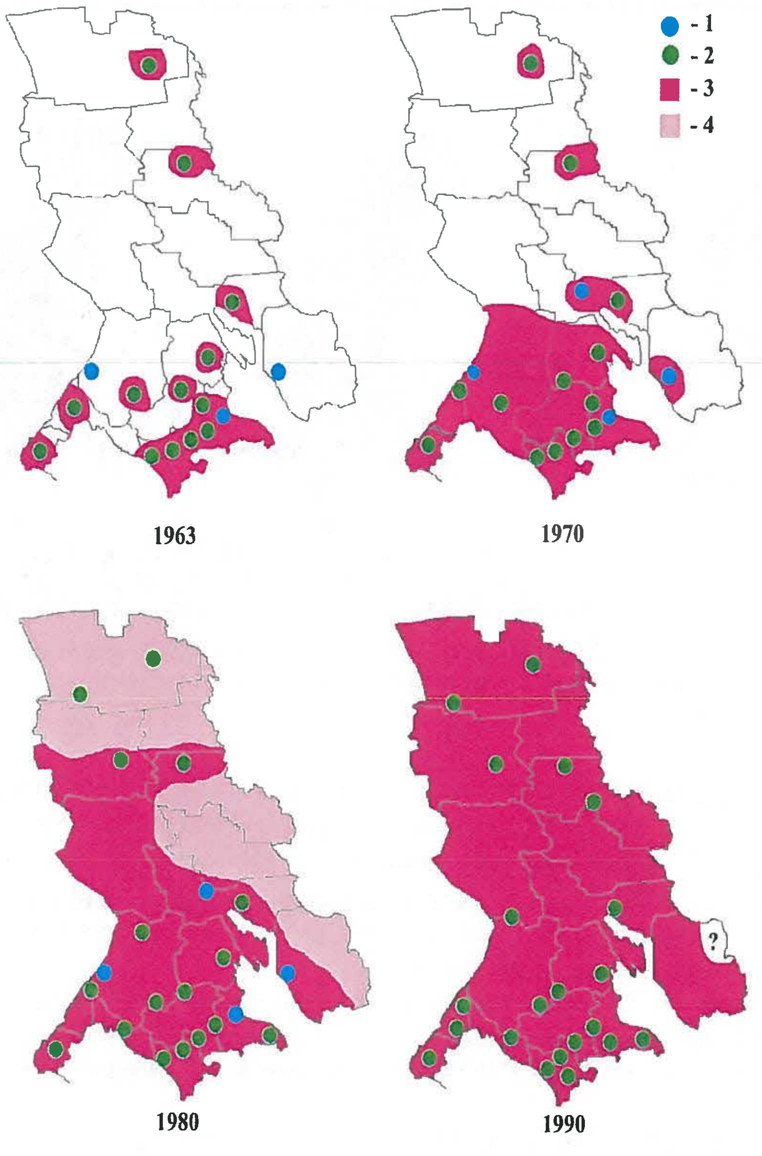

Fig. 3. Distribution of the american mink in Karelia (according to Danilov 1992), 1 – places of release, 2 – fur breeding farm, 3 – area of animals habitat, 4 – area of rare occurrence, ? – area where european mink could inhabit

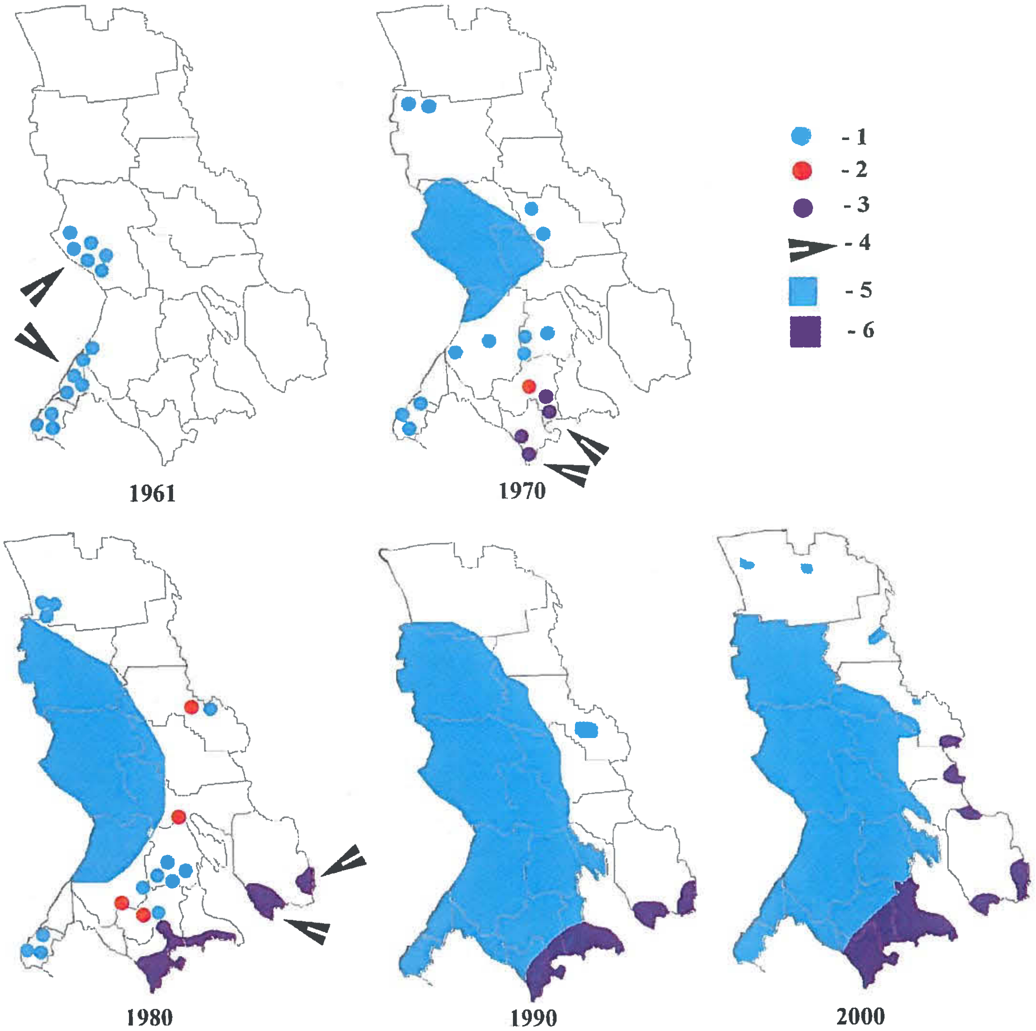

Fig. 4. Distribution of the Canadian and European beavers in Karelia, 1 – Canadian beavers settlements, 2 – places of Canadian beavers releases, 3 – European beavers settlements, 4 – ways of animals spreading, 5 – area inhabited by Canadian beaver, 6 – area inhabited by European beaver

Just a decade after the arrival of Canadian beaver, i.e. in the early 1960's Karelia was colonized also by European beaver spreading from the Leningrad region (Fig. 4). The total abundance of the species according to the 1999 inventory is not more than 1200 individuals. Further expansion of the animals and penetration of one species into the other's range creates a problem of competition between the species that could result in one species being displaced by the other one.

We have thus demonstrated that the composition of the terrestrial vertebrate fauna and the species distribution across Karelian territory changed significantly through the analyzed period. The aviafauna received 25, and the mammal fauna 7 new species.

Analysis of these phenomena and their causes revealed a highly dynamic and even somewhat unstable situation with the whole of the terrestrial vertebrate fauna population in the area, which is quite typical of the Northwest Russia and Fennoscandia in general. Similar phenomena can probably be assumed to occur with other groups of animals.

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Reptiles and anurans of the Kemeri National Park, Latvia

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Introduction

The Kemeri National Park, located in the central part of Latvia (Fig. 1), was established in 1997, when several smaller protected nature areas were united in a joint complex under a common nature protection and management plan. The total area of the National Park is 42 790 ha: 51% forests, 24% mires, 10% waters, 12% agricultural land and shrubs, and 3% human settlements (Latvian Fund for Nature 1999).

Coastal raised bogs cover most of the territory of the National Park. One of the largest rivers of Latvia, the Lielupe River, marks the eastern border of the National Park. The wet flood plain meadows of the river are rich in rare plant species. There are also several old wet black alder forest territories with especially high biological value. The coastal area of the Gulf of Riga includes sandy dunes, dry meadows and dry old pine forests on dunes. There are several inland dune rows along the coastline of the ancient Littorina Sea. Three lagoon lakes are located in the northern and north-eastern part of the National Park, one of which (Lake Kanieris, 1130 ha) is a waterfowl habitat and rest site of international importance during migration (Racinskis 2000).

Ten of the 20 reptile and amphibian species that are found in Latvia are included in Appendix II to the Bern Convention (1979), and 11 in Appendices II and IV to the EU Species and Habitats Directive (92/43/EEC). Studies on these animals in Latvia are very limited. The information on their distribution and ecology is poor. The aim of the present survey was to determine the distribution of the reptile and amphibian species in the territory of Kemeri National Park, to estimate their occurrence in various habitats, and to determine the status of the species in the area.

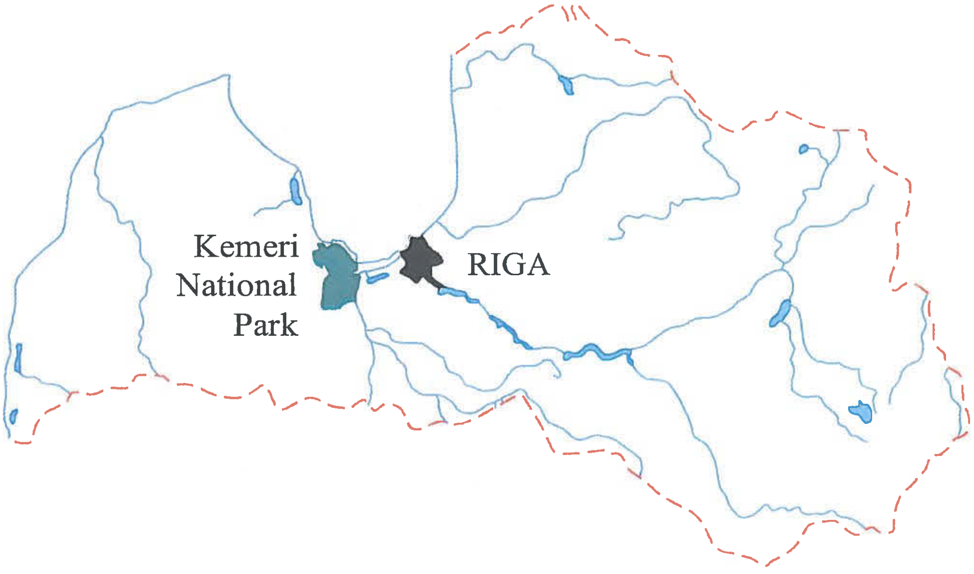

Figure 1. Location of the Kemeri National Park in Latvia.

Methods

Data was collected in 1994-1997 along transects located throughout the territory of the Kemeri National Park, excepting the interior parts of the largest raised bog of the National Park (Kemeru Tirelis in the south-central part of the park) which was not visited. The total length of transects was more than 200 km.

The main attention was paid to reptiles. Additional observations of anurans were recorded also. Censuses were carried out in warm and dry weather conditions. Each observation of a specimen was mapped at an 1:50 000 scale and species distribution maps were prepared using the Baltic Co-ordinate System, Transverse Mercator Projection (TM-1993) with 1x1 km square size. A total of 188 or 49.7 % of all squares of the National Park were visited in the survey. For reptiles, in each case the habitat was described in the field. The information was supplemented with stand characteristics from the data base of the State Forest Service. For anurans, the type of forest was determined from forest plans, according to the forest classification applied in Latvia (Buss 1997).

Results

Species distribution maps (not included due to the restrictions on the size of the article) using a 1x1 km grid were prepared. At least one reptile or anuran species was found in 134 or 71.3 % of the visited squares (Table 1.).

Table 1. Occurrence of reptiles and anurans in 1x1 km squares of the Baltic Co-ordinate System that were crossed by transects in the Kemeri National Park.

Species	Number of squares	% of visited squares
Reptiles		
Anguis fragilis	17	9.0
Lacerta agilis	5	2.7
Lacerta vivipara	36	19.1
Natrix natrix	31	16.5
Coronella austriaca	2	1.1
Vipera berus	3	1.6
Anurans		
Bufo bufo	31	16.5
Rana temporaria	54	28.7
Rana arvalis	14	7.4
Rana kl. esculenta	18	9.6

Reptiles

Slow worm (*Anguis fragilis*) was observed in dry or drained forests (usually oligotrophic or mesotrophic), apparently avoids wet habitats (Table 2). It was found mostly in pine forests, which were sometimes mixed with spruce and birch (Fig. 2). The species prefers mature stands (Fig. 3). The mean age of stands was 86.5± ±5.4 years (52-117, n=14) and height 23.1± ±1.4 m (12-29, n=14). This secretive lizard was found mainly on paths (very often these were dead specimens) or under diverse flat objects.

Sand lizard (*Lacerta agilis*). Typically, populations of this rare species have been found on inland dune rows. Usually these are the fragments of dry open forest (*Cladinosa-callunosa, Vaccinosa*) which are located near or surrounded by completely different habitats, such as raised bogs. In four cases, the species was found in sparse pine or pine-birch stands (tree height 1.5-14 m) with heath (*Calluna vulgaris*) and grasses (*Festuca, Deschampsia*) on dry sand. In one case, it was found on the edge of dry forest (*Hylocomiosa*) with sparse but tall (21 m) pines and grass cover (*Calamagrostis, Festuca, Poa*).

Common lizard (*Lacerta vivipara*) was observed in diverse types of dry, wet or drained forest and in a raised bog (Tab. 2). Usually these were stands dominated by pine, sometimes by spruce (Fig. 2), with mean age 63.4± ±6.4 years (15-152, n=29) and height 15.1± ±1.5 m (1-27, n=29). The common lizard preferred young stands (Fig. 3), especially regarding spruce dominant stands: mean age 27.8± ±3.2 years (15-42, n=9) and height 6.7± ±1.1 m (1-11, n=9). In mature and dense forests, the species occupies specific habitats such as forest edges, grassy roadsides, open banks of small lakes and creeks.

Smooth snake (*Coronella austriaca*). A few specimens were found near a flooded peat quarry which was situated in a raised bog and wet open pine-birch forest (*Sphagnosa*). There are also data on findings on inland old sand dunes beside bogs and in dry pine forest (*Cladinoso-callunosa, Vaccinosa*) clearings (Ceirans 2000).

Grass snake (*Natrix natrix*) was observed in almost all natural and semi-natural habitats that are found in the National Park (Tab. 2.). The grass snake inhabits both pine and deciduous tree dominated stands (Fig. 2) of various age (Fig. 3). The mean age of the forest stands was 73.6± ±4.4 years (29-102, n=22) and height 19.5± ±1.4 m (6-26, n=22). The species often occurs in man-altered habitats such as wet meadows with shrubs. It does not avoid even large human settlements such as the town of Kemeri and coastal villages.

Adder (*Vipera berus*). Only two populations were found in the survey. In the first case, a few individuals were observed near an old flooded peat quarry in a raised bog with pine, and near a presumed wintering place in a birch dominated forest on drained peat (*Vaccinosa turf. mel.*). In the other case, one individual was found at the edge of a dense pine dominated drained forest (*Myrtillosa mel.*) (tree height 20 m), and also near an old peat quarry covered mainly with reed (*Phragmites australis*).

Table 2. Occurrence of the slow worm (*Anguis fragilis*), common lizard (*Lacerta vivipara*) and grass snake (*Natrix natrix*) in habitats of the Kemeri National Park. Forest types after Buss (1997). For species, the first value indicates the number of records*, and the second one records/km.

Habitat	Transect lenght (km)	Anguis fragilis	Lacerta vivipara	Natrix natrix
Cladinoso-Callunosa, Vaccinosa	21.0	1/0.05	1/0.05	1/0.05
Myrtillosa, Hylocomiosa	37.3	6/0.16	1/0.03	3/0.08
Vaccinoso-sphagnosa	3.9	0	0	0
Myrtilloso-sphagnosa, Myrtilloso-polytrichosa	14.9	0	4/0.27	4/0.27
Dryopteriosa	2.9	0	0	1/0.35
Sphagnosa, raised bog with pine	26.1	0	5/0.19	3/0.11
Caricoso-phragmitosa	19.4	0	3/0.15	1/0.05
Dryopterioso-caricosa, Filipendulosa	9.4	0	0	1/0.11
Myrtillosa mel.	11.1	4/0.36	3/0.27	1/0.09
Mercurialiosa mel.	13.3	0	2/0.15	0
Callunosa turf. mel., Vaccinosa turf. mel.	6.0	1/0.17	2/0.33	3/0.50
Myrtillosa turf. mel.	18.3	1/0.05	4/0.22	1/0.05
Oxalidosa turf. mel.	14.4	1/0.07	0	5/0.35

* two records were considered to be separate if the distance between two individuals on a transect was more than 100 m, newborns are excluded from the data.

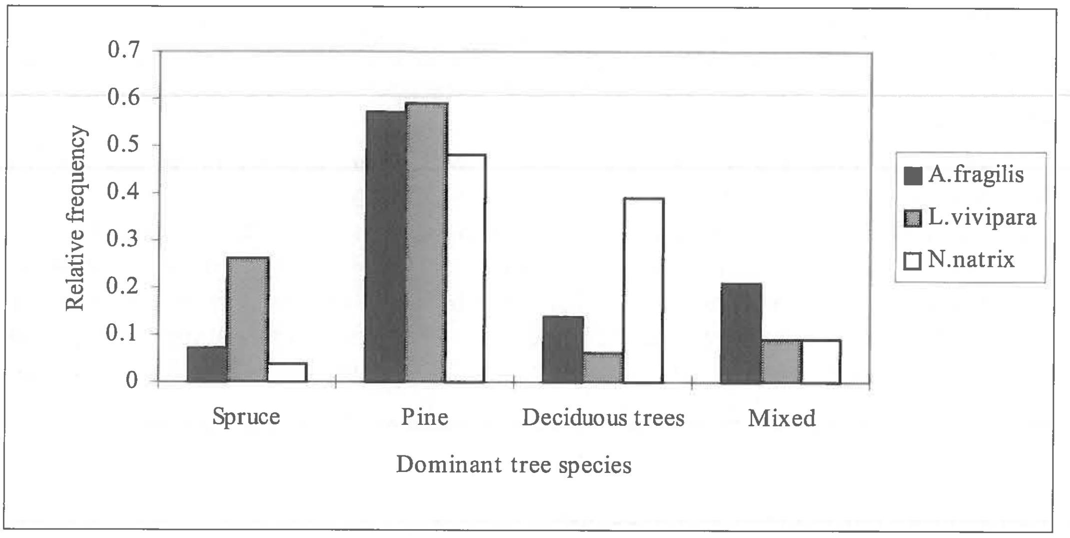

*Figure 2. Dominant tree species in forest and bog habitats of the slow worm (*Anguis fragilis*) (n=14), common lizard (*Lacerta vivipara*) (n=34) and grass snake (*Natrix natrix*) (n=23) in the Kemeri National Park.*

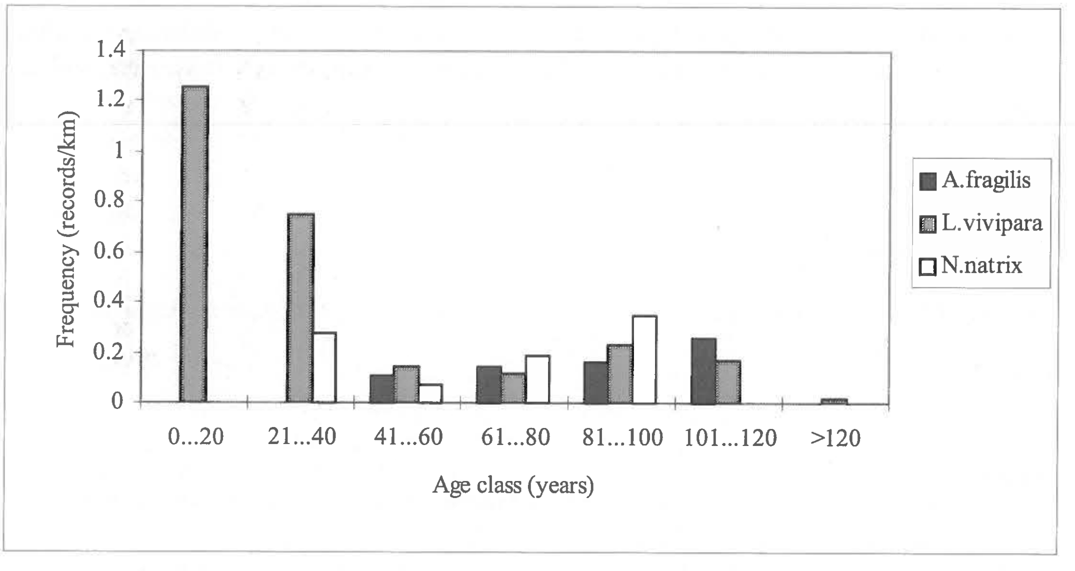

*Figure 3. Frequency of records of the slow worm (*Anguis fragilis*) (n=14), common lizard (*Lacerta vivipara*) (n=29) and grass snake (*Natrix natrix*) (n=22) on transects in forest stands of various age in the Kemeri National Park.*

Anurans

Common toad (*Bufo bufo*) is relatively common in dry, periodically wet or drained conifer or mixed forests on mesotrophic and eutrophic mineral soil (*Hylocomiosa, Myrtilloso-sphagnosa, Myrtillosa mel., Mercurialiosa mel.*). Sometimes it was found also in some other habitats (*Vaccinosa, Myrtillosa, Sphagnosa, Caricoso-phragmitosa, Oxalidosa turf. mel.* forest stands).

Common frog (*Rana temporaria*) was found in all habitats, except oligotrophic pine forest on drained peat (*Callunosa turf. mel., Vaccinosa turf. mel.*). Abundant in wet or drained deciduous tree and spruce forests on rich mineral or peat soil (*Dryopteriosa, Dryopterioso-caricosa, Filipendulosa, Mercurialidosa mel., Myrtillosa turf. mel., Oxalidosa turf. mel.*).

Moor frog (*Rana arvalis*) inhabits diverse wet and drained forests (*Myrtilloso-sphagnosa, Sphagnosa, Caricoso-phragmitosa, Myrtillosa mel., Callunosa turf. mel., Vaccinosa turf. mel., Myrtillosa turf. mel.*, and, particularly, *Oxalidosa turf. mel.*), especially near the lake (Kanieris) and raised bogs.

There are at least 2 species from the green frog complex found in the Kemeri National Park. The green frog (*Rana esculenta*) inhabits lakes and inflowing deep ditches. The pool frog (*Rana lessonae*) forms mixed populations with the previous species. Pure populations of this species inhabit small waterbodies, roadside ditches, pools etc. Some individuals were found far from the water in wet or drained forests (*Dryopteriosa, Myrtillosa mel., Myrtillosa turf. mel., Oxalidosa turf. mel*). The presence of the third species of this frog complex - marsh frog (*Rana ridibunda*) - is highly possible in the Lielupe River along the eastern border of the National Park.

Comments on some other species

There is one old record of the European pond turtle (*Emys orbicularis*) for the territory of the Kemeri National Park (Silins & Lamsters 1934). Future confirmation of this semi-aquatic species in the area will depend on further survey.

Two rare anuran species - spadefoot toad (*Pelobates fuscus*) and natterjack toad (*Bufo calamita*), are present in the National Park, according to data of the Latvian Fund for Nature (unpublished). The first species has been found near a lagoon lake (Kanieris), and the second on old dunes (Zala kapa) beside a bog. There are also data on the presence of two new species (*Triturus cristatus, T. vulgaris*) in the area (Latvian Fund for Nature, unpublished).

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The Lepidopterous fauna of Nature Reserve Friendship.

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Introduction

Through ages the butterflies and moths have been the target of peoples interest. A fragile moth has been thought to represent the vulnerability of nature, which it in fact well is. Moths react rather rapidly to different environmental changes in nature and very often irreversibly. Our forests, declining more and more rapidly in area, give less and less opportunities to study the species of old primevals. Some possibilities to this are offered in the different parts of Nature Reserve Friendship (Juntunen & Isokääntä 2000).

The aim of this article is to give guidelines of the moth monitoring which we have carried in Nature Reserve Friendship.

Study areas and methods

Studies and monitoring of lepidoptera in the Nature Reserve Friendship's area were started in 1991. Basic inventories lasting through the flying season were carried out in six subareas as follows; Elimyssalo in 1991, Iso-Palonen-Maariansärkät in 1992, Juortanansalo-Lapinsuo in 1993, Lentua in1994, Ulvinsalo in 1995 and Kostamus in 1997 (see also Leinonen 1991, 1992, 1993 manuscript and Leinonen et al 1998). After the basic inventory some sporadic observations on certain species have been done and in some spots it was moved to continuous trapping in order to get time serial data.

Study methods were: catching by lights, by baits, by malaise trap, netting and linetransects. We used light traps with generator and permanent electricity equipped with 160 W blended light lamp and 125 W halogen lamp. Baittrapping was both permanent and active. Two trap-types were used. The new Oulu-model, with two baits: red-wine vinegar and more traditional beer-based bait. The Oulu-traps were used only in Juortanansalo area. The traditional Jalas-model bait-trap was used in all the other areas with beer-based liquid. With Malaise- trap (model Bioquip. USA) we collected only in one summer at Elimyssalo, and it brought some new microlepidopterans for this area.. One of the most used method has been the netting, always when we moved on the field during day or night and it was also used for larvae. For monitoring the butterflies we used the linetransect method (see Pollard et al 1975, Kullberg 1995, Kuussaari et al 2000). It was counted all the observed individuals from a stripe of five meters wide. The counting was done once a week according to suitable weather from May to September.

Weather demands were; minimum temperature +13° C, counting time between 10 and 14 a'clock, rainless day, most preferably sunny weather and no hard wind. In average, the countings numbered ten per summer per transect.

We counted alpha-diversity and HQI indexes. The alpha-diversity was calculated using the formula S= alpha log(1+N/alfa) (see Taylor et al. 1976). With Kruskal-Wallis test we tested the differences between sites in these values. To fullfill the alpha-diversity we have developed together with Finnish Environment Institute a certificate index of forest quality. Habitat Quality Index-report will be published in NORD-series from Nordic council of ministers (Söderman et al 2000). A habitat quality index has been developed to value different forest habitats as a tool for landscape planning and identifying the importance of various woodlands for preserving biodiversity. The total test material covers some 680 species and 3 million individuals from the Moth Monitoring Scheme. The theoretical maximum index value is 48, in practice they are close to 20 when both northern taiga indicators and nemoral decicuous forest indicators are used. It has six criteria, which are expressing following things: 1. Healthy large forest stands. 2. Regular inflorescence of main tree species. 3. Abundance of epiphytic lichens and acceptable limit of deposition of atmospheric pollution. 4. Presence of typical taiga forest 5. Presence of typical nemoral deciduous wood stands 6. Equilibrium between populations in the habitat mosaics (see also Söderman et al. 2000).

(R.Leinonen)

Figure 1. All bait traps had to be lifted to five metres height in Ulvinsalo oving the bear.

During the study, especially at Ulvinsalo, we pumped now and then to some small trouble. Close to Ulvinsalo there lived a bear, which had got a nick name "Big thick". It had been tempted to carcass for photographing by adding feed sugar-liquid and that had Mr. Thick preserved to his memory. Our bait liquid is rather similar to feed sugar-liquid. Even a trap lifted by line to five metres was not let untouched by him! After this bear's visit we had to lift traps without lines to five metres height (Fig. 1).

Results

The total number of species observed was 711, where from macrolepidopterans are represented by 296 species and microlepidopetrans by 415. This makes about two thirds of the whole species number of Kainuu biogeographical province. Totally we identified 85 000 individuals. In macrolepidoptera also sexes were separated. The high numbers found at Elimyssalo and Ulvinsalo can be explained by the fact that close to these areas there has been permanent light traps, at Viiksimo from 1991 onwards and at Rajakangas from 1994 onwards (Leinonen 1991, Söderman et al 1994, 1995)(table1).

Table 1. Total captures of lepidoptera species in different subareas in Nature Reserve Friendship.Abbreviations: ELI= Elimyssalo, ISO= Iso-Palonen- Maariansärkät. JUO= Juortanansalo- Lapinsuo. LEN= Lentua. ULV= Ulvinsalo and KOS= Kostamus.

	ELI	ISO	JUO	LEN	ULV	KOS
Microlepidoptera species	340	174	128	178	261	239
Macrolepidoptera species	238	172	148	190	209	196
Lepidotera species	578	346	276	368	470	435

All the subareas of the Nature Reserve Friendship are located in the middleborealzone and the moth composition follows more or less the typical fauna of those areas (Kashevarov 1996). There are, however, some northern and some southern species which give a nice breath to the species list. Representatives of northern species are *Lasionycta skraelingia* and *Apamea maillardi*. The closest known site for *L.skraelingia* is at Kittilä about 400 km to the NorthWest. The species *A. maillardi* instead has an occurrence also at Häme, otherwise it is a clear northern species in Finland (Huldén et al 2000). *L.skraelingia* was observed in Juortanansalo and Elimyssalo area and *A.maillardi* in Juortanansalo and Ulvinsalo. Representatives of southern species were *Lobophora temerata, Aethalura punctulata* and *Allophyes oxyacanthae*. They were observed in Rajakangas near Ulvinsalo. The proportion of spreading species looks like to be rising along the eastern frontier.

The Dotted carpet (Alcis jubatus) is typical indicator species for abundant of Alectoria and Usnea species in the Nature Reserve Friendship.

Next some species with special interest are presented. The Dotted carpet (*Alcis jubatus*), which has rather rich numbers in the spruce forests with abundant *Alectoria* and *Usnea* species in the Nature Reserve Friendship. It is living just on the lichens (Mikkola et al 1989a). The occurrence of *Caryocolum schleichi* at Kostamus is surprising, because it is said to live only on *Dianthus arenarius*, which so far has not been reported from that area. We suppose it to live also on other *Dianthus* species, which may be growing there. The nearest population of *C. schleichi* is to be found at Sotkamo, Räätäkangas, about 150 km west from Kostamus (Somerma 1997). The rarest observation is the one larva of *Xestia brunneopicta*, which however, has still a small question mark, because the larva has not yet been described at all. The species was found at Oulanka in 1983 as a new one to whole Europe (Mikkola et al 1989b). At the same site it was also collected two larvae, which differ from the nearest relative, *X. gelida*, by certain characters. That larva found at Elimyssalo on spruce is similar to those two larvae. The case must, however, still be inspected by ex ovo breedings.

Light traps at Nature Reserve Friendship area have been implanted to the Finnish Moth Monitoring network which was started at 1993 (Väisänen 1993, Somerma 1993, Söderman et al 1994, 1995).

From the Moth Monitoring material it has been calculated inventory-diversity, i.e. alpha- diversity. It had a low value in the present area. This is influenced by the fact that the number of species is not high. This is a weak point of alpha-diversity. It does not give any weigth to the species, but the alfa is counted based on species and individual numbers. Correspondingly low values have also occurred around large cities. Higher than average values can be found among other places in grove center areas. In the time serials of alpha we can observe the low values of year 1994, which was rainy and altogether a "bad" summer (Fig. 2). At this moment it seems to be increasing. In long collecting series (Mäntyharju, Lahti ja Kajaani) alpha-diversity seems to follow a rhythm of ten years (Söderman et al 1999). Currently in Kainuu monitoring sites the alpha-diversity-values are going upwards. Although the alpha-values at Kajaani seem to be somewhat higher than in the other places they do not differ significantly, when corresponding years (i.e. 1994-99) are surveyed(P=0.073). Instead if we include all the data then Kajaani difffers significantly from the other two sites, but this is not so remarkable because the collecting series is so much longer at Kajaani than in the other places.

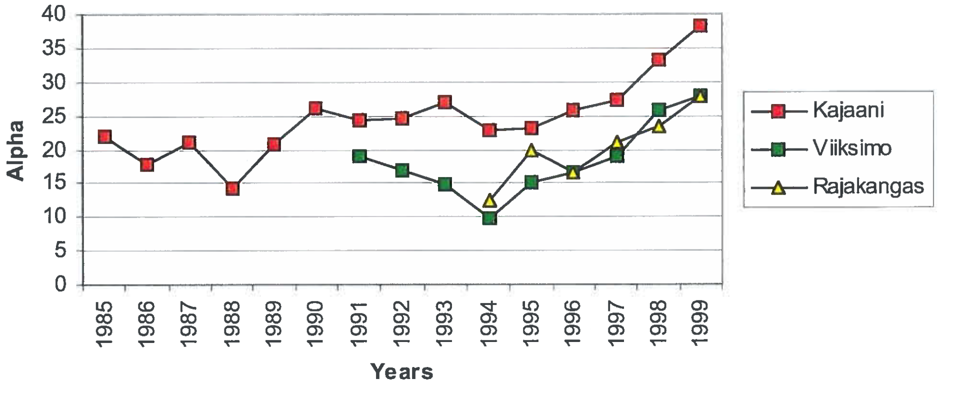

Figure 2. Time series of alpha- diversity in Kajaani, Viiksimo and Rajakangas sites.

One of the special features of Nature Reserve Friendship is the abundance of *Xestia*-species. The Kajaani point is between economic forest and a garden, the point of Viiksimo between economic forest and a ruderate area and point of Rajakangas close to the nature park of Ulvinsalo. It is the only area of these where we found *X. sincera*, most tightly bound to old primeval spruce forests (see e.g. Imby & Palmqvist 1978). *X. alpicola, speciosa* and *rhaetica* all three species show the superiority of Rajakangas what comes to the yearly catches (Fig. 3).

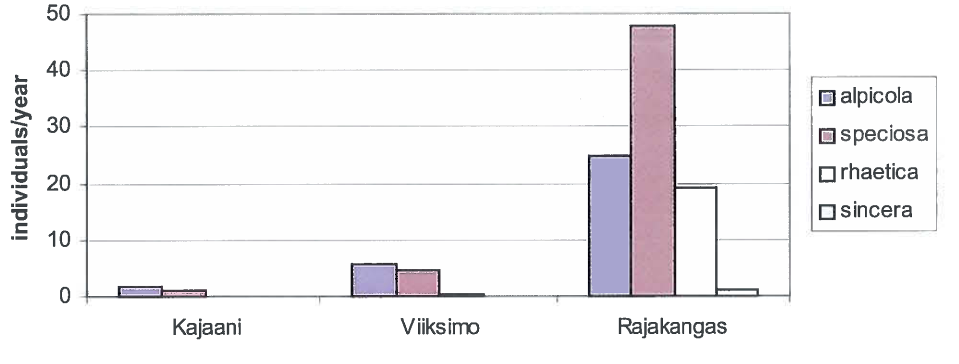

Figure 3. Comparison of Xestia-*species between three monitoring sites in Kainuu.*

When we survey the impact of the large Russian primevals upon the forest islets on Finnish side, we can notice some features. At Ulvinsalo we did not observe anymore *Xestia gelida* and *X. distensa* most clearly bound to these old forests. Also the catch of *X. rhaetica* was a little bit lower than in the two other sites, Juortanansalo and Malahvia, which are in continuous connection to Russian side (table 2). This macrocorridor connection or its lacking is one of our coming targets, because it may have an influence upon the observed difference. The Malahvia area does not belong to Nature Reserve Friendship, but it is an extension of it. Also this area is an important part of the Green belt zone (Leinonen & Itämies 2000).

Table 2. Xestia-species in three sites in Green belt zone.

	Malahvia	Juortana	Ulvinsalo
alpicola	9	13	14
speciosa	376	574	426
rhaetica	32	28	12
gelida	1	0,3	0
sincera	2	1	1
distensa	0,1	0,3	0

Next a little bit of application of above mentioned facts by aid of three time series of light traps is from Moth Monitoring. One site is Kajaani, which is relatively even and fluctuates only based on weather conditions and or environmental changes. The HQI-values of Rajakangas make a sicsac, due to *Xestia* species, between odd and even years. While the point of Tankavaara on the other hand fluctuates on an even year rhythm (Fig. 4). This flight pattern is well known in Finland (Mikkola 1976, Pulliainen & Itämies 1988).

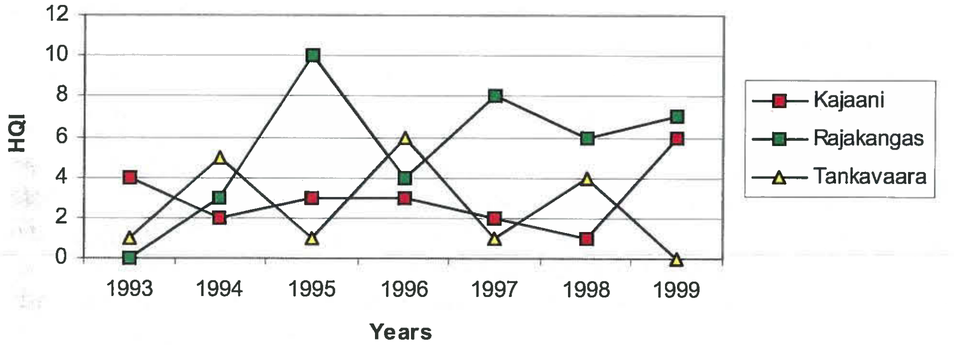

Figure 4. Time series of HQI-index in three monitoring sites in Finland.

The fluctuation of *Xestia* flight years is thus clearly seen in the values of index. Based on the test results three years is adequate to produce a reliable level. Years after that do not remarkably increase the value of index. In cumulative values the counting of dominance aspect must be based on five years moving average, because after that all traps usually get the maximal points (2 points) on this dominance criteria.

Conclusions

Summarising we can say some features from the moth fauna of Nature Reserve Friendship. The area is mainly natural taiga forest. We have found several old primeval forest species. The area has high quality biodiversity, especially in the point of view of research. The straight connection via the macrocorridors to the large Russian primevals makes the populations steady and makes it possible even for demanding species to have living conditions also on the Finnish side.

Acknowledgements

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The study of Orthocentrinae s. l. (Hymenoptera, Ichneumonidae) in Eastern Fennoscandia

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Introduction

The biological diversity in a very significant degree depends on insect species diversity, as insects is one of the richest in species class of living organisms. Among them hymenopterous insects, and especially parasitic Hymenoptera occupy one of the first places. For instance, according to the modern data, there are more than 6000 known species of these insects occurring in Finland (Koponen et al. 1995). As a result, its fauna is not satisfactorily studied.

This group is characterized by an exceptional species diversity, surpassing other groups of insects. Taxonomy of the family Ichneumonidae is for the present day poorly developed in comparison with other groups of insects (e.g. Lepidoptera or Coleoptera). Occupying the highest level in food chains, ichneumon-flies thus represent one of the vulnerable groups of organisms.

The subject of my research is the fauna of Orthocentrinae, one of the least-studied subfamilies of ichneumon wasps. For a long time the species composition of this group and its position within the family Ichneumonidae were obscure. It is necessary to note that this group of ichneumon-flies is of significant theoretical interest, as it occupies a key position for the solving of some difficult questions in Ichneumonidae phylogeny.

Orthocentrines are small, seldom medium-sized parasitic wasps. The average size of its body is about 3-5 mm. The diversity of morphological structure of Orthocentrinae is very significant. The present study was mainly restricted to the Microleptinae Townes = Oxytorinae van Rossem = Helictinae (Dasch 1992). These ichneumon-flies are extremely various in habitus. Thus different genera were considered earlier in different subfamilies. Even the subfamily name is unstable and has changed several times during last 30 years. It has traditionally been known by the name Microleptinae. Henry Townes – the best specialist in Ichneumonidae of our time, who devoted whole his life to its study, called this subfamily a "waste-basket" group (Townes 1971). The majority of specialists in this field of study consider now the group inside Orthocentrinae s. l. (Wahl 1986, Wahl & Gauld 1998). New views have persisted for the last 15 years and have been generally applied (Yu & Horstmann 1997).

Until the beginning of XX century, when Walther Hellén started his Ichneumonidae study, the data on Eastern Fennoscandian fauna of this group was extremely scant. In a set of articles he observed Finnish fauna of ichneumonids and reported many species new for Finland.

Since 1960s Reijo Jussila has began the study of Finnish Ichneumonidae, and covered many groups of this family. Based on van Rossem (1980) who revised the West Palaearctic fauna, he reported many species as new for the Finnish fauna and described two new species of Orthocentrinae as well (Jussila 1994). Karelian fauna of this subfamily was practically unstudied until the end of 1980s.

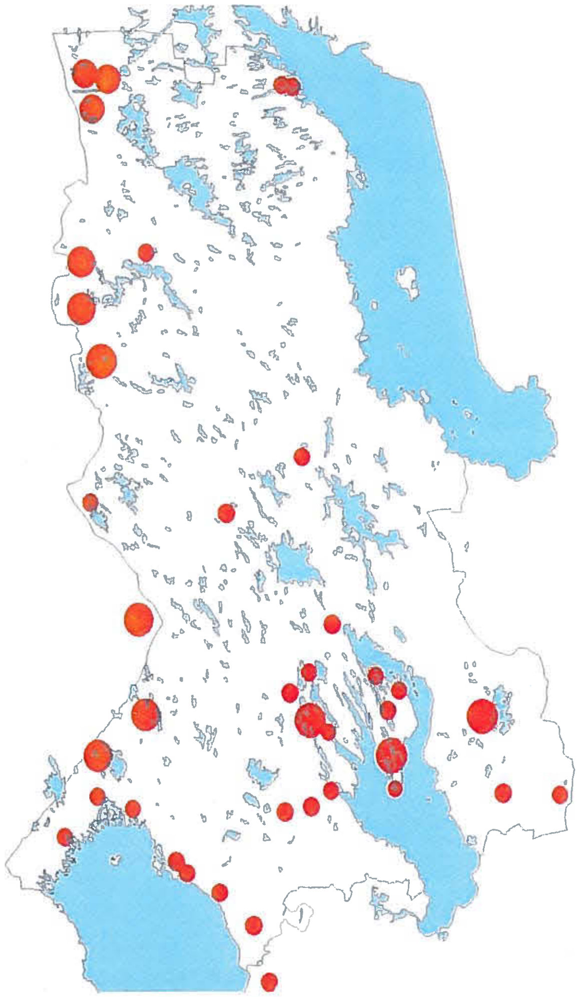

Fig. 1 Collecting areas: large dots - places where extensive collections were made. small dots - places where only small and occasional samples were collected

Materials and methods

For the present study extensive collections have been made in Karelia (Fig. 1), especially in nature reserves Kivach and Kostomukshski, National parks Vodlozerski and Paanajärvi, planned Kalevala National Park, biosphere reserve "Northern Karelia" and Kizhi skerries. Concerning other areas, as a rule briefly visited, only small and occasional samples were available. Malaise traps, window traps of different modifications, light traps as well as sweep netting and rearing from mushroom fruit bodies were applied for the original materials collecting. Additional materials for the study were obtained from the collections of the Zoological Museum of Helsinki University and collections stored at the Department of Applied Zoology of Helsinki University, which I could study in 1996 and in 1998. Available collections of the Zoological Museum (St.Petersburg) from Eastern Fennoscandia were treated as well.

The study of insects associated with various ecological groups of mushrooms has been conducted at the Forest Research Institute of Karelian Centre of Russian Academy of Sciences during many years. Mycetophagous insects, their predators and parasites, as was found out in our researches, are very diverse and numerous in boreal forests. At the present, the structure of Diptera and Coleoptera communities associated with mushrooms is rather well investigated. But not less various and numerous complex of their parasites until now practically was not investigated. Such data in the world literature are extremely scant, and the species-rich group of ichneumon-flies, as Orthocentrinae, parasitizing on larvae of fungus gnats, was almost not studied. Very little was known about the biology of the group, but some species indicated as koinobiont endoparasitoids of the Mycetophilidae larvae (Wahl 1986).

Results and discussion

Special study aimed to make up for the deficiency of knowledge and to clarify the host preference of Orthocentrinae was performed in Karelia. Reliable data on the hosts preference were received by rearing from mushrooms fruit bodies. 21 species of ichneumon-flies, which are considered as the parasitoids of dipterous mycetobiontes, were reared from mushrooms. The range of the potential hosts of helictines includes 53 species of fungus gnats from 26 genera. According to literature essentially added by the original data, the majority of the subfamily representatives is a group, where main or even the only known hosts are Diptera, and moreover, only the primitive representatives of this order, such as fungus gnats (superfamily Sciaroidea, mainly Mycetophilidae). Most of them are mycetofagous.

It should be noted, that orthocentrines are an essential component of entomofauna in forest and especially in taiga ecosystems. In boreal forests, caracterized by presence of rather cool, damp, shaded habitats, these ichneumon wasps could be extremely numerous. According to my own experience, in a Malaise trap sample (Fig. 2), permanently operating whole season per different years in Karelia (Kivach Nature reserve) and in Finland (North Karelian Biosphere reserve), Orthocentrinae in various biotopes comprise from 11% (in herb-rich aspen forest) up to 23% (in *Cladonia* pine forest), 26% (*Myrtillus* pine forest) and even 34% (mixed forest) of all individuals ichneumonids, which, in turn, exceeded half of all hymenopterous insects. During a season this ratio strongly varied, reaching a maximum in September, up to 50-65%.

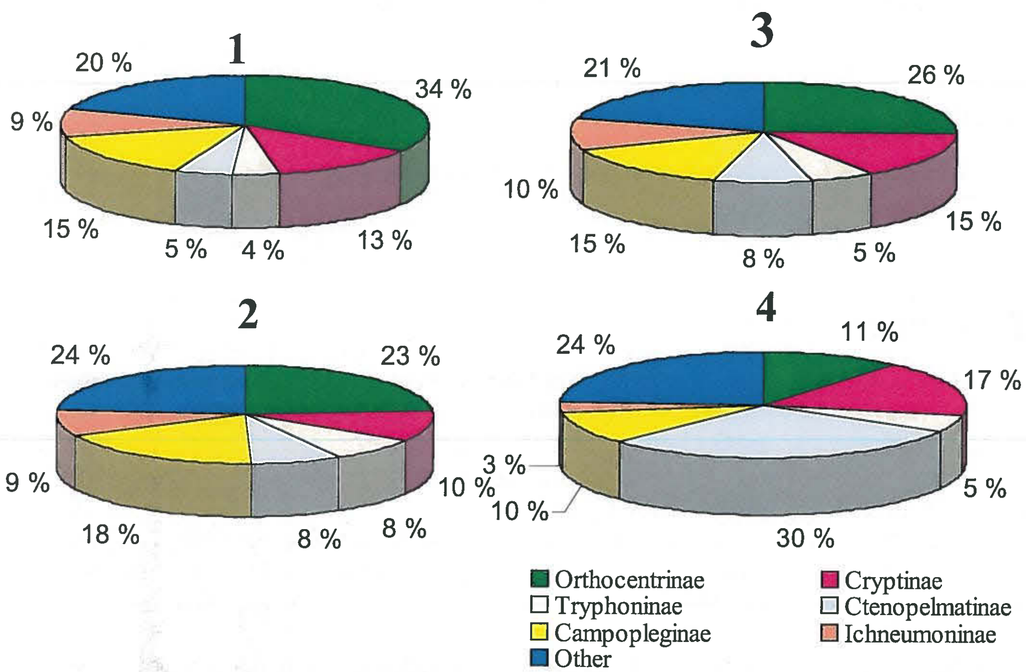

Fig. 2 Structure of the family Ichneumonidae in Malaise trap samples in different forest types: 1 - mixed forest (North Karelian Biosphere reserve, Finland); 2-4 Karelia, Kivach Nature reserve: 2 - Cladonia *type pine forest, 3 -* Myrtillus *type pine forest, 4 - herb-rich aspen forest.*

Species composition and the population structure of Orthocentrinae in various forest types are similar: the representatives of genera Plectiscidea, *Plectiscus* and *Orthocentrus* dominate in all biotopes, making up to about 25% of all Orthocentrinae individuals. Other abundant genera in Eastern Fennoscandia, as well as in all taiga zone, are also *Proclitus, Pantisarthrus, Helictes, Aperileptus* and *Stenomacrus*.

Speaking about the zonal and landscape distribution of Orthocentrinae it is possible to assert that it is a group of ichneumon-flies with distinctly forest distribution. Within the Russian fauna the areas of the overwhelming majority of species (almost 90%) wholly or mostly are situated within the borders of a forest zone. In general, orthocentrine fauna of Eastern Fennoscandia is typical for taiga zone. The species with wide areas, mainly Holarctic and Trans-Palaearctic boreal areas prevail here. Outside the forest zone orthocentrines are not so abundant and occur mostly in mountain areas.

For the present study based on materials from Eastern Fennoscandia new data adding faunistic lists of ichneumonids of Karelia and Finland were obtained.

As a result of researches there are revealed, that 23 of these ichneumon-flies (*Microleptes rectangulus, Cylloceria tenuicornis, Allomacrus subtilis, Aniseres caudatus, A. subarcticus, Hemiphanes performidatum, H. townesi, Gnathochorisis xanthocephala, Proeliator proprius, Eusterinx (Holomeristus) aquilonigena, E. (Holomeristus) minima, E. (Holomeristus) refractaria, E. (Trestis) trifasciata, E. (Divinatrix) inaequalis, Helictes carinatus, H. karelicus, Plectiscidea fuscifemur, P. helleni, P. deviata, P. koponeni*) have been found to occur in Finland and are recorded for the first time for the Finnish fauna. Within 9 species new for science, description of two has already been published and seven more will be published soon. Two species should be excluded from the Finnish list. *Helictes fabularis* earlier reported for Karelia (Humala 1997) actually is the new species *H. karelicus*. Ten species also should be added to the check-list of Karelia.

Hellén's list of Hymenoptera Parasitica of Finland (1940) is out-of-date and the new one is under preparation now (Koponen et al. 1995).

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Zoogeographical notes on the Fennoscandian fauna of fungus gnats (Diptera, Mycetophilidae s.l.)

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Introduction

Fungus gnats (Mycetophilidae and related families) is an extremely diverse group of Diptera. The estimated number of species in the world fauna is nearly 3000. Fungus gnats have been quite intensively studied in the Palaearctic in XX century. However, the knowledge of their fauna in different countries is not uniform. Considerable progress has been achieved in Great Britain, Germany and Finland, whereas other territories were comparatively poorly studied for a long period. In the end of XX century Mycetophilidae studies in Norway, Sweden, Czech Republic, Estonia and Russian Karelia enlarged local species lists so that they became comparable with other well studied countries. All these studies revealed a range of species, the occurrence of which in Europe was not expected. New data on the distribution of Mycetophlidae thus showed that zoogeographic ranges of many species should be revised. The objective of the present work is to review and discuss remarkable patterns of zoogeographic distribution met in Fennoscandian Mycetophilidae.

Material and methods

The work is based on the original materials collected in Russian Karelia and Finland in 1989-99 as well as on numerous publications containing the data on Holarctic fauna of fungus gnats. Materials are stored in the collections of Forest Research Instituttе (Petrozavodsk), Zoological Institute (St. Petersburg) and A.N.Severtsov Institute of Ecology and Evolutionary Problems (Moscow). Nomenclature of zoogeographic ranges is adopted from Городков (1984).

Results and discussion

The recent faunistic studies revealed many remarkable distribution patterns in Palaearctic Mycetophilidae. It becomes evident that many species known previously only by single records from certain regions are in fact more widely distributed forming transpalaearctic or even circumpolar ranges. On the other hand quite a large group of potentially endemic species is not known outside Fennoscandia.

Nearctic species

Over 10 species earlier known from North America have been found in Fennoscandia during the recent years. Some of them: *Sciophila minuta* A. Zaitzev, *Allodia adunca* A.Zaitzev, *Brevicornu cristatum* A. Zaitzev, *Phronia gagnei* Chandler, *Mycetophila spleniata* Laffoon and *M. stricklandi* Laffoon were up to now recorded only from Russian Karelia. Others have been recently discovered in other European countries: *Allodia simplex* A. Zaitzev and *Brevicornu occidentale* A. Zaitzev in Norway (Økland 1994, 1995), and *Brevicornu improvisum* A. Zaitzev in Germany (Caspers 1996), Switzerland (Chandler 1998b) and Czech Republic (Ševčík 1999). Such findings are not surprising. Latest revisions in large genera showed that many American species also occur in Palaearctic and vice versa (Gagné 1975, 1981; Väisänen 1984; Зайцев 1982).

Disjunctions

Of special interest are Fennoscandian records of Palaearctic species previously known only from remote areas. According to available data the ranges of such species are characterized by disjunctions of various extention.

First group of species: *Mycomya forestaria* Plassmann, *M. spinicoxa* Väisänen, *Syntemna daisetsusana* Okada, *Boletina kurilensis* A.Zaitzev, *B. takagii* Sasakawa et Kimura, *Epicypta latiuscala* A. Zaitzev and *Anatella dentata* A. Zaitzev were known from the Far East of Russia (Sakhalin, Kuril Islands, Primorje) and Japan (Зайцев 1987, Зайцев 1989, Зайцев 1994a, Sasakawa & Kimura 1974). The records from Karelia (Fig. 1) show that

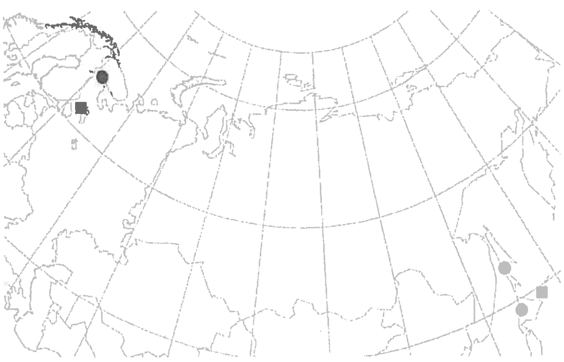

Fig 1.

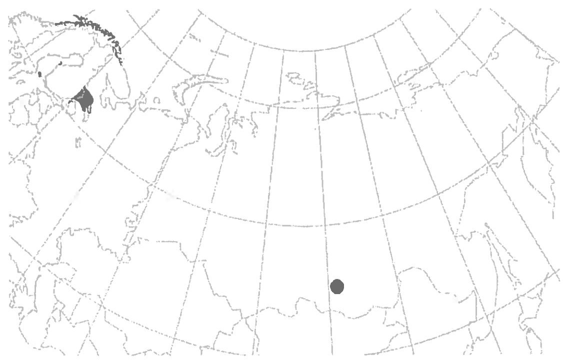

Fig 2.

Fig 3.

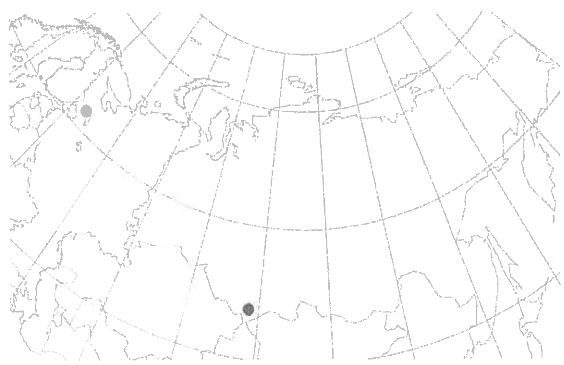

Fig 4.

Fig. 1-4. Distribution of former Eastern Palaearctic species: 1 Boletina takagii (circle), B. kurilensis (square); 2 Greenomyia baikalica; 3 Boletina nitiduloides; 4 Anatella crispa.

such species may have truly disjunctive amphiboreal distribution connected to soft oceanic climate, though there is a possibility that they also will be found in the intermediate regions.

Another group: *Keroplatus tuvensis* A. Zaitzev, *Greenomyia baikalica* A. Zaitzev, *Boletina nitiduloides* A. Zaitzev and *Anatella crispa* A. Zaitzev were described from Siberia (Зайцев 1994a, Zaitzev 1994b), and could be earlier referred to the Ural-Siberian distribution type. However, Fennoscandian records (Fig. 2-4) suggest at least Euro-Siberian range. Rather extensive disjunction in this case apparently reflects the insufficiency of data from intermediate areas of Russia.

Five species were up to recent times known from Central Europe. One of them, *Mycomya tridens* Lundström (Fig. 5) has been recorded from several alpine localities (Väisänen 1984), but now also found in Moscow region (Зайцев 1994a) and Russian Karelia. Other four species, *Synplasta bayardi* Matile, *S. dulcia* Dziedzicki, *Brevicornu neofasciculatum* A. Zaitzev and *Allodia subpistillata* Ševčík (Fig. 6,7) also were known as single records from mountainous regions of Europe (Hackman 1988, Caspers 1996, Ševčík 1999). The ranges of all these species could be considered earlier as Central-European, but taking into account Fennoscandian records we can suppose a boreo-mountain distribution pattern. In the latter case they are to be found in the eastern part of Palaearctic and very probably in North America. Nevertheless there is a chance that these species have been just overlooked in the North Europe and may present Western-Palaearctic distribution type.

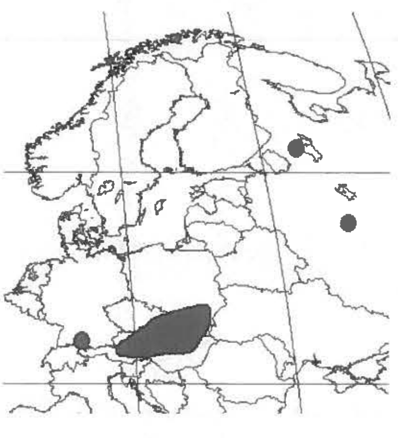

Fig. 5

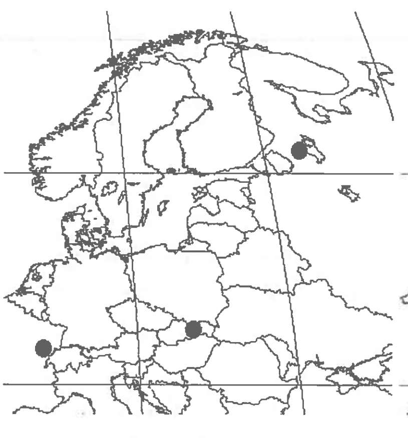

Fig. 6

Fig. 7

Fig. 5-7. Distribution of former Central-European species: 5 Mycomya tridens; 6 Synplasta bayardi; 7 S. dulcia.

Endemism

Distribution of a rather large group of fungus gnats, as far as it is known for now, is limited to Fennoscandia. In Russian Karelia such species make up more than 10% of total fauna. Most of these species are fairly rare and recorded only sporadically, but several species like *Boletina dissipata* Plassmann, *B. onegensis* Polevoi and *Neoempheria tuomikoskii* Väisänen (Fig. 8-10) appear to be abundant at least in Eastern Finland and Russian Karelia. Such species can be tentatively characterized as possible endemics of Fennoscandia. Väisänen (1984), analysing the distribution of the genus *Mycomya*, though mentioned a group of species known only from Scandinavian countries, doubted the existence of true endemics here. Nowadays Väisänen's suggestion is supported by faunistic records. The range of *Mycomya festivalis* Väisänen described from three Finnish localities (Fig. 11), is now extended to Southern Germany (Plassmann & Schacht

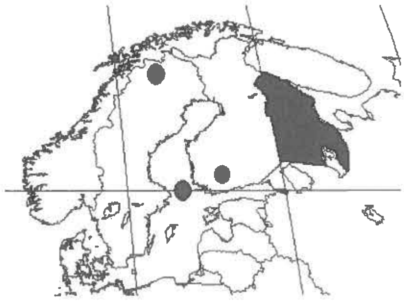

Fig 8.

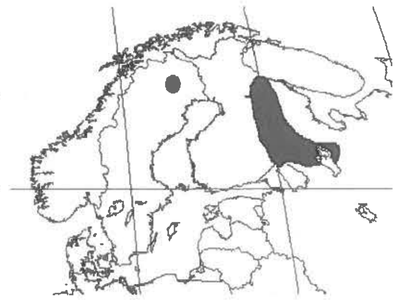

Fig 9.

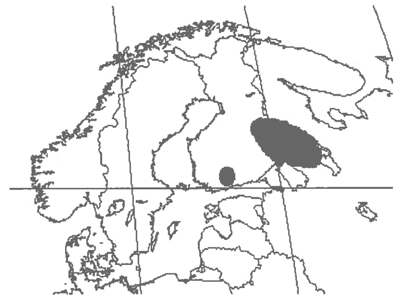

Fig 10.

Fig. 8-10. Distribution of potential Fennoscandian endemics: 8 Boletina dissipata; 9 B. onegensis; 10 Neoempheria tuomikoskii.

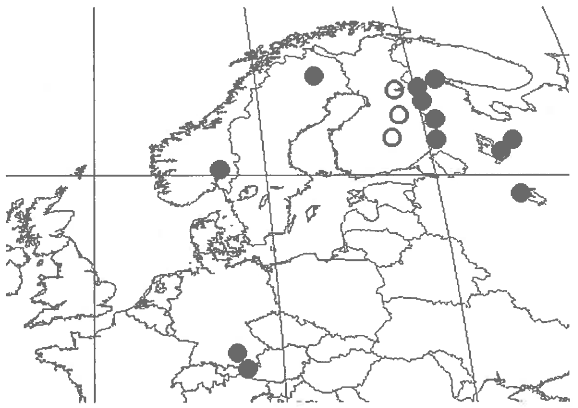

Fig 11.

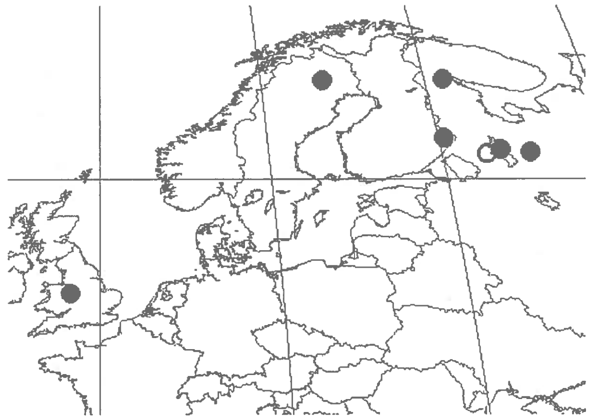

Fig 12.

Fig. 11, 12. Distribution of former potential Fennoscandian endemics: 11 Mycomya festivalis (1984 open circle; 2000 solid circle); 12 Boletina populina (1995 open circle; 2000 solid circle).

1997) and Austria (Plassmann 1996), and to the Eastern Vologda Province (Зайцев 1994a). *Boletina populina* described in 1995 from one Karelian locality (Fig. 12) is now found not only in other Fennoscandian regions (Hedmark 1998) but also in Great Britain (Chandler 1998). Obviously the absence of certain Fennoscandian species in neighbouring areas is rather explained by the lack of data than real endemism. The ranges of most of these species probably will be extended in the future.

Conclusion

Fungus gnats are very actively studied now in Palaearctic. Every year tens of new species are described and new data on distribution are published. Considering the extreme diversity of Mycetophilidae and their wide distribution in general, we can forecast extension of the zoogeographic ranges with more intensive studies in regions of the Holarctic still poorly known. Central and Eastern regions of Russia appear to be most interesting in this respect.

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Beetles of the Nature Reserve Friendship and their monitoring

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Objectives

The main goal of the study was to get knowledge about the structure of soil-dwelling beetles' associations in various biotopes on both sides of the Russian-Finnish border. More consideration was given to *Carabidae* as they are good indicators of environment quality and one of the most abundant groups. The objective of the more precious study of ground beetles was an attempt to find if there are any differences of their ecology in different regions.

Study area and methods

In 1986, studying of beetles of northern taiga was begun in the Kostomuksha nature reserve by the method of pitfall traps (Крыжановский 1983) on constant sample sites and by manual collecting from various substrata in various biotopes. During 1986-94 the catches by pitfall traps were conducted in 10 various biotopes, then the amount of constant sample sites for monitoring was reduced. Nevertheless, these sample sites give a general notion about biodiversity of the Kostomuksha nature reserve, which is rather a large uniform area of northern taiga of Eastern Fennoscandia, only slightly disturbed by human activities (Kashevarov 1996). In 1990, it was joined with 5 Finnish protected areas into the international Nature reserve Friendship. In 1996, the study with the same methods was continued also in Elimyssalo (Finland) that is on a distance of about 60 km from Kostamus. The catches are conducted during the whole summer in bilberry-lingonberry and lichen pine forests, grass and bilberry spruce forests, sedge-sphagnum mires, meadows, heather-lichen wasteland and (up to 1994) in birch forest.

Results and discussion

Nowadays the beetle species list of the nature reserve include more than 200 species from 30 families (Rutanen & Kashevarov 1997), 6 species being listed in the Red Data Book of Karelia (Ивантер & Кузнецов 1995). They are: *Platynus mannerheimi*, *Platycerus caraboides*, *Phaenops cyanea*, *Boros schneideri*, *Lamia textor* and *Pytho kolwensis*. During the study period only 3 specimens of *Platynus mannerheimi* were caught in wet grass spruce forest. In the same type of forest *Pytho kolwensis* was registered. Like *Platycerus caraboides* it is not very rare for the territory. The last 3 species are known by a few specimens caught by different researchers.

The best studied group both quantitatively and qualitatively is soil-dwelling beetles. Ground beetles *(Carabidae)* and road beetles *(Staphylinidae)* are the most abundant in the catches, *Zyras humeralis (Staphylinidae)*, being the absolute dominant. The most numerous this species is on the sample sites where are the colonies of hill-ants *(Formica)* influencing very negatively on ground beetles and not so strongly on road beetles (Рыбалов *et al.* 1998). Sometimes pitfall traps were even overfilled with ants and *Zyras humeralis*. From the other groups, dung-beetle *Geotrupes stercorosus (Scarabaeidae)*, which is common in the middle taiga zone should be mentioned. The investigations carried out in the Nature Reserve Friendship showed that this species is rather rare in the northern taiga forests. This dung beetle has been regularly caught only in the birch forest. It is possible to consider the rarity of this species due to the poverty of northern taiga forests with suitable nutrients. The second species from the same genus *G. stercorarius* was registered only once in one of the meadows. Both of these dung beetles can be considered to be rare in the region.

More consideration was given to the study of ground beetles as they are good indicators of environment quality. Amount (dynamic density) of ground beetles was low during the whole study period. A little more than 3000 specimens of imago have been caught up to nowadays. On the territory of the Nature Reserve Friendship, 57 species of ground beetles were registered: 35 species were registered by the method of monitoring on constant sample sites on the Russian side and 23 species on the Finnish side, from the total amount for the region, a little more than 60 species (Кашеваров 1999). During the comparison period 31 species totally were registered on both sides. The most richly represented genera are *Bembidion* and *Amara*, but also *Notiophilus*, *Pterostichus and Agonum* (tab.1). It is necessary to mention that the most of *Bembidion* and all *Dyschirius* species have been caught on the sandy beach of the Kamennaya River. In addition to the above mentioned *Platynus mannerheimi*, several species that are known

Table 1. List of Carabidae of the Nature Reserve Friendship

Species	Amount	Species	Amount
Cicindela sylvatica	c	Pterostichus diligens	c
C.campestris	r	P.oblongopunctatus	a
Carabus glabratus	a	P.adstrictus	r
C.violaceus	a	P.minor	r
Cychrus caraboides	a	P.rhaeticus	a
Leistus terminatus	r	P.strenuus	c
Notiophilus aquaticus	c	Agonum ericeti	a
N.biguttatus	a	A.sexpunctatum	r
N.germinyi	a	A.mannerheimi	r
N.palustis	r	A.fuliginosum	c
N.reitteri	c	A.gracile	r
Elaphrus cupreus	r	A.quadripunctatum	r
E.uliginosus	r	Calathus melanocephalus	r
Loricera pilicornis	r	C.micropterus	a
Miscodera arctica	r	Amara communis	c
Dyschirius globosus	r	A.lunicollis	a
D. septentrionum	r	A. famelica	r
D.politus	r	A.nitida	c
Bembidion lampros	r	A.similata	r
B.properans	r	A.erratica	r
B.doris	r	A.brunnea	r
B.obliquum	r	A.aulica	r
B.bruxellense	r	Harpalus latus	r
B.tetracolum	r	H.quadripunctatus	r
B.quadrimaculatum	r	Bradycellus caucasicus	r
B. mannerheimi	r	Trichocellus placidus	c
Trechus rivularis	r	Cymindis vaporariorum	r
T.rubens	r	Dromius agilis	r
Patrobus assimilis	c		

A – abundant, C – common, R – Rare.

by 1-3 specimens should be included in the group of species rare for the area. They are: *Bembidion mannerheimi, Agonum sexpunctatus, Agonum quadripunctatus and Amara aulica.* Species new for the area have not been registered for several latest years. So, it is possible to say that the basic inventory of *Carabidae* is finished, though findings of some specific or introduced species can occur from time to time.

The largest amount of ground beetles was registered in the birch forest but even here only around 200 specimens per season were caught. The lowest amount was registered in the lichen pine forest and in the mires. During three years of comparing studies on constant sample sites about 1000 imago specimens belonging to 25 species were caught from which 18 species were registered in Kostomuksha NR, and 23 in Elimyssalo. The richest assemblage was in the meadow.

Analysis of the data (Table 2) showed that the most abundant species are *Notiophilus germinii, Pterostichus rhaeticus, Carabus glabratus, Calathus micropterus* and *Amara lunicollis,* but the first two species were registered only on 2-3 sample sites and the last three were registered on all of them. One third of the catch is constituted by *Calathus micropterus* that was a dominant in absolute majority of biotopes. The constitution of dominants hardly changed from year to year. On almost every sample site of the Kostomuksha nature reserve *Pterostichus oblongopunctatus* has been registered, being known from Elimyssalo only thanks to one specimen. In 1998, a large amount of *Trichocellus placidus* and *Bradycellus caucasicus* was registered in Elimyssalo but not a single specimen of both of them was caught in the Kostomuksha nature reserve.

Table 2. Dominating Carabidae of the Nature Reserve "Friendship" in 1996-99 (in %% of total catch).

Species	Kostomuksha NR						Friendship Park, Elimyssalo					
	1	2	3	4	5	6	7	8	9	10	11	12
Carabus glabratus	15,5	-	16,0	5,3	14,4	25,0	23,6	-	5,5	25,3	7,0	-
Carabus violaceus	1,0	-	-	4,5	15,3	-	29,1	1,4	-	33	-	-
Cychrus caraboides	8,2	-	1,0	6,8	16,1	11,7	9,1	-	-	-	-	-
Notiophilus biguttatus	9,3	-	-	2,3	0,8	3,3	1,8	-	30,1	-	-	-
Notiophilus germinii	-	-	3,0	59,8	37,3	-	7,3	-	-	14,3	0,4	-
Patrobus assimilis	-	-	-	-	-	-	-	-	-	-	-	9,1
Pterostichus oblongo-punctatus	13,4	-	2,0	0,8	0,8	3,3	2,0	-	-	-	-	1,3
Pterostichus diligens	-	28,0	3,0	-	-	-	-	24,8	-	-	-	-
Pterostichus strenuus	-	-	8,0	-	-	-	1,8	-	-	-	15,6	1,3
Pterostichus rhaeticus	-	24,0	-	-	-	-	-	67,6	-	-	-	-
Agonun ericeti	-	32,0	-	-	-	-	-	6,9	-	-	-	-
Calathus micropterus	47,4	-	21,0	11,4	14,4	53,3	18,2	-	63,6	3,3	4,1	87,0
Amara lunicollis	1,0	16,0	23,0	3,0	0,8	-	1,8	-	-	7,7	42,6	-
Amara nitida	1,0	-	17,0	-	-	-	-	-	-	-	5,6	-
Trichocellus placidus	-	-	-	-	-	-	-	-	-	-	14,4	-
Harpalus latus	-	-	-	-	-	-	-	-	-	-	5,2	-
Species amount	9	4	14	12	8	7	11	4	3	10	11	5
Specimen amount	97	25	100	132	118	60	55	145	55	91	270	77

1 – 6 – Kostomuksha nature reserve; 7 – 12 – Friendship Park (Elimyssalo); 1, 7 – bilberry-lingonberry pine forest; 2, 8 – sedge-sphagnum mires; 3, 11 – meadows; 4 – lichen pine forest, 5 – lingonberry-heather pine forest; 6, 9 – bilberry spruce forests; 10 – heather-lichen clearcut; 12 – grass spruce forest along a brook.

The largest dynamic density of ground beetles in the meadows and mires was registered just after the snow melting. In the forests it happened around 10 days later. The summer-autumn quantity pinnacle was not evident. The quantity of the most abundant ground beetles varied greatly from year to year both in Kostomuksha nature reserve and in Elimyssalo. But due to the low amount of them, especially in the mires, it is not yet possible to make any decisions about their long-term dynamics.

Comparison of ground beetles' assemblages of various biotopes using so called coefficient of biocenotic similarity (Вайнштейн 1976) showed rather high similarity of all forests. The ground beetles' assemblages of meadows are greatly influenced by adjacent forests and similarity between them is not very high. On the contrary, ground beetles assemblages of mires stand aside from all other biotopes and they are rather similar only with each other.

Conclusions

The studies of soil dwelling beetles' assemblages:

- Gave an idea about their composition and structure in the northern taiga slightly disturbed by human activities;
- Revealed the poverty of their species composition and amount in the northern taiga of Fennoscandia in comparison with the other taiga regions;
- Showed that formation of new biotopes due to human activities is enriching the fauna of beetles;
- Showed significant homogeneity of soil beetles' assemblages of various types of forests and, on the contrary, significant heterogeneity of assemblages of small unspecific for taiga patches.

Continuation of entomological monitoring studies and comparison the data from various protected areas of Russia and Finland will give us knowledge to understand the ways of beetles fauna formation and maybe to forecast the future changes.

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Population of soil-dwelling invertebrates of the old-growth spruce forests of the Nature Reserve Friendship

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Objectives

- To study the structure, dynamics and biodiversity of soil invertebrate population of old-growth forest in northern boreal zone of Fennoscandia (with details for spruce forest in Friendship Park).
- To compare the soil populations of the Nature Reserve Friendship with the populations of other parts of the northern boreal zone.
- To find a correlation within various parts of population and due to soil conditions of the region.
- To give an assessment of biodiversity of main soil systematic groups of old-growth forests at the investigated area.
- To find out different factors which affect the soil population.

Methods

The first and main type of the watershed spruce forest *is Picea abies - Hylocomium splendens - Vaccinium myrtillus* and *V. vitis-idea* type.

The second type is the spruce forest along brooks which is obviously more diverse. The most common type of this forest is *Picea abies - Athyrium filix-femina* (or *Thelypteris phegopteris*) - *Equisetum palustre - Rhytidiadelphus triquetrus* type.

For studying the soil fauna population we used standard soil zoological methods such as estimations with the usage of hand-sorting method at the samples which as big as 0.0625 m^2 ("total" estimation). 8 or 16 soil samples per plot have been taken. The other method is the estimation of forest floor and litter fauna (the herpetobios) with the usage of Barber pitfall traps (the dynamic density assessment).

The red hill ants are the most important component of all the old-growth forests of the investigated area. In Taiga zone at the relatively little disturbed landscapes the amount of the red hill ants can be significant. In such a case the ants don't live in single colonies but in highly organized settlements like federations which look like some series of connected ant-hills (Захаров 1991). The same settlements of ants were found in our investigations in North Karelia in Kostomuksha Nature Reserve, and in Friendship Park in Finland. The most common species here is *Formica aquilonia* and sometimes also *F. polyctena*.

When making an assessment of the biodiversity of soil fauna, it is necessary to take into consideration the influence of the settlements of the red hill ants. To determine the amount of the ants at the investigated plots direct counting and mapping of the anthills in plots with the size of 2 –2,5 ha was made. On the sites the diameter of the outer side of the anthills was determined, and the amount of ant routes coming out of the hills was counted (Захаров 1978).

To compare the results, data collected by the author in the Yenisei Taiga region at the same North Taiga zone (according to the Russian classification) was used.

Results and discussion

Usually, the primary assessment of the soil fauna is made in accordance with the total indexes of the numbers and biomass of the invertebrates. It is summary level reflected total condition of soil.

In comparison with the other population of North Taiga (the lowest density is 90-120 ind/ m^2 and the highest density is 250 - 300 ind/ m2), all the investigated soil groups in this case are characterized by low and middle densities of the invertebrates. The biomass of the soil communities is also relatively low: 1-2 g/m^2 for the most typical old watershed spruce forests, and the highest values of biomass - 3,2 - 4,5 g/m^2 for the spruce-tree forests near brooks. It points at relatively poor soils and relatively young (undeveloped) soil cover of this part of Karelia. When compared with investigations made in some North Taiga areas of Siberia, the value of such indexes as the average density and biomass are much lower then the same ones in North Taiga communities of European and Asian parts of Russia. The average value of the invertebrate densities in Yenisei Taiga is 1,2 – 1,5 times more and the biomass is 2 - 5 times more than in Karelia.

The comparison of the compositions of systematic groups (the level of orders and families) shows that:

Like in the majority of the communities of Kostomuksha Nature Reserve and Friendship Park, the soil fauna composition of the investigated area is rather similar at the level of families as well as at the level of genus and species. So, in the majority of soil population the most numerous groups were only four systematic groups: spiders (Aranei), larvae of Staphylinidae, larvae of Curculionidae and larvae of Elateridae. In some years there were also found rather numerous amount of larvae of Cantharidae and Lithobiomorpha - Lithobiidae.

Among them, the spiders (Aranei) predominated completely in all the coenoses. We shall take into consideration that these groups are the most common in the most Taiga communities of Eurasia, too.

But in many complexes of European and Siberian Taiga the other groups such as earthworms, Lithobiomorpha, Geophilomorpha, Opiliones, Carabidae, etc. are also diverse.

The species composition of forest litter and soil population of the area is not very diverse either. In all the investigated biocoenoses in many groups of the invertebrates there were found a few species. For example, it was found only one species of the earthworms - *Dendrobaena octaedra* (in Siberia in the same zone there were 3 of them) and as for the Lithobiidae, it was also found only one species: *Monotarsobius curtipes* (and 3 in Siberia) and 2-3 species of larvae of Elateridae and two the most common species - *Paranomus costalis* and *Athous subfuscus*, and sometimes *Selatosomus impressus*. In the territory of the National Park Friendship found 6 species of Elateridae were found. In Siberia in the same types of forest sites 10 species were found. In the traps and soil samples of the investigated area there were found 16 species of Carabidae. Only 5 of them were really common in the spruce forests: *Calathus micropterus, Cychrus caraboides, Carabus glabratus, Notiophilus reitteri, N. biguttatus*. In some years among them were also found *Pterostichus oblongopunctatus* and *Patrobus atrorufus*. To compare it, in the old-growth forests of Yenisei taiga we found 18 species. In accordance with the data of Boris Kashevarov, during 15 years of investigations of all the biototopes in general (including the meadows) there were found 56 species of ground beetles (Kashevarov 1995, Кашеваров 1999). And in comparison with Yenisei taiga, there were found 120 species (Рыбалов 1997).

Almost all the above-mentioned species which are typical for the old-growth spruce-tree forests of the National Park Friendship refer to the group of the forest mesophylile.

So, the amount of species in different systematic groups living in old-growth of this part of Fennoscandia is 2-3 times less than in the same old-growth forests of North Taiga in Siberia.

An exception from the general rule of "species poorness of soil population" were two systematic groups, Aranei and Staphylinidae. Until now in the collections from all the investigated forest biocoenoses of Kostomuksha Reserve and Friendship Park 135 species of Aranei and 108 species of Staphylinidae were found. In old-growth forest there were about 25- 40 species in each group. In comparison, the diversity of the same groups of the soils of old-growth forests of Siberia is not too much bigger: in Siberian taiga were found 140 species of Aranei and 120 species of Staphylinidae.

In 1995-1999 106 species of Aranei and 105 species of Staphylinidae were found in Kostomuksha Reserve. At the Finnish territory of Friendship Park during the two years of collection of materials (1998-1999) 51 species of spiders and 101 species of Staphylinidae were found. So, the amount of spiders which were found in the forest soil of Kostomuksha Reserve is larger than at the Finnish part of "Park Friendship". Probably, this difference will reduce after further investigations at the Finnish territory.

In the old-growth spruce watershed forests with green moss and cowberries in Kostomuksha Reserve 35 species of spiders were found.The total amount of spiders in the spruce forest of this type varied within 30-100 ind/m^2. The following species dominated here: *Robertus scoticus, Astjenagus paganus* and *Centromerus arcanus.* Relatively numerous were also *Porrhomma pallidum* and *Hilaira herniosa.* Until now in Finland in Friendship Park, in the same kind of spruce forests, two times less spider species than in the territory of Kostomuksha Reserve, only 15 species, were found. The spider population in the Finnish forests is very similar to the spider population in Kostomuksha Reserve. The composition of the dominant species, *Robertus scoticus, Asthenargus paganus, Centromerus arcanus and Tapinocyba pallens*, is just the same in both territories. Some differences of Aranei population at the Finnish territory are found only within the groups with smaller amount of species.

In the old-growth spruce forests near brooks in Karelia 25 species of spiders were found. With the common dominant *species Astjenagus paganus, Centromerus arcanus* and *Tapinocyba pallens*, which are typical for all the spruce forests of this territory, such species as *Tenuiphantes alacris, T. tenebricola, Hilaira herniosa* and *Robertus lividus* also dominated in some years.

In Kostomuksha Reserve in the old-growth watershed spruce forests with green moss and cowberries, 26 species of Staphylinidae were found. The amount of Staphylinidae in the above mentioned old-growth spruce forests varied from 12 (1997) to 42 (1995) ind/m^2. The structure of the population of Staphylinidae in the spruce forests varied insignificantly year after year, the same dominant species were noticed during all the period of our investigation. In the watershed spruce forests there were the following dominant forest mesophyla species: *Atheta myrmecobia, Oxypoda annularis, Othius myrmecophilus, Othius lapidicola* and *Liogluta micans*. In some years relatively numerous were also *Quedius fulvicollism* and *Stenus flavipalpis*. The dominant species were obviously seen in comparison to the other population and the Shannon diversity index shows this comparison as well. For the Staphylinidae of the spruce forests with the green moss (of both territories) the Shannon index was 2,2-2,3.

In Finland in Friendship Park in the same type of spruce forests 20 species of Srtaphylinidae were found. The amount of Staphylinidae in the old-growth forests in the Finnish territory varied within approximately the same limits, 20-50 ind/m^2. The composition of the dominant species included almost the same species. The most numerous of them were *Oxypoda annularis, Atheta myrmecobia* and *Liogluta micans*, and the subdominant species were *Othius lapidicola* and *Othius myrmecophilus*.

In the spruce forests near brooks in both territories the amount (12-25 ind/m^2) and diversities (14 species) were slightly lower than in the watershed forests. At the same time, relatively more numerous in such communities of Kostomuksha Reserve were *Atheta myrmecobia* and *Othius lapidicola,* and in the Finnish part two more species: *Liogluta micans* and *Oxypoda annularis*. The population of Staphylinidae of the spruce forests near brooks is more even in comparison with the watershed spruce forests which is reflected by Shannon index - its value is higher here (2,6-2,7).

As well as species diversity of old-growth forests in general, the diversity of population of a particular forests is low. Only one or (rarely) two species of every concrete systematic group predominated among the whole population of a a particular biocoenosis during the period of study. For example, the absolute dominant among the ground beetles was *Calathus micropter*us (compare Kashevarov 1999). Among Elateridae in the soils of all the spruce forests predominated *Paranomus costalis*. The most common species among Staphylinidae in the spruce forests was *Atheta myrmecobia* and sometimes *Oxypoda annularis.* Among the forest litter and soil spiders in the spruce forests dominated *Asthenargus paganus* (Linyphiidae) or *Robertus scoticus* (Theridiidae).

Evaluation of soil groups of different types of spruce forests of the Friendship Park and their further comparison with North taiga forest was also made with the usage of Shannon diversity index. The meaning of these indices confirms obvious decline of diversity in the forests of Karelia in comparison with the Siberian forests. In the forests of the Friendship Park this index usually was 2.2 - 2.5 and in Siberian old-growth forests in the similar groups it was 3.0 - 3.2. Such an index shows not only diversity but also "the degree of equality" of the group composition, as it is shown from the given data, "the degree of equality" in Siberian forests is obviously higher, so it shows a smoother species domination.

Another important feature of soil fauna is typical for this region of Karelia: in the watershed spruce biocoenoses participate some groups of saprophiles, first of all, the earthworms. Among earthworms only a forest litter species *Dendrobaea octaedra* was found. This species don't play a significant role in the process of decomposition of forest litter and humus accumulation. Some saprophages in these spruce forests were scanty such as the larvae of Diptera - Tipulidae and Bibionidae. Relatively low activities of saprophages of soil fauna of the watershed spruce forests decreases the rate of organic decomposition and changes of humus type in the spruce forests. The humus type called Mor prevails there .

The most distinctive soil groups were found in the old-growth spruce forests near brooks where the highest indices of density and biomass were noticed. Also there were found the highest diversities of the soil groups and species among all the investigated communities of the old-growth forests in Karelia. It is refers to all the levels, total indexes abundance, biomass, diversities within families, and species of some groups. In such a type of spruce forest some saprophile groups prevail among the soil invertebrates, such as earthworms and larvae of Sciaridae, Bibionidae and Tipulidae. The soil invertebrates are more active there and have obviously deeper penetration into the lower layers of the soil. The densities of soil fauna and especially the soil saprophages allow to form the mull layers.

Among the other species which inhabit this spruce forest there are many species which are common in the south such as *Aloconota sulcifrons, Geostiba circellaris* (Staphylinidae), *Trechus rivularius* (Carabidae), *Dolopius marginatus* (Elateridae), *Allomengea scopigera, Leptorhoptrum robustum* and *Maro sublestus* (Aranei). On the basis of the research data it can be considered that the population of the old-growth forest along rivers and brooks is relatively "southern" with the tendency to settle in the mid-taiga subzone. Such conclusion is based on some of the above-mentioned indicators and the presence of some "southern" species of the invertebrate.

But of all the investigated biocoenoses of the Kostamuksha Reserve and Friendship Park, the most diverse group was found not in an old-growth site but in a mixed birch tree forest which is gradually being replaced by a spruce forest. Here we found the highest possible amount of microbiotopes.

In all studied old-growth forests, numerous settlements of the red hill ants (*Formica aquilonia and F. polyctaena*) of federative type were found. It can bring obvious changes into the composition of the populations of soil invertebrates and change the amount of some species, especially the predators.

At every plot there are biotopes which are good for the ants and there are biotopes which are almost unfavorable for them. There is a lot of variation in the densities of the ant settlements (Tables 1-2). All the plots in the table 1 are placed in accordance with increasing of the amount of ants. In the communities where the ant estimations were made it was found out an obvious tendency of increasing of the predatory invertebrate densities in the line of the plots 1-4. This data correlate with the gradual decrease of the ant densities (Table 1).

Such a phenomenon connects with the densities of the Carabidae, Aranei and Staphylinidae - the main predatory groups of the forest litter complex. If the amount of the ants decreases the biomass of the predatory invertebrates increases with the highest rate (more than in 2 times) and the amount increases with a less rate - in 1,2 - 1,5 times (table 2).

Table 1. The main characteristics, showing the ant densities at the 4 investigated plots.

	The area of the plot [1]	The amount of the ant-hills	The amount of the columns in general	Total area of the ant-hills	Total area of the ant-hills/1 ha [2]
Spruce forest N1	3,24(2,84)	12	50	12,59	5,27 (4,73)
Spruce forest N2	4,2(2,35)	8	41	7,43	3,77 (3,03)
Spruce forest N3	4,68(4,68)	8	34	5,03	2,50 (2,30)
Spruce forest N4	4,32(3,6)	5	26	3,1	1,18 (1,42)

1) in the brackets is the area, which suits for the ant foraging; 2) in the brackets is the area of the ant settlements per ha which suits for the ant foraging at a part of a site.

Table 2. The amount (ind/m^2) and the biomass (mg/m^2) of the predatory invertebrates in summer 1997 and 1998 in different biocoenoses of Kostomukshsa Reserve

	Plots 1	2	3	4
The amount of the predators [1]	80(47)	108(55)	122(62)	160(72)
The biomass of the predatory groups in general [1]	92 (8)	120 (12)	148 (17)	332(25)

Comments. [1] in the brackets % of total number and biomass.

Increasing of the biomass of the predatory groups and decreasing of the amount of ants in the absolute numbers as well as in the percentage can be seen. Such a tendency remains during the three seasons. This study showed the correlation of the dynamic density of the ground beetles and the densities of the ants especially for the similar (in accordance with their hydrothermal conditions) plots. The lowest level of the ground beetles density was found in the spruce forest with highest level of abundance of ants.

Besides the increasing of Carabidae density, their species composition also changed. In the spruce forest where the maximal density of the ants was observed, three species were found, and only one of them dominated, *Calathus micropterus*. This is the species which prefers the deeper (to compare it with the ants) layers of the forest litter. In the forest with low density of ants more diverse communities of Carabidae (7 species) were found. Having similar ecological niches with the ants, these species of the ground beetles are their competitors.

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Ground-living spider communities (Araneae) on boreal and hemiboreal peatbogs

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Introduction

Peatbogs are typical biotopes in the northern coniferous forest zone. Approximately a third of the land area of Finland was covered by peatlands, of which about a half has been drained for forestry, farming and peat harvesting (Wahlström et al. 1996). So peatland ecosystems (mires, bogs, fens) are endangered even in northern Europe, and many organisms living in peatland habitats are nowadays considered as threatened. This is true also for spiders (e.g. Koponen 1985). For example, in the recent Finnish Red Data Book (Rassi et al. 2000) six of the total 34 listed spider species are inhabitants of mires. Some general information is here given on typical peatbogs spiders, both abundant and rare ones, and on their distributional trends, along a transect from the southernmost parts of the hemiboreal vegetation zone to northern borders of the northern boreal zone.

Material

Spiders were collected along a transect from southern Lithuania (54°N) to Lapland (northern Finland, 69°30'N). Peatbogs studied included both open treeless and pine growing *Sphagnum* bogs in the hemiboreal and boreal vegetation zones. Ground-living, epigeic spiders were collected using pitfall traps. For details of study sites and collecting methods, see Koponen et al. (2001). Additional data used here is based on studies by Asta Vilbaste on Estonian peatbogs (e.g. Vilbaste 1980-81) and on the present author's published (Koponen 1968, 1979a, 1979b, 1985, Lehtinen et al. 1979) and unpublished works in Finland.

Abundant species

Some typical and abundant peatbog species occurred more or less regularly on bogs along the whole transect from Lithuania to Lapland. This group of widely distributed spiders included *Pardosa sphagnicola, Agyneta cauta, Centromerus arcanus, Lepthyphantes angulatus, Meioneta mossica, Cnephalocotes obscurus, Pocadicnemis pumila*, and *Walckenaeria nudipalpis*.

Dominant species on Lithuanian peatbogs were *Aulonia albimana, Pardosa sphagnicola, Pirata uliginosus, Scotina palliardi, Centromerus arcanus,* and *Trochosa spinipalpis*. Dominants in southern Finland were *Arctosa alpigena, Pardosa hyperborea, P. sphagnicola,*

Alopecosa pulverulenta, Antistea elegans, and *Agyneta cauta*. Dominant species on peatbogs in central Finland included *Pardosa sphagnicola, P. hyperborea, Arctosa alpigena, Agyneta cauta,* and *A. decora*. The following species dominated in northern Finland: *Pardosa hyperborea, P. atrata, Arctosa alpigena, Pelecopsis mengei, Hilaira nubigena*, and *H. herniosa*.

The great majority of abundant and typical peatbog spiders belonged to two families: Lycosidae (wolf spiders; e.g. genera *Pardosa, Pirata, Trochosa, Aulonia,* and *Arctosa*) and Linyphiidae (money spiders; e.g. *Agyneta, Centromerus, Lepthyphantes, Meioneta, Hilaira,* and *Walckenaeria*).

Rare species

Six mire-living spiders have been included in the recent Finnish Red Data Book (Rassi et al. 2000): *Emblyna brevidens, Ceraticelus bulbosus, Mecynargus* (sub *Rhaebothorax*) *foveatus, Satilatlas britteni, Ozyptila gertschi,* and *Zora parallela*. Most of them were found at the present study localities. The small-sized linyphiid *Ceraticelus bulbosus* has an interesting range; it is widely-distributed in North America, spread throughout Siberia but known in Europe only from Kuusamo in Finland and from a few localities in Central Europe. Also other spiders which are not included in the Finnish Red Data Book but considered rare in northern Europe were found on the studied peatbogs (Table 1). These species are typical of mires, although some of them can be found also in other type of habitats.

Table 1. Examples of rare bog spiders; species of the Finnish Red Data Book are excluded.

Species	Family	General range in northern Europe
Centromerus unidentatus	Linyphiidae	southern
C. incultus	Linyphiidae	southern
Minicia marginella	Linyphiidae	southern
Taranucnus setosus	Linyphiidae	southern
Lepthyphantes ericaeus	Linyphiidae	southern
Carorita limnaea	Linyphiidae	southern
Glyphesis cottonae	Linyphiidae	southern
Agyneta suecica	Linyphiidae	?
Agyneta breviceps	Linyphiidae	northern
Semljicola angulatus	Linyphiidae	northern
Wabasso questio	Linyphiidae	northern
Dipoena prona	Theridiidae	southern
Pardosa maisa	Lycosidae	northern?
Neon valentulus	Salticidae	southern
Agroeca dentigera	Liocranidae	southern
Drassyllus pusillus	Gnaphosidae	southern

Distributional patterns

Spiders living on the studied hemiboreal-boreal peatbogs can be roughly divided into three groups: widely-distributed (see above), southern and northern species (cf. also Koponen et al. 2001).

Of the southern species, *Aulonia albimana* was found only on Lithuanian peatbogs where it was the most dominant species; it is not known in Estonia (Vilbaste 1987) but in Finland it is rarely collected in dry places, not on bogs (e.g. Lehtinen et al. 1979). *Phrurolithus minimus*, a southern bog species in Lithuania, is known from a stony shore in Estonia (Vilbaste 1987) but not found in Finland. The following bog species with a southern general range were found as far north as in southern Finland: *Drassyllus lutetianus, Zelotes latreillei, Maro minutus, Sintula corniger,* and *Walckenaeria nodosa;* and some species reach their northern limit in central Finland: *Pirata insularis, P. uliginosus, Pelecopsis parallela*, and *Meioneta affinis*.

Of the northern species, e.g. *Gnaphosa orites* and *Semljicola lapponicus* were found only in northern Lapland, *Hilaira nubigena* and *Walckenaeria karpinskii* also in central Finland, and *Gnaphosa lapponum* and *Mecynargus sphagnicola* even in southern Finland. The known southern limit of *Pardosa atrata, Latithorax faustus* and *Robertus lyrifer* is in Estonia (Vilbaste 1980-81) and the range of *Gnaphosa microps, Pardosa hyperborea* and *Arctosa alpigena* extends to Lithuanian peatbogs.

Conclusion

Typical peatbog spiders belong especially to the families Linyphiidae, Lycosidae and Gnaphosidae. Clear differences were found in communities at different latitudes. In general, faunas found in the hemiboreal zone (from Lithuania to southernmost Finland) resembled each others. However, some marked differences were found between sites in the hemiboreal zone, the most striking one was the absence of the dominant species of Lithuanian bogs, *Aulonia albimana*, both on Estonian and Finnish peatbogs. The assemblage of abundant species on boreal (Finnish) peabogs also showed geographical differences, especially the northern boreal bog sites differed from the middle and southern boreal ones. For example, *Hilaira* species and *Pelecopsis mengei* were typical of the northern boreal, and *P. parallela* and *Pirata uliginosus* of middle and southern boreal peatbogs. Marked number of threatened and other rare spider species was found on peatbogs. This indicates the importance of protecting remaining mire habitats, especially in areas where natural bogs are scattered.

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Terrestrial molluscs as indicator species of natural forests

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Introduction

During the last 100-200 years, more and more intensive destruction of the natural forests as well as their replacement with planted tree cultures, can be observed in Latvia (Zunde 1999, Suško 1997). Land molluscs are among those animals, which are very sensitive to human caused disturbances in the forest and therefore can be used as bioindicators of anthropogenic influence (Ehnström & Waldén 1986, Ssymank 1994, Møller 1997, Niemelä 1997, Лихарев1962, Лихарев & Виктор 1980, Шилейко 1978). The aim of this study was to find out mollusc species most sensitive to forest management, which therefore could indicate biologically valuable forests in Latvia. Approbation of indicator species of natural forests is still continued in a course of forest key habitat inventory started in Latvia in 1998 (Ek et al. 2000).

Materials and methods

The studies were curried out in 1995 and 1997 as part of complex investigation on natural forests of Latvia conducted by Suško (1997). Material was collected in four distant areas having different climatic features, topography, soil conditions and forest management history (Table 1). Altogether 42 study plots were set in following groups of forest biotopes: forests with natural or human caused disturbances /CDF/ (windfalls, clear cuts, young naturally regenerated stands after clear-cutting, plantations), forests of pioneer tree species /PTSF/, pine forests /PF/, spruce forests /SF/, wet deciduous forests /WDF/ and broad-leaved forests /BLF/. Each study plot has different history of forest management and different amount of key elements supporting biodiversity as well as different tree and log continuity (Suško 1997). Investigations were carried out in all three classes of natural forests represented in Latvia (Priedītis 1999): Cl. Vaccinio-Picetea, Cl. Querco-Fagetea and Cl. Alnetea glutinosae.

Two methods – volume method and square method (Balogh 1958, Dunger & Fiedler 1997) were used to collect samples of the litter. The volume sample was collected from plot sized 20 x 10 m. In total, 3 litres of forest litter (decomposing leaves and humus) were sifted at random from ground cover in each relevé using a soil sieve with 1 x 1 cm mesh. In square method 25 samples sized 20x20 cm were collected along the transect set in each study plot. Later the litter was sifted using soil sieve with 1 x 1 mm mesh. Besides that, molluscs were collected from relevant substrata (tree trunks, snags and logs and under their bark, different parts of fungi, lichens, bryophytes and vascular plants) as recommended by Лихарев (1962) and Шилейко (1978). Altogether 1260 l of the litter were sifted and 11 421 mollusc specimens were counted. Species of molluscs were identified using guidebooks of Kerney et al. (1983) and Лихарев (1962).

The species requiring specific conditions in prolonged time period (e.g., forest continuity, stable microclimate, large diameter logs and old trees) as well as endangered by certain forest management practices (e.g., clear-cuttings, soil tillage, establishment of plantations and artificial regeneration, land drainage, removal of dead wood and injured trees) were chosen as indicator species (Suško 1997, Ek et al. 2000).

Table I.Characterization of natural forest study sites (from Suško 1997)

Study site	Slitere	Livberze	Aizkraukle	Mezole
Area (ha)	715	632	616	716
Location in Latvia	North-western part	Southern (coastal) part	Southern (central) part	North-estern part
Climate	Moderately warm, the most oceanic region	Warm	Warm	Cool, the most continental region
Forests	Outstanding nemoral broad-leaved and boreal coniferous forests	One of the main nemoral broad-leaved forest distribution areas in Latvia	One of the main nemoral broad-leaved forest distribution areas in Latvia	One of the main boreal spruce forest distribution areas in Latvia
Biological values	High ecosystem naturalness, extremely high biodiversity, standards of Eurosiberian alder swamp and European broad-leaved forest communities, a great number of rare species	Presence of little influenced wetland forests, oldgrowth broad-leaved forests, significant community samples of ash wetlands (mixed decidious wetland forests), a great number of rare species	High ecosystem naturalneness, unique forest-bog mosaic and transitional community complex, little influenced broad-leaved forests on islands in the bog, a great number of rare species	High ecosystem naturalneness, presence of little influenced wetland forests, oldgrowth spruce and pine forests around tracts of bog, a great number of rare species
Management status	Not managed in the last 75 years	Under intensive management	Under intensive management	Not managed in the last 30-35 years
Conservation status	Strict Nature Reserve since 1921	Not protected	Not protected	Restricted Nature area since late 1960-s

Results and discussion

More than 60 of the 85 terrestrial mollusc species found in Latvia inhabit forests (Rudzîte et.al 1997). 52 land mollusc species representing 16 families were found in forest areas studied. Three species: *Discus ruderatus, Euconulus fulvus* and *Nesovitrea hammonis* were recorded in all study plots regardless of biotope's transformation stage and it's biological features. In the same time 15 species were recorded only in those study plots having high biological values (Suško 1997). Results of studies in other forest areas (Pilāte 1997, unpubl. data) reveal that additional 5 species are closely connected with structures supporting biodiversity in forests. Therefore, altogether 20 species were chosen as indicators for natural forests (Table 2). Due to practical reasons (easiness to find and identify) 15 species of them are used in the fieldworks of general forest key habitat inventory.

Table 2. Mollusc indicator species of natural forests in Latvia (PF- pine forest, SF- spruce forest, BLF- broadleaved forest, WDF-wet deciduous forest).

Species name	Forest biotopes inhabited	Forest key habitat inventory	Protected	Red-listed (category)
Acicula polita	BLF, WDF, SF		X	4
Aegopinella nitidula	BLF, WDF			4
Bulgarica cana	BLF, SF	X	X	3
Clausilia bidentata	PM, SF, WDF, BLF	X	X	3
Clausilia cruciata	SF, WDF, BLF	X	X	3
Clausilia dubia	SF, WDF, BLF	X	X	3
Clausilia pumila	WDF, BLF	X	X	3
Cochlodina orthostoma	SF, BLF	X	X	3
Ena montana	BLF	X	X	3
Ena obscura	BLF	X	X	
Isognomostoma isognomostoma	BLF	X	X	3
Laciniaria biplicata	BLF			
Laciniaria plicata	SF, BLF	X	X	
Lehmania marginata	BLF			
Limax cinereoniger	WDF, BLF	X	X	
Macrogastra latestriata	SF, BLF	X	X	
Macrogastra plicatula	SF, WDF, BLF	X	X	
Macrogastra ventricosa	PF, SF, WDF, BLF	X	X	
Ruthenica filograna	WDF, BLF	X	X	3
Spermodea lamellata	SF			

Factors determining the occurrence of indicator species

Long lasting relationship of indicator species with biologically valuable forests are determined by several natural factors: shadowness of forest, stable microclimate, richness of vegetation, deadfall, decomposing stumps, old trees, ravines covered by forest (Ehnström & Waldén 1986, Ssymank 1994, Møller 1997, Niemelä 1997, Suško 1997, Лихарев1962, Лихарев & Виктор 1980, Шилейко 1978).

Most of the indicator species are found in broad-leaved forests and in forests of pioneer tree species. Less species occur in wet deciduous forests, in spruce forests and in forests with natural disturbances. Minor part of the species are found in pine forests and in forest with human caused disturbances.

In Latvia, indicator species of molluscs are most threatened by planting the spruce plantation on rich deciduous woodland soils and the cultivation of these cultures. In forests where forest management activities during the long period (the last 50-90 years) were less intensive (selective cutting or single clear-cut), the number of indicator species does not decrease. It is observed that indicator species decolonise 80-90 years old, unmanaged plantations, if the ecological corridors are maintained or if the plantation is adjacent to natural forests (Suško 1997).

Characteristics of indicator species

The larger part (12 species) belongs to Clausiliidae. Almost all of them are included in the Red Book of Latvia (Spuris 1998).

In Latvia almost all indicator species inhabit exclusively in forests (Suško 1997, Pilāte unpubl. data). Some species (*Macrogastra ventricosa*, calciphilous *Macrogastra plicatula, Aegopinella nitidula* and *Limax cinereoniger*) can be found also in old, unmanaged estate parks. *Limax cinereoniger* sometimes is found in cellars of old houses. These snails favour moist conditions as well as rich microflora and mycoflora serving as food.

Aegopinella nitidula, Arion circumscriptus and most species of Clausiliidae are typical for broad-leaved forests. Almost all species of Clausiliidae are found also in moist spruce forests. *Ena montana, Lehmania marginata* and *Isognomostoma isognomostoma* inhabit particularly old broad-leaved forests, mainly in ravines (Pilāte et al.1994). *Clausilia pumila* and calciphilous *Ruthenica filograna* are typical for moist broad-leaved, spruce and black alder forests. *Laciniaria plicata* and *Ena obscura* can be found mostly in river valleys and in ravines covered by trees.

Spermodea lamellata, Laciniaria biplicata, Ena montana, Isognomostoma isognomostoma and *Lehmania marginata* are very rare species, and have been found only in few localities in Latvia.

Acicula polita, Bulgarica cana, Clausilia cruciata, Cochlodina orthostoma, Macrogastra latestriata and *Ruthenica filograna* are generally rare.

Arion circumscriptus, Clausilia bidentata, Clausilia pumila and *Laciniaria plicata* are rather rare.

The abundance of *Clausilia dubia, Clausilia bidentata* and *Clausilia pumila* varies in different regions of Latvia.

Macrogastra plicatula, Macrogastra ventricosa and *Limax cinereoniger* are the most common indicator species.

Ena montana, Isognomostoma isognomostoma and *Spermodea lammelata* have particularly high indicative value.

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The habitat use of molluscs in the forests of Latvia

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Introduction

General information about habitat preferences of terrestrial molluscs in Northern Europe can be found in several papers, mainly handbooks (Sloka & Sloka 1957, Kerney et al.1983, Ehnström & Waldén 1986, Лихарев1962, Лихарев & Виктор 1980, Лихарев & Раммельмейер 1952, Шилейко 1978). By now there were little relevant data regarding molluscs in Latvia. In most cases the studies deals with deciduous forests, more rarely with coniferous forests (Pētersons 1932, 1933, Schlesch 1942, Pilāte 1997, Spuris 1998). The aim of this study was to find out habitat preferences of forest molluscs and identify factors determining distribution of mollusc species according the groups of forest biotopes in Latvia.

Materials and methods

The studies were carried out in 1995 and 1997 as a part of the complex investigation on natural forests of Latvia conducted by Suško (1997). Collection of material is described in another paper (Pilāte 2003). Data were processed and analysed using classification software (TWINSPAN) (Hill 1979). Of 42 study plots two were excluded from the analyses because the transect was set in heterogeneous biotopes.

Results and discussion

In the forest areas studied, 52 species were found. 16 of them were found in all forest biotope groups studied. Three species - *Discus ruderatus, Euconulus fulvus* and *Nesovitrea hammonis*, were recorded in all study plots regardless of biotope's transformation stage and it's biological features. The number of species found in each forest biotope group varies from 20 to 46 species, but in each study plot from 2 to 30 species. The multiple dichotomous divisions of study plots were done until the second level (Fig. 1). At the first distribution level all 40 study plots are grouped in two groups, each differing with species composition and mollusc abundance. Forests of pioneer tree species, mixed spruce forests, wet black alder forests and broad-leaved forests are included in group *0, representing forest biotopes the most rich with mollusc species. It means that the mentioned biotopes are the most typical for forest molluscs. They correspond with mollusc ecological demands, i.e. they give sufficient shadowness and humidity, stable microclimate, sufficient amount of coarse woody debris, to species requiring specific conditions in prolonged time period (e.g., forest continuity, rich vegetation and forest litter). In respect to forest management these biotopes are rather untouched or with limited influence: selective cutting or single clear-cut followed by natural regeneration.

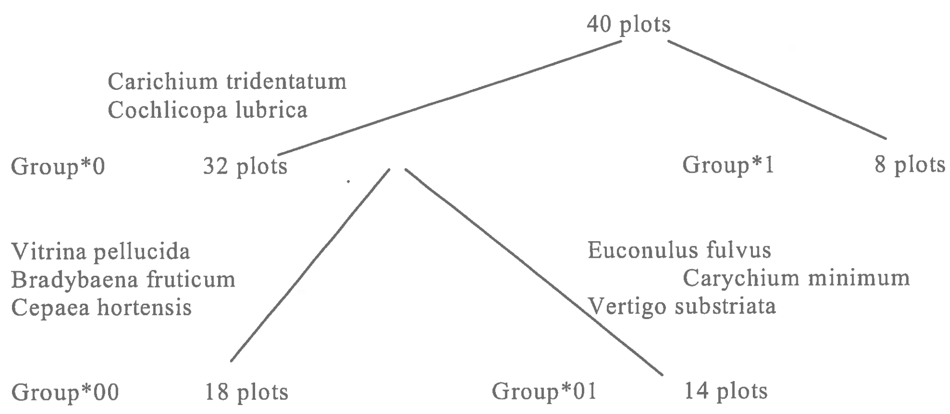

Figure 1. TWINSPAN dendrogram of 40 study plots

Forest biotopes most scarce with the mollusc species are separated at group *1. Dry pine forests as well as pine and spruce forest plantations are present in this group. These are biotopes not corresponding with mollusc ecological demands. Forest management there includes repeated clear-cuttings, drainage, soil tillage and artificial regeneration. Among these biotopes are also spruce plantations growing even on rich deciduous woodland soils. An exception in this group of biotopes is one study plot (29), a wet black alder forest, which was too wet to be suitable for terrestrial molluscs.

A large number of diagnostic species (20) representing III-V incidence class is characteristic for the group *0 (Table 1). All these species are typical and widely distributed forest dwellers. II - I incidence class includes 28 mollusc species. Distinguishing species for group *0 are hygrophilous *Carychium tridentatum* and *Cochlicopa lubrica* - typical for fertile to moderately fertile litter.

Forest biotopes most scarce with the mollusc species (group *1) are represented by species of V, IV and II incidence class. These are the most common and highly adaptive terrestrial molluscs in Latvia. An exception is *Vertigo ronnebyensis*, a species typical for pine forests.

At the second distribution level the 32 study plots of group *0 are furthermore divided into two groups (Fig.1) with different forest vegetation types and mollusc species compositions. Distinguishing species for group *00, such as *Vitrina pellucida, Bradybaena fruticum* and *Cepaea hortensis* are typical for moderately wet and fertile litter. Group *00 includes forest biotopes with the most rich forest mollusc fauna. These are mainly forests of pioneer tree species and broad-leaved forests. These biotopes have limited amount of the spruce, optimal moisture conditions and shadowness, rich vegetation and forest litter. In respect to forest management these biotopes are almost untouched or with limited influence.

Another group, *01 includes forest biotopes not so rich with forest mollusc species, and is represented mainly by wet mixed spruce and wet black alder forests. Increased moisture, greater admixture of spruce and rather scarce vegetation is typical for biotopes of this group. In respect to forest management they have different degree of influence. Among them are untouched wet forests and also broad-leaved forests where repeated clear-cuts have been done. Three distinguishing species, the hygrophilous *Euconulus fulvus, Vertigo substriata* and *Carychium minimum* are found in the group *01.

Group *00 is characterized by a great number of diagnostic species, 24 of all 43 identified within this group. In the group *00 II and I incidence class is reached by 19 species. 18 diagnostic species of 39 recorded are distributed for the group *01. In this group, II and I incidence class is reached by 21 species (Table 1).

Table 1. Frequency classes of terrestrial mollusc species in forests groups of Latvia (using TWINSPAN, see Fig. 1)

At the 1st level	Groups and frequency classes		At the 2nd level	Groups and frequency classes	
Species	*0	*1	Species	*00	*01
Carychium tridentatum	V	-	Vitrina pellucida	V	I
Cochlicopa lubrica	V	-	Aegopinella pura	V	III
Vitrea crystallina	V	I	Carychium tridentatum	V	V
Punctum pygmaeum	V	II	Cochlicopa lubrica	V	V
Vertigo substriata	V	II	Perforatella bidentata	V	IV
Columella edentula	V	II	Vitrea crystallina	V	V
Nesovitrea hammonis	V	V	Vertigo pusilla	V	III
Nesovitrea petronella	V	IV	Punctum pygmaeum	V	V
Euconulus fulvus	V	IV	Vertigo substriata	V	V
Columella aspera	V	II	Columella edentula	V	IV
Aegopinella pura	IV	-	Nesovitrea hammonis	V	V
Acanthynula aculeata	IV	-	Nesovitrea petronella	V	V
Cochlodina laminata	IV	-	Euconulus fulvus	V	V
Perforatella bidentata	IV	-	Columella aspera	V	IV
Vertigo pusilla	IV	I	Acanthynula aculeata	IV	III
Carychium minimum	IV	-	Cochlodina laminata	IV	III
Vitrina pellucida	III	I	Carychium minimum	IV	IV
Acicula polita	III	-	Cepaea hortensis	III	I
Succinea oblonga	III	-	Bradybaena fruticum	III	-
Discus ruderatus	III	II	Macrogastra plicatula	III	II
Cepaea hortensis	II	I	Acicula polita	III	II
Bradybaena fruticum	II	-	Succinea putris	III	II
Ruthenica filograna	II	-	Macrogastra ventricosa	III	I
Macrogastra plicatula	II	-	Succinea oblonga	III	II
Clausilia bidentata	II	-	Vallonia costata	II	-
Succinea putris	II	-	Oxychilus alliarius	II	-
Macrogastra ventricosa	II	-	Trichia hispida	II	-
Vallonia costata	II	-	Clausilia pumila	II	I
Zonitoides nitidus	II	-	Ruthenica filograna	II	I
Cochlicopa lubricella	I	-	Clausilia bidentata	II	I
Limax cinereoniger	I	-	Discus ruderatus	II	IV
Oxychilus allearius	I	-	Cochlicopa lubricella	I	-
Trichia hispida	I	-	Limax cinereoniger	I	-
Bulgarica cana	I	-	Spermodea lammelata	I	-
Clausilia pumila	I	-	Vertigo alpestris	I	-
Clausilia cruciata	I	-	Arion circumscriptus	I	-
Macrogastra latestriata	I	-	Bulgarica cana	I	I
Aegopinella nitidula	I	-	Clausilia dubia	I	I
Arion subfuscus	I	-	Clausilia cruciata	I	I
Vertigo antivertigo	I	-	Macrogastra latestriata	I	I
Vertigo geyeri	I	-	Aegopinella nitidula	I	I
Vertigo ronnebyensis	I	II	Zonitoides nitidus	I	III
Spermodea lammelata	I	-	Arion subfuscus	I	II
Vertigo alpestris	I	-	Vertigo ronnebyensis	-	II
Arion circumscriptus	I	-	Vertigo antivertigo	-	I
Perforatella rubiginosa	I	-	Vertigo geyeri	-	I
Vertigo genesii	I	-	Vertigo genesii	-	I
			Perforatella rubiginosa	-	I
Total:	49 sp.	13 sp.		43 sp.	39 sp.

In group *01 diagnostic level in respect to group *00 is reached by *Zonitoides nitidus*, which indicates wet biotopes, as well as *Discus ruderatus*. The species *Vertigo antivertigo, V. geyeri, V. genesii* and *Perforatella rubiginosa* are found only in the group *01 as they are typical for wet and marshy biotopes. At the same time, most species of the group *00 (such as *Aegopinella pura, Vertigo pusilla* and *Acanthynula acuelata*) in group *01 have incidence class lower for 1-2 steps. It can be explained by more wet conditions, scarce litter and by the presence of spruce.

The data treated by TWINSPAN reveals that all forest biotopes can be divided in 3 major groups: biotopes with rich mollusc fauna, with moderate richness and with poor fauna. This difference is determined by the richness of vegetation, humidity and forest management activities such as main felling, drainage, and artificial regeneration.

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Multivariate analysis of intraspecies diversity of curly (Karelian) birch for its conservation and breeding

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Introduction

Karelian birch *Betula pendula* Roth, var. *carelica* Merckl. is a specific form of common birch *Betula pendula* Roth var. *pendula* Roth., and is phenotypically distinguished by swellings on the stem surface. The growth forms recognized for Karelian birch are high-stemmed, low-stemmed and shrub-like, and the stem shape types are trees with large protuberances and neck, with small protuberances and with stripes. There occur also transitional forms (tuberculate). Curly grain of Karelian birch is known to be inherited, but the genetic rules of the phenomenon have not been identified yet. It is very difficult to experimentally check the action of Mendel's laws at segregation in Karelian birch.

The authors suggest that a complex of multivariate statistical methods is used to estimate the dynamics of Karelian birch intraspecies diversity as regards the presence of curly grain in the hybrid progeny through 35 years. The task for the first stage was to estimate intraspecies diversity and relationship between the growth form and stem surface.The second stage was to find out the pattern of "curly grain" diversity manifestation in hybrid progeny through the ontogenesis.

Materials and methods

The study objects were 24 hybrid families aged 35 years obtained by controlled crossing of Karelian birch onto Karelian birch.

Initial data used to fulfill the task were the results of 35-year investigations into the growth and development of the progeny generalized by decades: I – in 1975 when the plants were 10 years old and phenotypic manifestation of "curly" traits started, II – in 1986 and III – in 1999. Each stem was described by two categorized variables – growth form with values from 1 to 3: high-stemmed (№ 1), low-stemmed (№ 2) and shrub-like (№ 3), and stem surface with values from 4 to 9: with large protuberances and neck (№ 4), with small protuberances (№ 5), tuberculate (№ 6), with stripes (№ 7), with no traces of curly grain (№ 8) and with slightly curly grain (№ 9). Cluster analysis (to group families) and step-wise discriminant analysis (to assess grouping accuracy) were used in searching for the regularities of curly grain manifestation. Pair-wise tabulation tables were used as initial data for multivariate analysis.

Results and discussion

Results of categorized analysis of data on Karelian birch hybrid families revealed a relationship between the growth form and the stem surface.

In the first decade (1975) of plant development, three clusters (groups) and the stem shapes that dominate them as regards centroid values for the variables were singled out for high-stemmed families (fig. A). Step-wise discriminant analysis revealed three discriminators most notably separating the family groups (stem forms №4, №7, №8) (Table 1). The most informative growth form for division into groups, according to the F-test of elimination, discriminator from discriminant functions, is the form with large protuberances and neck (greatest F-test value) followed by the straight-grain and striped forms. Group classification results demonstrated a 100% accurate assignment of families to groups (Table 2). Family groups show statistically reliable pair-wise differences (Table 3).

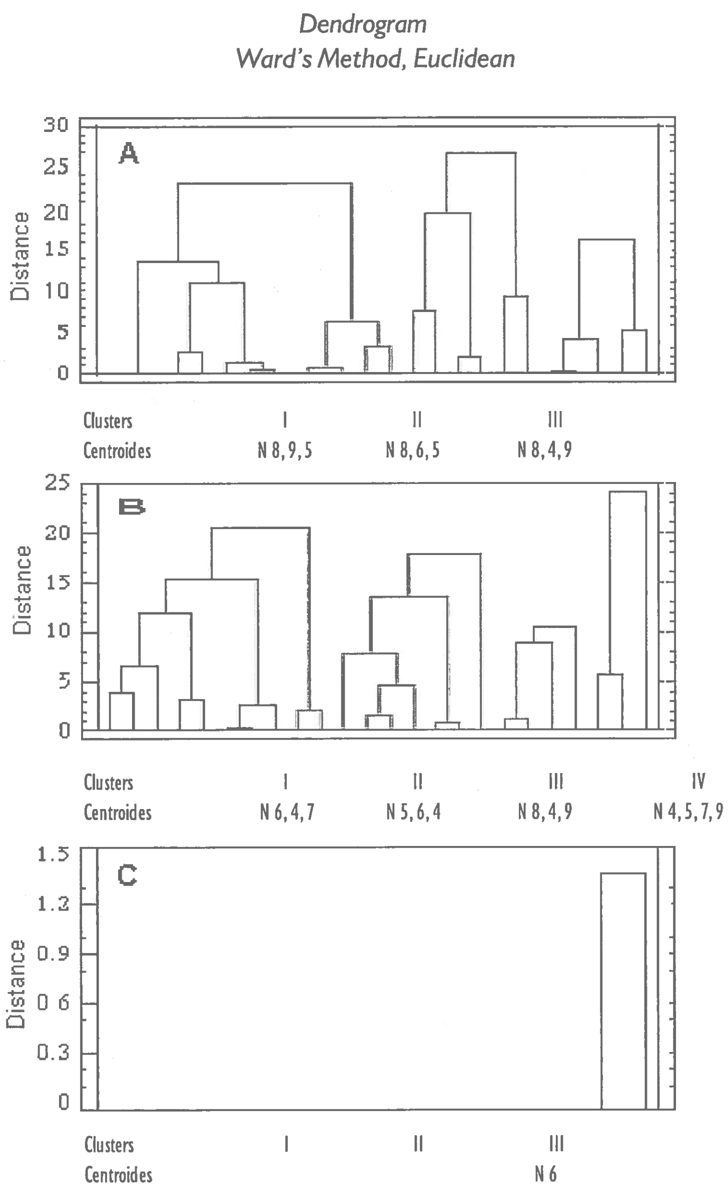

Figure 1. Hybrid family grouping for A – high-stemmed, B – low-stemmed, C – shrub-like.

Classification of families with low-stemmed growth form revealed four groups (fig. B) dominated by distinctly curly forms, and pair-wise discriminant analysis proved the classification to be accurate. The most informative forms as regards the F-test of elimination were the straight-grain, followed by small-protuberance and tuberculate stem shapes.

Family clustering for the shrub-like growth form yielded three groups (Fig. 1 C). The first, most numerous group lacks dominant forms. The dominant position in the second group belongs to the form with large protuberances and neck, and in the third to the tuberculate stem shape. According to stepwise discriminant analysis the stem shape most informative for dividing the three groups is the form with large protuberances and neck.

Thus, phenotypic manifestation of curly grain pattern in Karelian birch starts in the first decade of its development. Clustering showed that high-stemmed growth forms most often had straight grain whereas low-stemmed and shrub-like forms typically had curly grain. The dominant position in most cases belonged to the stem shapes with large protuberances and neck, and with tuberculate surface. The stem shapes occurring most frequently in all growth forms are those with large protuberances and neck, tuberculate, as well as straight-grain forms.

Comparative analysis of the effect of parent plants on the range of manifestation of curly grain and growth forms in the progeny (Table 4) indicated that Karelian birch trees № 115 (20.8%) and № 51 (16.7%) dominated high-stemmed trees.

Table 1. Discriminator selection results

Included discriminators (stem shapes)	F-inclusion statistics	F-inclusion statistics	Note
	First growth form (high-stemmed)		
Large protuberances and neck (N 4)	48.28	46.98	F-enter. = 3.47
Straight-grain (N 8)	13.38	14.11	F-remove = 3.46
Stripes (N 7)	4.96	4.96	
	Second growth form (low-stemmed)		
Straight-grain (N 8)	125.36	114.92	F-enter. = 3.1
Small protuberances (N 5)	7.63	11.87	F-remove = 3.0
Tuberculate (N 6)	11.60	11.60	
	Third growth form (shrub-like)		
Large protuberances and neck (N 4)	225.20	225.20	F-enter. = 3.47
			F-remove = 3.46

Table 2. Group classification matrices

Family groups	accuracy %	No of families in other groups			
		I	II	III	IV
		First (N 1) growth form (high-stemmed)			
I	100	13	0	0	
II	100	0	6	0	
III	100	0	0	5	
Total	100	13	6	5	
		Second (N 2) growth form (low-stemmed)			
I	100	10	0	0	0
II	85,7	1	6	0	0
III	100	0	0	4	0
IV	100	0	0	0	3
Total	95,8	11	6	4	3
		Third (N 3) growth form (shrub-like)			
I	100	13	0	0	
II	100	0	6	0	
III	20	4	0	1	
Total	83,3	17	6	1	

Low-stemmed and shrub-like trees are most frequently affected by the parent trees № 115 (20.9%) and № 60 (208%). When estimating the contribution of pollinator trees on curly grain manifestation in the progeny, strong effect of Karelian birch from joint use of pollen from trees № 24 and № 5 was recorded for high- and low-stemmed trees, and mixture of pollen from trees № 332 and № 102 for shrub-like growth forms. These results can be used in the future to select crossing combinations to obtain hybrid progeny for specific purposes.

Table 3. Results of pair-wise comparison of family groups

Matrix F	Family groups			Tabular F
	I	II	III	
	First (N I) growth form (high-stemmed)			
II	14,53		0	3,19,0,05=3,52
III	31,26	25,36	0	
	Second (N 2) growth form (low-stemmed)			
II	7,8	0	0	3,18,0,05=3,16
III	102,43	91,63	0	
IV	9,16	13,48	60,1	
	Third (N 3) growth form (shrub-like)			
II	431,05			1,21,0.05=4,32
III	3,79	231,95		

Table 4. Contribution (%) of Karelian birch mother plants to curly grain manifestation in the progeny according to growth forms

Clusters	Karelian birch mother plants							
	N 44	N 51	N 60	N 63	N 112	N 115	N 124	N 273
	First (N I) growth form (high-stemmed)							
I	0	12,5	4,2	4,2	8,3	8,3	4,2	12,5
II	8,3	4,2	0	0	0	8,3	4,2	0
III	4,2	0	8,3	4,2	0	4,2	0	0
Total	12,5	16,7	12,5	8,4	8,3	20,8	8,4	12,5
	Second (N 2) growth form (low-stemmed)							
I	4,2	8,3	0	8,3	8,3	4,2	4,2	4,2
II	4,2	0	4,2	0	0	16,7	4,2	0
III	4,2	0	8,3	0	0	0	0	4,2
IV	0	0	8,3	0	0	0	0	4,2
Total	20,8	8,3	20,8	8,3	8,3	20,9	8,4	12,6
	Third (N 3) growth form (shrub-like)							
I	8,3	4,2	8,3	8,2	0	8,3	8,3	8,3
II	4,2	0	12,5	0	4,2	0	0	4,2
III	0	4,2	0	0	4,2	12,5	0	0
Total	12,5	8,4	20,8	8,2	8,4	20,8	8,3	12,5
Grand total	37,6	33,4	54,1	24,9	25	62,5	25,1	37,6

The same procedure was used to classify of the intraspecies diversity of curly grain manifestation in the hybrid progeny in the second (1986) and third (1999) decades of plant development. Analysis showed that in terms of stability of stem shape dominance, the leading position in all growth forms through the 35 years of plant development (1965-99) is occupied by the stem shape with large protuberances and neck. Its dominance is particularly conspicuous in the shrub-like growth form throughout the study period. Then follows the tuberculate form which is most explicit in high- and low-stemmed plants, and very poorly represented in shrub-like forms. Tuberculate form, which appears mainly in all families in plants with the low-stemmed growth form, can also be said to be stable as regards dominance. Straight-grain stem shape is the first dominant only for the high-stemmed form. While estimating the similarity of stem shapes, the weakest degree of manifestation in all families was demonstrated by stems with slightly curly grain, and particularly by those with stripes. As to the frequency of occurrence of curly grain forms in all clusters throughout the study period a conclusion can be made about the uniformity of the families' pair-wise similarity. This uniformity is most probably due to the nature of hybridization.

Clustering covering the whole study period revealed considerable diversity in the structure of similarity of the families with the low-stemmed growth form (4 clusters identified by 1975, 3 by 1996; 3 by 1999); lower diversity in high-stemmed trees (3 clusters in 1975, 1986 and 1999) and poor diversity in shrub-like plants (3 clusters in 1975; 2 both in 1986 and 1999). Tuberculate form was best represented in all families in low-stemmed plants in 1975. Small protuberances were very distinct in high- and low-stemmed plants, and very poorly expressed in shrub-like trees. Stem shape with large protuberances and neck dominated shrub-like growth forms. Straight-grain forms were the dominants as regards centroid values only among high-stemmed growth forms, which was best expressed in 1975-1986, i.e. the second decade of plant development.

Conclusion

Application of multivariate statistical methods to over 30-year phenotypic studies of Karelian birch intraspecies diversity, as regards curly grain heritability, allowed us to relatively accurately identify some patterns in the dynamics of curly grain manifestation dynamics in the progeny. Groups of families with typical dominant stem surface were singled out for different growth forms.

Intraspecies diversity of spruce forests in Karelia

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Introduction

The study of the phenotypic and genetic diversity and the population structure of woody plants, which are of high economic and ecological importance, is one of the principal aspects of biodiversity conservation in forest ecosystems. Moreover, it allows for solution of a number of fundamental problems concerning species selective improvement on the population basis, study of the patterns of intraspecies differentiation and microevolutionary processes.

The territory of Karelia belongs to the zone of introgressive hybridisation of Norway spruce (*Picea abies* (L.) Karsten) and Siberian spruce (*Picea obovata* Ledebour). There mainly grows *Picea* x *fennica* Regel Kom. (Правдин 1975, Щербакова 1975), which together with *P. abies* and *P. obovata* is one of the major species forming the boreal forest, and is of great importance for the economy of the East Fennoscandian countries as well as Republic of Karelia.

This study aims at investigating the phenotypic and genetic diversity, and population structure of *P.* x *fennica* in Karelia in order to provide theoretical substantiation for the measures to preserve the gene pool and selectively improve the species in the region.

Materials and methods

The material (cones) for the analysis was collected from 20 sites in Republic of Karelia and adjacent regions in 1989-90 (Fig. 1). The features, which are of great taxonomic and phylogenetic importance, were chosen as phenotypic markers of the interpopulation structure (Table 1). Single- (calculation of means, variance and repeatability coefficients with their standard errors) and multidimensional (calculation of Machalanobis distance, cluster, factor and discriminant analyses) statistical methods was used to calculate the results.

P. x *fennica* population genetic structure and diversity were investigated by starch gel electrophoresis (Cheliak & Pitel 1984, Conkle et al. 1982, Гончаренко & Потенко 1991) in the Laboratory for Molecular Genetics of the Byelorussian Academy of Sciences Forest Research Institute. Seed material for electrophoresis was collected from seven sampling points (Fig. 1), from a total of 125 trees. To investigate the individual genotype of a tree, 6-8 megagametophytes were sampled randomly from a set of no less than 500 seeds.

Electrophoresis of 15 enzymes (Alcohol dehydrogenase ADH, Aspartate aminotrasferase AAT, Diaphorase DIA, Fluorescent esterase FE, Glutamate dehydrogenase GDH, Hexokinase HE, Isocitrate dehydrogenase IDH, Leucine aminopeptidase LAP, Malate dehydrogenase MDH, Malic enzyme ME, Phosphoglucomutase PGM, 6-Phosphogluconate dehydrogenase 6-PGD, Phosphoglucose isomerase GPI, Shikimate dehydrogenase SKDH, Sorbitol dehydrogenase SDH) was conducted in three buffer systems (Гончаренко & Потенко 1990, Гончаренко et al. 1989). Recipes for histochemical enzyme staining followed the standard methods (Cheliak & Pitel 1984, Conkle et al. 1982) with insignificant modifications. Alleles were discriminated as described by Prakash et al. (1969). The principal parameters were calculated to investigate the genetic variation, diversity and differentiation of *P.* x *fennica* populations.

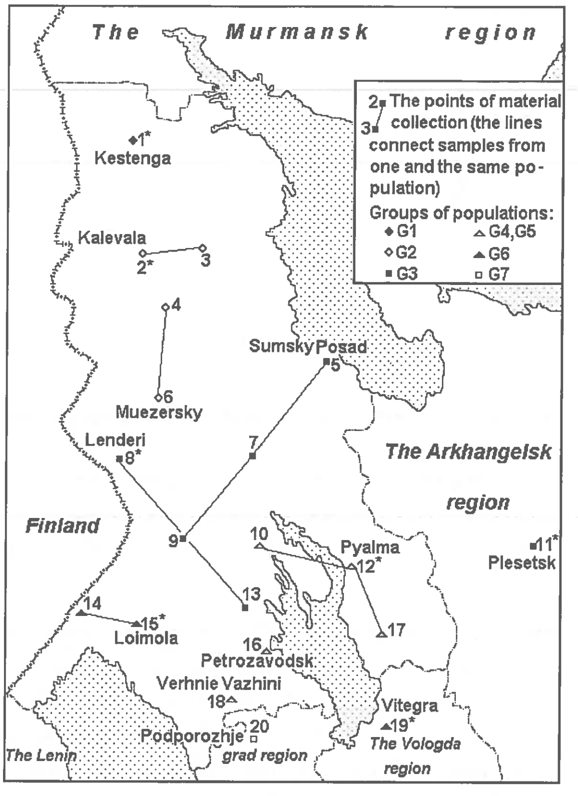

*Fig. 1. Location of the sampling points and populations of P. x fennica in Karelia. The sampling points for isoenzyme analysis are marked by *.*

Results and discussion

When the phenotypic variation of *P.* x *fennica* in Karelia was studied it was found that individual variability of cone and seed traits is characterized by middle and low levels of variation by Mamaev's scale (Мамаев 1973), Cv ranged from 9.6% to 28.2%. Endogenic variability of most traits is lower than individual variability (Cv ranged from 5.4% to 23.9%). Ecological-geographical variability has the least variation coefficients (Cv ranged from 4.5% to 23.2%). This proportion of the variation sources allows to assume that the characteristics of generative organs of *P.* x *fennica* in Karelia are under strong genotyping control.

Indirect evaluation of heritability using repeatability coefficient demonstrated that all investigated traits were largely genetically predetermined (R ranged from 0.53 to 0.68), which agrees well with the results of the analysis of variance.

Machalanobis distances (D^2) were calculated to study the population structure using all investigated traits. The results of the calculations show a low level of differentiation between neighbouring stands. D^2 values were clustered using the unweighted pair group method UPGMA (Fig. 2).

After the first step of clustering one can see that the neighbouring samples join into individual clusters. It is however not yet a reliable criterion to determine whether the two stands belong to the same or to different populations. We assumed that the stands belonged to the same population when the Machalanobis distance between them was not statistically significant (0.01 level). Using the cluster analysis, *P.* x *fennica* in the studied area is shown to be differentiated into twelve phenotypically different local populations (Fig. 1, 2): Kestenga (1Ks), Kalevala (2Kl), Muezersky (3Mz), Central Karelian (4CK), Plesetsk (5Pl), Lendery (6Ld), Zaonezhskaya (7Zon), Petrozavodsk (8Pt), Verhnie Vazhiny (9Vv), Loimola (10Lm), Vytegra (11Vt) and Podporozhje (12Pdp).

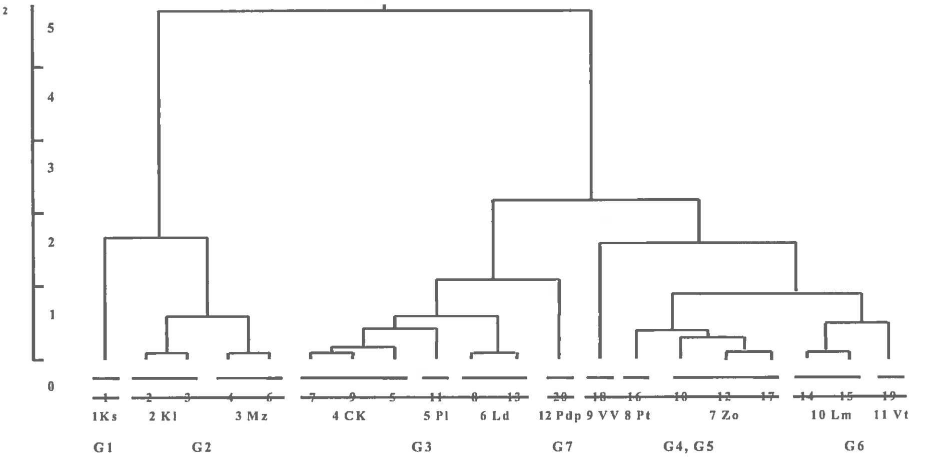

Fig. 2. The dendrogram based on Machalanobis distance for the investigated populations of P. x fennica ($F_{0,01}$=0,33); 1,.., 20 – the numbers of sampling points; 1Ks, ..., 12Pdp – abbreviations of the populations; G1,...,G7 – the groups of the populations

After the second step of clustering the neighbouring populations join into seven groups (G1-G7). Populations from the same group are phenotypically alike and grow under similar environmental conditions. These groups probably correspond to population groups. The populations 1Ks and 12Pdp stand out for high Machalanobis distance from other populations, and they were chosen as individual groups G1 and G7, respectively.

It is recommended that cluster analysis is combined with factor and discriminant analyses since the application of different techniques raises the reliability of classification (Факторный анализ... 1992). Factor analysis, that reflects hidden regularity of interconnections between features, indicated that all investigated traits could be grouped into two factors (Table 1). The contributions of the former and latter factors to the complete variance of the features are approximately equal comprising 76.8% in total. The first factor makes a larger contribution to the complete variance of the features (43.95%) than the second one, and has considerable positive loading estimations of the features, the combination of which characterizes the shape of cone scale and elongation of its top, and is one of the main indicators used in the intraspecies taxonomy of Norway spruce. The second factor is described by the variables with positive loading estimations – X1, X2, X4-X7 (Table 1). This combination of the features reflecting absolute parameters of cones and seeds can be interpreted as a characteristic of generative organs.

Table 1. Interrelations of the features and their grouping into factors.

Features	Factor loadings F_1	F_2
Cone lenght (X1)	- 0,02	1,01
Cone diameter (X2)	-0,12	0,84
Coefficient of the cone shape (X3)	-0,08	-0,78
Cone weight (X4)	0,04	0,91
Weight of 1000 seeds (X5)	-0,06	0,82
Lenght of the seed with a wing (X6)	0,20	0,79
Width of the scale at the widest point (X7)	0,31	0,57
Lenght of cone scale (X8)	0,82	0,27
Coefficient of the scale shape (X9)	0,90	-0,04
Coefficient of the cone tip elongation (X10)	0,52	-0,02
Contribution to the complete variance of the features, %	43,95	32,85

In the space of the two factors F1 and F2 the samples fell into seven groups (Fig. 3) which corresponded to groups of populations. It should be pointed out (Fig. 3) that both factors grew more pronounced from north to south (Fig. 3). In other words, cone and seed size and the extension of the cone scale tip in the populations increased from north to south. The diagram shows that the composition of the groups did not change, which proves the accuracy of the classification made with the help of cluster analysis.

Homogeneity of the identified population groups and distinctions between them were estimated using discriminant analysis. The F-matrix obtained with the help of discriminant analysis indicates the degree of distinctions between the stand groups found (Table 2). It follows from Table 2 that the distinctions between the groups are statistically significant (0.01 level) except for some cases.

It is known that the shape of cone scales is the basic characteristic for distinguishing between *P. abies*, *P.* x *fennica* and *P. obovata*. It would be interesting to determine the form structure of *P.* x *fennica* populations by the type of cone scale shape (Fig. 4). As seen from the diagram, the percentage of trees with the cone types "abies" and "fennica" increased from northern to southern populations. The "obovata" trees are not numerous even in the northernmost population 1Ks and are absent from southern populations. Thus, *P.* x *fennica* in Karelia is genetically more closely affiliated to *P. abies* than to *P. obovata*.

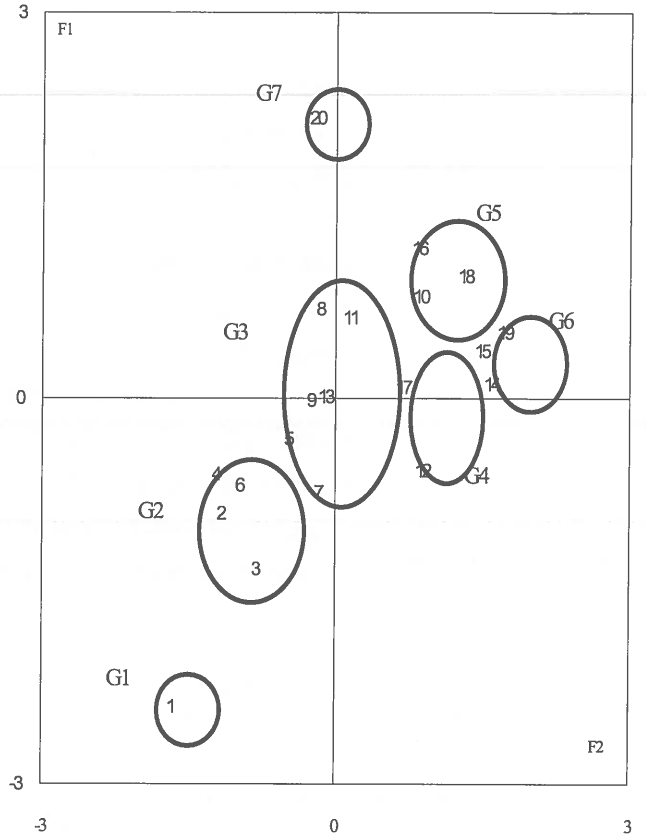

Fig. 3. Arrangement of the population samples (1, 2, ..., 20) in the space of the factors F1 and F2. The group of populations are G1, ..., G7.

Table 2. F- matrix (comparison of groups in pairs)

Groups	G1	G2	G3	G4	G5	G6
G2	7,60					
G3	48,90	47,70				
G4	103,30	116,60	35,30			
G5	135,00	184,00	69,90	1,24		
G6	208,00	316,00	166,00	21,50	15,5	
G7	24,25	11,98	0,30	20,05	31,70	70,80

F_{05}=3,59

Variability of morphological features along the geographic (and climatic) gradient was recorded for other conifers as well (Мамаев 1973, Правдин 1975, Путенихин 1993). A similar phenomenon is intrinsic to species with a continuous population system occupying a wide area with gradually changing environmental conditions (Grant 1981) and this allows to assume that natural selection is the one of the main evolutionary factors determining the population structure of *P.* x *fennica* in Karelia. Moreover the direction in which spruce was colonizing the region in the postglacial period coincides with the gradient of interpopulation variability of features studied by us (Правдин 1975, Щербакова 1975). Therefore the events connected with the last glaciation and also the processes of introgressive hybridization were other possible factors in *P.* x *fennica* evolution.

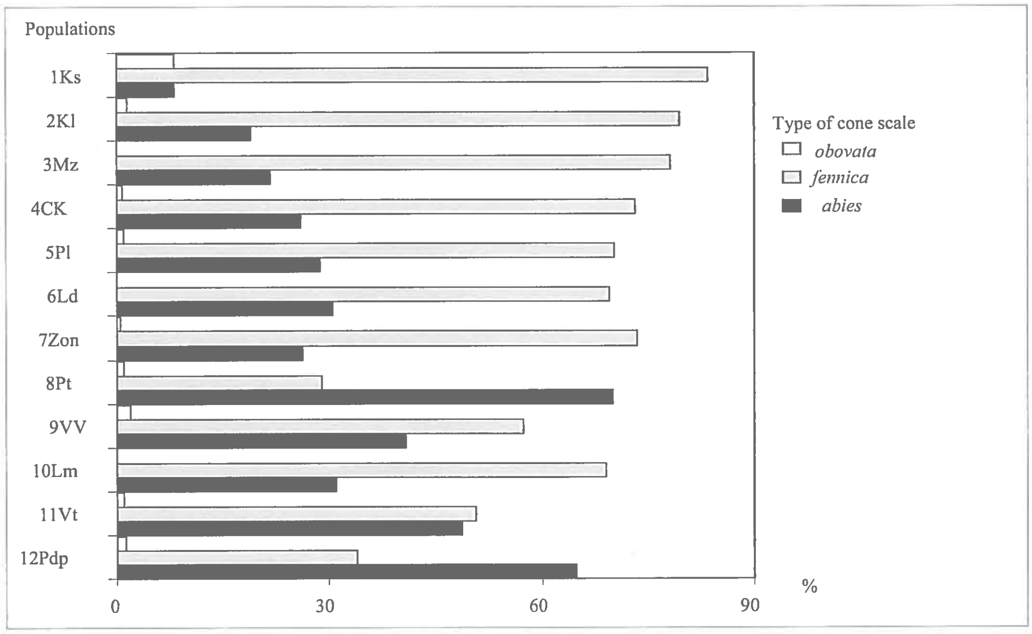

Fig. 4. Form structure (by type of cone scale) of the P. x fennica populations in Karelia; 1Ks,..., 12Pdp – abbreviations of the populations

Table 3. Allelic variants at 25 loci found in *P. x fennica*

Locus	Allele
Aat-1	1,00; 1,10
Aat-2	0,30*; 0,65; 1,00
Adh	1
Gdh	0,75; 1,00
Idh-1	0***; 1,00; 1,10
Idh-2	1
Mdh-1	1
Mdh-2	0,80***; 1,00
Mdh-3	0***; 1,00; 1,15; 1,30
Sdh	0,95; 1,00; 1,05*
Skdh	1,00; 1,05**
6-Pgd-1	0,90; 1,00; 1,10
6-Pgd-2	0,65; 0,85; 1,00
6-Pgd-3	0,50*; 1,00
Lap-1	0; 0,94*; 1,00;1,04; 1,00/1,04**;1,10*
Lap-2	0,95; 1,00; 1,05; 1,10*
Pgm-1	0,90*; 1,00
Pgm-2	0,85*; 1,00; 1,15*
Hk	0,90*; 1,00; 1,10*
Me	0,10*; 0,60;
Dia-1	0*; 0,80***; 1,00
Dia-2	0,70**; 1,00; 1,30
Dia-4	1,00; 1,10; 1,15**; 1,50***
Gpi	0,80*; 1,00; 1,25
Fe	0,70**; 1,00; 1,30

*Alleles common on with *P. abies*; **alleles common on with *P. obovata*; *** alleles found only in *P. x fennica*

Electrophoretic analysis revealed 70 allelic variants at 25 loci (Table 3). Allelic frequencies were used to calculate the main parameters of genetic variability. It is obvious from Table 4 that the values of variability of each population do not differ significantly from each other. Thus, on the basis of the data obtained, we can say that about 64% of loci in P. x fennica populations in Karelia are polymorphic and, on average, each tree is heterozygous in 19.2 % of its gene loci. On the whole, the level of genetic variability of P. x fennica populations is similar to that of P. abies and P. obovata (Гончаренко & Потенко 1990, 1991).

The genetic structure of *P. x fennica* was analysed with the help of Nei's *G*-statistic and Wright's *F*-statistic (Nei 1975, Guries & Ledig 1982). One can see from Table 5 that F_{IS} and F_{IT} have negative average values (3.6% and 1.0%, respectively), indicating a slight excess of the observed heterozygotes relative to the Hardy-Weinberg ratio for *P. x fennica* in total. F_{ST} mean was equal to 0.025. In other words, more than 97% of the total variation is contained within each *P. x fennica* population while only 2.5% is due to interpopulation variation. The other parameter G_{ST} is equivalent to the parameter F_{ST} and practically does not differ from it (Table 5). It is evident from the genetic structure analysis of seven populations that there is no true differentiation between the populations and free gene exchange is going on between them.

Table 4. Genetic variation in populations of *P.* x *fennica*

Population	n	P_{95}, %	P_{99}, %	He	Ho	A
1Ks	25	40,00	60,00	0,179	0,178	1,88
2Kl	25	44,00	68,00	0,201	0,222	2,00
6Ld	25	40,00	64,00	0,170	0,174	2,00
5Pl	25	48,00	56,00	0,180	0,205	1,84
7Zon	25	44,00	68,00	0,179	0,204	2,04
10Lm	25	44,00	72,00	0,177	0,189	2,04
11Vt	25	48,00	60,00	0,182	0,176	1,92
Average	175	44,00	64,00	0,182	0,192	1,96

n – namber of trees analysed for a locus; P_{95},, P_{99}–percentage of poly-morphic loci at the 95 or 99% criteria; He – expected heterozygosity; Ho – observed heterozygo-sity; A – mean number of allels per locus

Genetic similarity between *P.* x *fennica* populations was quantified using Nei's genetic distance coefficient D_N (Nei 1972). The degree of similarity of the studied populations of *P.* x *fennica* in Karelia is visualised by the dendrogram (Fig. 5) constructed using the UPGMA-method. It is obvious from the dendrogram that D_N is no greater than 0.016. Such minor differentiation (less than 2%), proves once again that the seven populations studied are very closely related and there is free gene exchange between them.

Thus, the results of the investigations of phenotypic and genetic diversity of *P.* x *fennica* in Karelia have shown that the characteristics of generative organs are under strong genotyping control. *P.* x *fennica* is differentiated by the morphological features of generative organs into twelve local populations. Natural selection, processes of introgressive hybridization and the events connected with the last glaciation are the main factors determining the population structure of *P.* x *fennica* in Karelia. *P.* x *fennica* in Karelia is genetically more closely affiliated to *P. abies* than to *P. obovata*, and its populations have a high level of genetic variability and a common gene pool, and intensive exchange of genes takes place between them.

Table 5. Estimates of FIS, FIT, FST and GST in *P. x fennica*

Locus	F_{IS}	F_{IT}	F_{ST}	G_{ST}
Aat-1	-0,014	0,001	0,014	0,014
Aat-2	-0,066	-0,052	0,013	0,012
Adh	0,000	0,000	0,000	0,000
Gdh	0,096	0,124	0,031	0,031
Idh-1	-0,063	-0,04	0,021	0,024
Idh-2	0,000	0,000	0,000	0,000
Mdh-1	0,000	0,000	0,000	0,000
Mdh-2	-0,003	0,014	0,017	0,017
Mdh-3	-0,015	-0,002	0,013	0,011
Sdh	-0,087	-0,019	0,063	0,056
Skdh	-0,008	0,029	0,037	0,037
6-Pgd-1	-0,005	0,012	0,016	0,016
6-Pgd-2	-0,095	-0,054	0,038	0,03
6-Pgd-3	-0,166	-0,142	0,020	0,020
Lap-1	-0,092	-0,056	0,033	0,035
Lap-2	-0,108	-0,073	0,031	0,034
Pgm-1	-0,018	0,007	0,024	0,021
Pgm-2	-0,009	0,003	0,013	0,013
Hk	-0,032	-0,002	0,029	0,034
Me	-0,066	-0,045	0,020	0,020
Dia-1	-0,017	0,02	0,037	0,036
Dia-2	-0,010	0,011	0,021	0,021
Dia-4	-0,104	-0,069	0,032	0,042
Gpi	-0,016	0,074	0,089	0,123
Fe	-0,008	0,007	0,014	0,014
Average	-0,036	-0,01	0,025	0,026

* F_{IS}, F_{IT}, F_{ST} – values of Wright's F-statistics, G_{ST} – values of Nei's G- statistics [7, 10]

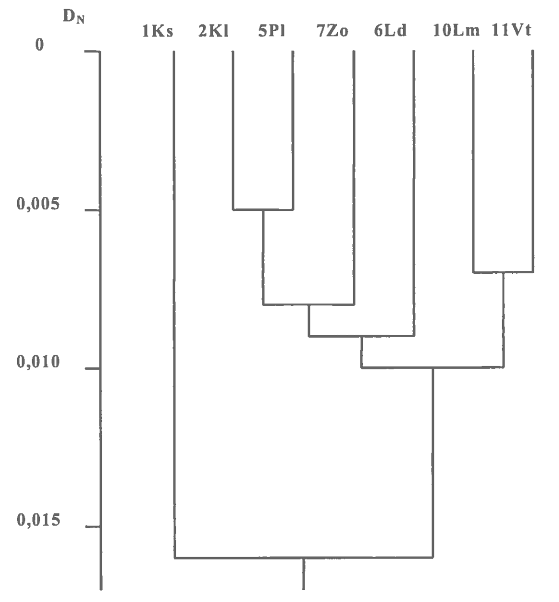

Fig. 5. Dendrogram showing the clustering of the seven natural populations of P. x fennica based on Nei's genetic distance coefficient (D_N);

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Morphometric analysis of species characters in Picea phylum in North Karelia

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Introduction

As it is well known, the biodiversity is based on genetic diversity. To estimate the latter on molecular, cytogenetic, biochemical or morphological levels one can use different methods. Morphometric analysis also can be practiced to investigate diversity of Picea species because the biodiversity of the boreal forests consist of coniferous predominantly.

The current variability of spruces in North Karelia is determined by the existence of three different species. They are Common spruce (*Picea abies*), Siberian spruce (*Picea obovata*) and Finnish spruce (*Picea fennica*) by one opinion (Миняев et al. 1981), and two species *P. abies, P. obovata* and hybrid form *P. fennica* by another (Раменская & Андреева 1982). Taxonomists use to discuss several traits that usually belong to each of these species. As a rule they determine the size of spruce-cone, the number of seed scales, the length of pine needles, the form of spruce crown, the type of branching, cone color, seed scales form and current annual increment. All the mentioned traits are firmly variable and, nevertheless, they are often used in species identification. In addition to morphological characters it was shown that *P. abies* and *P. obovata* have 24 chromosomes in diploid cells and they are not morphologically differed. However, *P. obovata* has B-chromosomes within 20-25% of metaphase plates. Beside this, both species have different curves of chromosome spiralization and different pattern of esterase forms on protein electrophoresis. Among these characters, a seed scale form is recommended as a systematic criterion in the vascular plants guide of Murmansk region. According to another opinions (Правдин 1975, Мамаев & Попов 1989), each spruce species has its own index that is 0,7 for *Picea obovata* and 1,3 for *Picea abies*. Seed scale index for *Picea fennica* is intermediate.

The goal of the present work was the investigation of the spruces in North Karelia concerning their systematic position.

Methodology

To estimate the variance of the main systematic character we have analyzed trees by two approaches.

The first one - we took one cone from one spruce, calculated the index between length and width and performed ordinary statistics procedure to evaluate parameters of distributions.

The second way in variance estimating dealt with the comparison of inter- and intra-individual variability. We have investigated ten scales in each of four cones from one of the 22 trees. Then we performed ordinary two-way analysis of variances.

Results and discussion

Results of analysis of one cone per tree (n=340) are presented in Fig 1. All spruces according to their indexes have disintegrated in two groups. First distribution is Gaussian and the second one has two peaks. However, both groups have similar variability. Statistic analysis depicts second distribution as the sum of two Gaussian plots. Finally, all the samples of spruces can be statistically divided into three groups having normal distribution of seed scale index within each one. These theoretical plots are presented in Fig 2. Their means are 1,2 (n=129), 1,5 (n=198) and 1,9 (n=13). These means seemed to correspond to *P. obovata, P. fennica* and *P. abies*. We must point out, that scale index of *P. obovata* from Siberia was counted to be 0.7 - 0.9 (Мамаев & Попов 1989), which is significantly lower than in North Karelia.

Figure 1. Empirical distributions of scales index obtained from analysis of one cone from one tree (n=340).

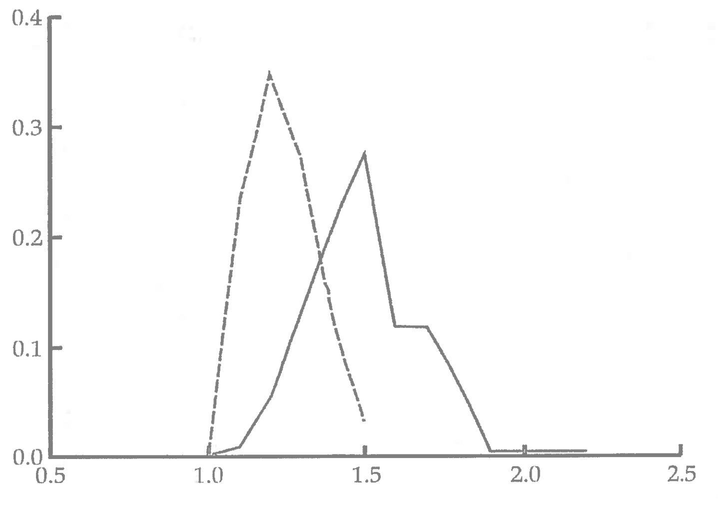
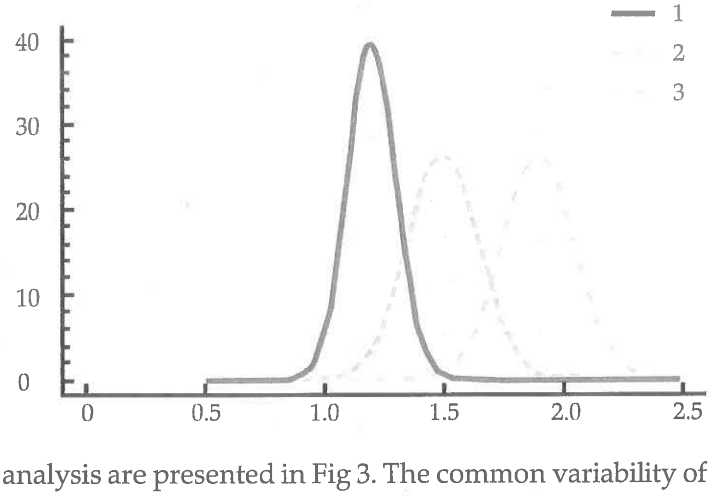


Figure 2. Approximation of empirical distributions by theoretical Gaussian distributions.



Results of second approach analysis are presented in Fig 3. The common variability of the seed scale index consists of 27% of variability between cones, 31% of the variability between trees and the most variability is 42% that shows intra individual variability. In addition, crown form and cone morphology of each of these spruces was also described and visual determination of the species was undertaken (Table 1.). Statistical analysis has differentiated two clusters of spruces. The first one consists of 21 trees in 8 groups with continuous variability and without significant distances between neighbor groups. The second cluster includes only one tree with scale index equal to 1.37. Thus, there was no correlation between statistical and visual detection of the species.

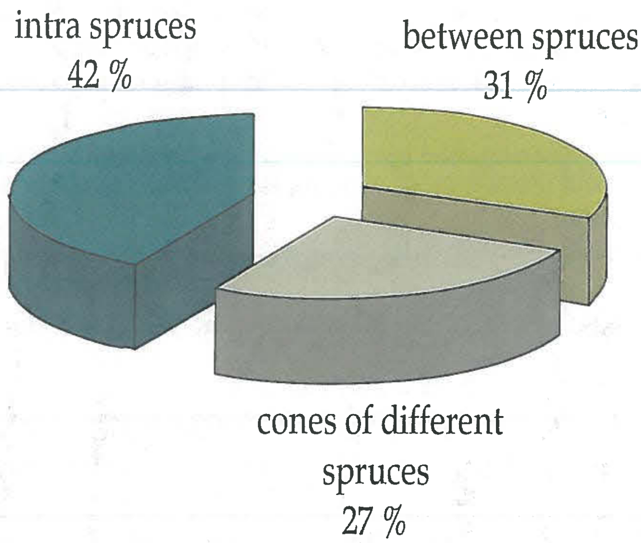


Figure 3. Components of common variability of scales index (results of two way analysis of variance).

Therefore, the variability of seed scale index by itself is small (0,95 - 1,37). Nevertheless, this small range hides enormous variability between spruces, cones and scales. The most surprising fact is that the variability in one individual is the largest in common variability of seed scale indexes. Obtained data again show that intra species variability can be compared with inter species variability.

Classic scheme of geographical speciation (Dobzhansky 1951) supposed the division of initial unit areal to several parts as first step. In all isolates evolutionary processes would have some peculiarities. Consequently, new ecotypes or ecological races may be formed.

Table 1. Results of visual and statistic differentiation of trees by measurement of scale index.

Tree	Index	Group									Differentiation	
		1	2	3	4	5	6	7	8	9	Statistic	Visual
6	0.95	X									"?"	"O"
14	0.98	X	X								"?"	"O"
15	0.99	X	X								"?"	"O"
9	1.04		X	X							"?"	"F"
7	1.04		X	X							"?"	"O"
5	1.07			X	X						"?"	"F"
17	1.11			X	X	X					"?"	"O"
18	1.11			X	X	X					"?"	"O"
8	1.13				X	X	X				"?"	"F"
13	1.16					X	X				"?"	"O"
3	1.15					X	X	X			"?"	"F"
16	1.16					X	X	X			"?"	"O"
10	1.17					X	X	X			"?"	"F"
11	1.19						X	X	X		"?"	"A"
12	1.19						X	X	X		"?"	"A"
2	1.19							X	X		"?"	"F"
21	1.21							X	X		"?"	"A"
1	1.21								X		"?"	"F"
22	1.24								X		"?"	"A"
19	1.25								X		"?"	"A"
4	1.25								X		"?"	"A"
20	1.37									X	"A"	"A"

Labels in table: X - membership of a tree to group, X - membership of a tree to group, "O" - P. obovata, "F" - P. fennica, "A" - P. abies.

After disappearing of the isolation threshold there are two possibilities for further development. In one case the viability of hybrids will be lower than in both parents. Natural selection should eliminate such individuals and its population go extinct. Then, we will see two new species.

If the viability of hybrids excesses those in both parents, the genofounds of two or more forms will mix, and we should return to initial situation with one species. In the best case, we would deal with several ecological races.

Because of coniferous biological peculiarities (long generation time and low differential survival), the current biodiversity is provided only with combinative variability. The time period that passed after the glacial period was not enough to form reproductive isolation.

Hence, in North Karelia we observe the evolutionary process, which was predicted earlier by Theodosius Dobzhansky (1951), the former assistant professor of the St.-Petersburg Department of genetics and then – geneticist number one in USA and all over the world.

According to his views, we are dealing with one *Picea* species with enormous variability because of introgressive hybridization between *P. obovata* and *P. abies* accompanied with excess of hybrid viability and strength.

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Use of the biodiversity of the genus Vaccinium for breeding

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Introduction

Plant species with a large distribution area often have several forms that can differ essentially from each other. By 'form' we mean "any distinct variant within a species", and by 'variety', "a group of individuals that differ distinctly from but can interbreed with other varieties of the same species; the characteristics of a variety are genetically inherited" (Martin et al., 1996, pp. 209 and 529, respectively).

Variability occurring in natural populations of the *Vacciniacea* family has for decades been used in breeding varieties of cranberry and high-bush blueberry in North America. Variability in lingonberry populations was noticed at the beginning of the last century by Braun-Blanquet (1926), who distinguished five forms:
(i) Vaccinium vitis-idaea f. *macrophyllum* (Hausm. apud Dalla Torres et Sarnth. pro var.);
(ii) V. vitis-idaea f. *longiflorum* (Hausm. apud Dalla Torres et Sarnth. pro var.);
(iii) V. vitis-idaea f. *ellipticum* (F.ger.);
(iv) V. vitis-idaea f. *leucocarpum* (Ascher. et Magn. pro var.);
(v) V. vitis-idaea f. *microcarpum* (Hausskn. pro var.).

Very soon after that, Синская & Щенкова (1928) described three additional varieties (in that time synonymus to 'form') in Russia:
(i) *V. vitis-idaea* var. *leucocarpum* (Ascher. et Magn.) – a form with white berries;
(ii) *V. vitis-idaea* var. *genuinum* Herd. – height of ramets 10-25 cm, leaves elliptical, flowers light pink, 4-8 (15) in cluster, occurring mainly in the forest zone;
(iii) *V. vitis-idaea* var. *pumilum* Hornem. (var. *microphyllum* Herd., var. *pulchellum* Fisch., ssp. *minor* (Lodd.) Hulten) – height of ramets 2.5-7 cm, leaves small, round, flowers reddish, 1-4 in a cluster, distributed in tundra areas and in highlands.

The last two varieties were for decades considered to be ecotypes until, at the beginnig of 1980s, Черепанов (1981) and Мазуренко (1982) recognized the var. *pumilum* as an independent species *Vaccinium minus* (Avr.) Worosh. *V.vitis-idaea* var. *genuinum* was interpreted as species *sensu lato*, while *V. vitis-idaea* var. *leucocarpum* was treated on the level of variety. Holloway & Stushnoff (1983) demonstrated that *V. vitis-idaea* and *V. minus* also have certain differences in physiology.

In fact, the morpology of both species, *V. vitis–idaea* s.l. as well as *V. minus*, are in their turn largely variable. These species often show a great deal of variation in the height of ramets, shape of leaves and fruits, in the color of flowers and fruits. It has also been observed that some parts of populations are in almost all years more fruitful than others (Paal & Paal 1989). Still, neither the amplitude of morphological variation nor the constancy of character differences has been studied properly yet. At the same time the selection of forms with desirable characteristics has a fundamental importance for lingonberry breeding. In this case, besides plant fruitfulness and berry ripening time, ramets habitus, their ability to produce shoots, etc. should also be considered (Gustavsson 1997).

The aim of our study was to test: are the visually distinguishable lingonberry forms inside a comparatively restricted area hereditarily fixed or not, i.e. should they be interpreted as varieties or as forms.

Methods

The sample area was located in north-western Estonia (Vihterpalu forest district) in a *Vaccinium*-type pine forest growing on old sand dunes. We established a plot of about 25x25 m there for sampling, where it was possible to distinguish visually – mainly according to height and leaf shape – five forms of lingonberry (Table 1).

Table 1. Characteristics of lingonberry forms in wild and their cuttings rooting percentage.

Form	Height, cm	Length of a leaf, mm	Widthof a leaf, mm	Ratio of leaf length and with	Rooting percentage
1	40	2.37 ± 0.08	0.92 ± 0.03	2.5	48.4
2	40	2.84 ± 0.05	1.00 ± 0.02	2.8	82.7
3	35	2.74 ± 0.07	1.17 ± 0.03	2.3	36.8
4	35	2.75 ± 0.07	1.30 ± 0.04	2.1	60.8
5	30	2.09 ± 0.06	1.11 ± 0.03	1.8	71.8

For the experiment, from the ramets of every form, only those having approximately the same age (two years) were used. From these ramets cuttings were taken at the beginning of May, 75 for every form. They were randomly divided between three replicates, each including 25 cuttings, and planted the next day into boxes with peat substrate. Boxes with cuttings were placed in a plastic greenhouse and the peat substrate was kept permanently moist.

At the end of September three parameters were measured: height of plants developed from cuttings, diameter of their root ball, and number of shoots. For data processing, variance analysis was used.

Results and discussion

Lingonberry forms selected in the field, having prolonged leaves, seem to be taller than those with round leaves (Table 1). The rooting percentage of cuttings taken from different forms was rather variable, from 36.8% to 82.7% and we can not detect any tendency for this parameter to depend on plant height or leaf shape.

The spreading abilities and growth parameters of genotypically different lingonberry plants (varieties) are rather diverse (Hjalmarsson & Ortiz 1998). Besides the genotype, lingonberry habitus, especially height, depends very much also on environmental factors (e.g. Lehmushovi & Hiirsalmi 1973, Пааль & Пааль 1989, Hjalmarsson & Ortiz 1998). In our trial all cuttings were grown in similar conditions, and thus we can discount the influence of environmental factors.

During cultivation the cuttings from the first two forms, with the most prolonged leaves (forms 1 and 2, Table 1), grew taller than the cuttings with more round leaves; they developed a bigger root ball, but not more shoots, than forms with round leaves (Fig. 1). According to visual estimations, all forms retained the same leaf shape during cultivation as in the wild.

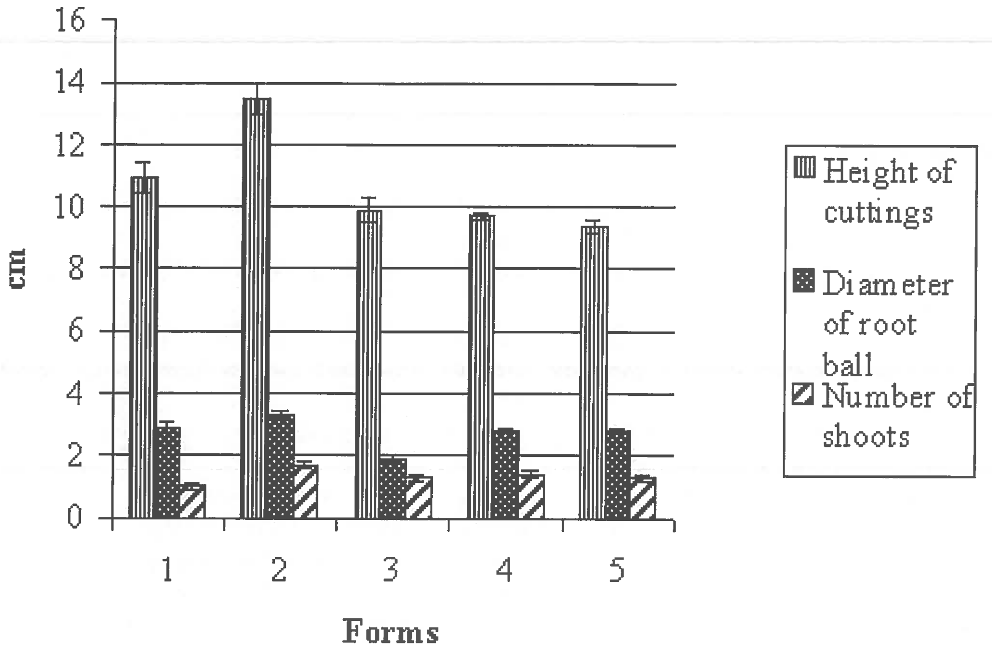

Figure 1. Developing of cuttings of different lingonberry forms.

Testing of the significance of differences between lingonberry forms according to the height of cultivated plants and according to their root ball diameter (Table 2) confirmed that both parameters depend clearly on the factor 'form'. The only factor in the trial, that can have an influence similar to environmental factors in the field, was the position of cultivated cuttings in the box. Therefore, this influence was taken into account by the analysis as a second factor and separated in that way from the effect of factor 'form'.

Table 2. Evaluation of development of cuttings of five lingonberry forms by variance analyse. F – value of F-criterion, p – level of significance

Factor	F	p
	Parameter: height of cuttings	
1. Place of cuttings in box	4.06	0.0001
2. Form	6.69	0.0002
	Parameter: diameter of root ball	
1. Place of cuttings in box	3.97	0.0001
2. Form	4.14	0.0059
	Parameter: number of shoots	
1. Place of cuttings in box	4.30	0.0001
2. Form	4.64	0.0031

On the basis of our results we can conclude that several characteristics of wild lingonberry forms, such as height, shape of leaves, as well as propagation abilities like increment and branching rate, and root ball development, are often genetically inheritated. Of course, due to the restricted material and scope of the trial we can not extrapolate these results very broadly yet, but they can stimulate further research in this direction.

Acknowledgement

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Phylogenetic diversity of Archaea in boreal forest soil and freshwater

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Objectives

The two main objectives were to describe the phylogenetic diversity of *Archaea* in boreal forest soil and freshwater, and to find out, whether anthropogenic changes in the environment have any effect on it.

Methodology

Samples were collected from 5 sites: 1) soil from Suomussalmi, experimental forest site managed by Finnish Forest Research Institute, three sampling sites: A, clear-cut, B, treated with clear-cutting and prescribed burning, and C, control standing forest; 2) water from three lakes in Evo forest area, Valkea Kotinen (mesohumic), Mekkojärvi (brown humic), Syrjänalunen (clear); 3) sediment from lake Valkea Kotinen; 4) forest soil from the water catchment area of lake Valkea Kotinen; and 5) forest soil from sites with heavy metal precipitation gradient close to Harjavalta melting plant. Soil samples were composites each consisting of a mixture from 20 subsamples. Lake samples were from the surface down to 7 m in 0.5 m intervals. Sediment samples were from upper sediment layer down to 40 cm in 2 cm intervals. Suomussalmi and Evo sampling sites have been described earlier by Pietikäinen and Fritze 1995, and Jurgens et al. 2000, correspondingly.

DNA was extracted and purified (Jurgens et al. 1997, Jurgens et al. 2000). DNA samples were prepared and analyzed, mostly, in the following order: 1) PCR amplification of 16S rDNA, 2) checking out the quality of the PCR products, 3) preliminary Restriction Fragment Length Polymorphism (RFLP) analysis in conjunction to Southern blot hybridization with basic probes for confirmative recognition of *Archaea*, 4) cloning of individual PCR products, 5) exact RFLP analysis with Southern blot hybridization using specific probes, 6) sequencing of clones representing the most characteristic RFLP-Southern blot profiles, 7) phylogenetic analyses of the sequences against international sequence databases, 8) design of new PCR primers and probes for Southern hybridization and in situ hybridization, 9) repetition of steps 1-8, 10) Fluorescent In Situ Hybridization (FISH) experiments with water samples, and 11) Denaturing Gradient Gel Electrophoresis (DGGE) (Jurgens et al. 1997, Jurgens and Saano 1999, Jurgens et al. 2000).

DGGE has been used to resolve PCR-amplified regions of genes based solely on differences in nucleotide sequence. This has proven to be a simple approach to obtain profiles of microbial communities that can be used to identify temporal or spatial differences in community structure. Since each DNA fragment in the profile is likely to be derived from one (or few) phylogenetically distinct populations, one can readily obtain an estimate of species number and abundance based on the number and intensity of amplified fragments in the profile. It has also been possible to infer the phylogeny of community members by DNA sequence analysis of amplified fragments after they have been sequenced (Øvreås et al. 1997).

Results

Soil samples

We found a previously undescribed terrestrial group of low-temperature *Archaea* in intact boreal forest soil samples. 138 clones were analyzed by RFLP-Southern blot hybridization, from which 15 clones were chosen for sequencing. The phylogenetic analysis of the 900 nucleotide long 16S rRNA gene sequences revealed that they formed a new cluster within the *Crenarchaeota* kingdom, which was only distantly related to *Crenarchaeota* 16S rRNA gene sequences described by others. This finding was one of the first reports on existence of the terrestrial low-temperature *Archaea* and gave us

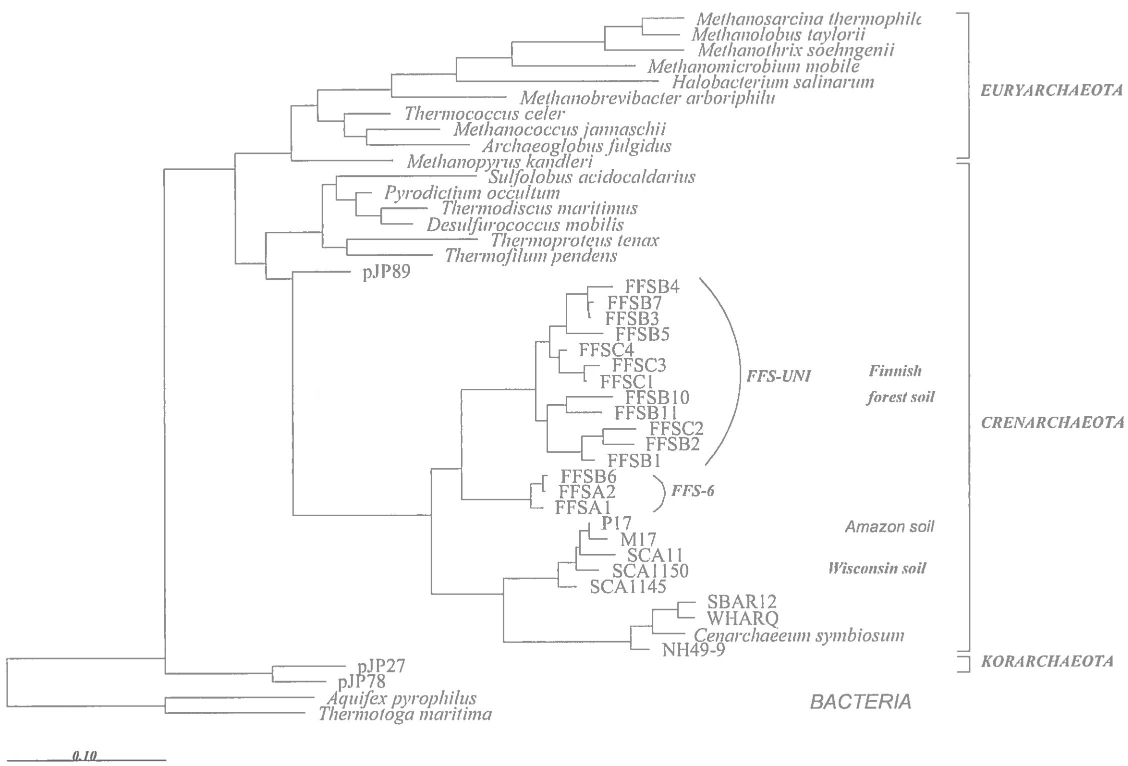

Figure 1. Phylogenetic tree, inferred by maximum-likelihood analysis showing the phylogenetic relations of sequences from Amazon and Wisconsin soils and two groups of Finnish forest soil sequences. FFS-Uni and FFS-6 mark two subgroups of sequences, which hybridize with FFS-Uni and FFS-6 probes, respectively. The probes were designed in this study. The scale bar represents the number of substitutions per one nucleotide.

strong background for a more comprehensive study of the molecular ecology of *Archaea* in low-temperature environments such as soil, sediment and water. As a following step, two additional soil samples were studied in the same manner and all three groups of obtained sequences were compared by RFLP - DNA-hybridizations and phylogenetic analysis. It was discovered that the clones from soils A and B are similar and differ from the clones isolated from the control soil C. Both the RFLP-hybridization study of the clones and phylogenetic analysis of selected sequences from all three types of soil supported the division of the new *Crenarchaeota* into two subgroups (Fig. 1).

Water samples

For each of the three lakes, Valkea Kotinen, Mekkojärvi, and Syrjänalunen, a library of 160-300 clones was created. 28 out of the 160 *Archaea* clones from lake Valkea Kotinen sample with around 900 bp 16S rRNA gene inserts, were sequenced. Phylogenetic analysis, including 642 *Archaea* sequences, available from the GenBank-EMBL database, confirmed that none of the freshwater clones were closely affiliated with known cultured *Archaea*. Twelve *Archaea* sequences from lake Valkea Kotinen (VAL) belonged to Group I of uncultivated *Crenarchaeota* and affiliated with environmental sequences from freshwater sediments, rice roots and soil as well as with sequences from an anaerobic digestor. Eight of the *Crenarchaeota* VAL clones formed a tight cluster. Sixteen sequences belonged to *Euryarchaeota*. Four of these formed a cluster together with environmental sequences from freshwater sediments and peat bogs within the order *Methanomicrob iales*. Five were affiliated with sequences from marine sediments situated close to marine Group II and three formed a novel cluster VAL III distantly related to the order "*Thermoplasmales*". The remaining four clones formed a distinct clade within a phylogenetic radiation of the orders "*Methanosaeceta*" and "*Methanomicrobiales*" on the same branch as rice cluster I, detected recently on rice roots and in anoxic bulk soil of flooded rice microcosms. Noteworthy, most of the obtained sequences from the kingdom *Eury-* and *Crenarchaeota* were not identical nor closely associated to other yet published *Archaea* sequences, which have previously been obtained by us from Finnish forest soils (Fig 2).

In this study, new *Archaea* rRNA-targeted oligonucleotide probes were developed. This enabled us to quantitatively study the indigenous *Archaea* distribution in the water column and its potential contribution to the microbial food web, by using PCR and FISH. The latter with oligo-probes revealed the presence of *Methanomicrobiales* in the studied lake (Jurgens et al. 2000).

Archaea community structure of the lake Valkea Kotinen was examined by nested PCR amplification of V3 region of 16S rRNA from microbial communities recovered from various depths in the water column and in the sediment. Amplified DNA fragments were resolved thereafter by DGGE, and the resulting profiles were reproducible and specific for the communities from different depths (Fig. 3). Several dominant fragments in the DGGE profiles were excised and sequenced, showing from 80% to 94% sequence similarity with VAL - *Archaea* clones, obtained by PCR-cloning approach.

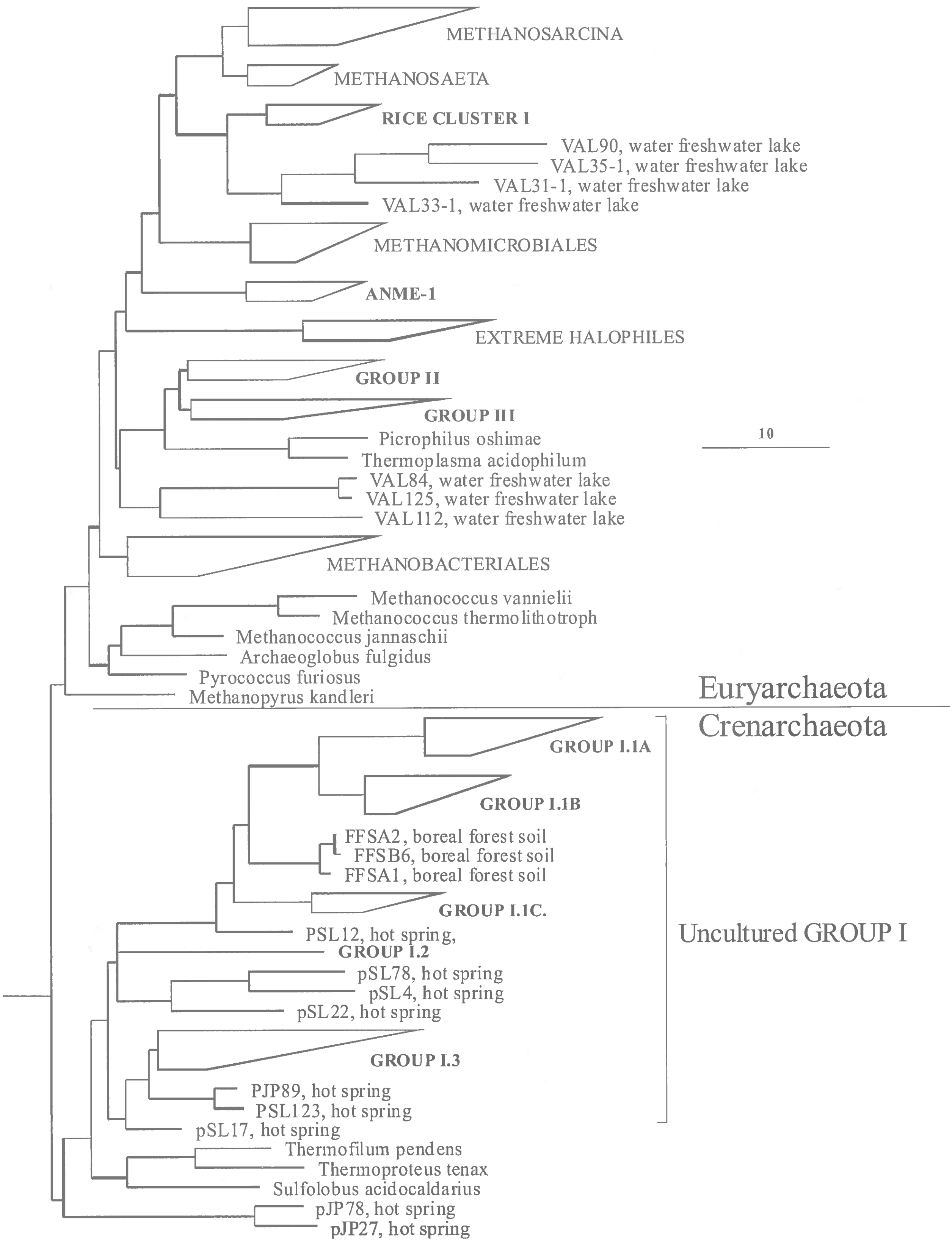

Figure 2. Phylogenetic analysis of the novel freshwater Archaea *from lake Valkea Kotinen was made by using ARB program package (Strunk et al. 2000). This 16S rRNA gene sequence tree was built up by maximum likelihood method. The scale bar represents the estimated number of substitutions per 100 nucleotide positions.*

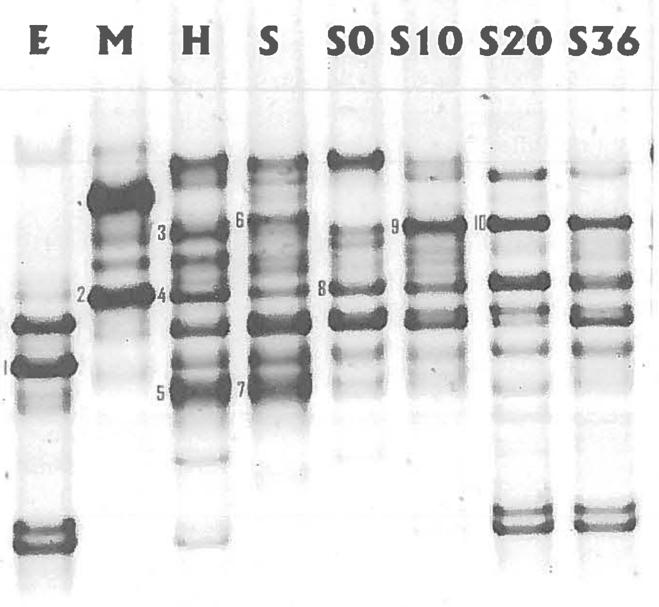

Figure 3. DGGE analysis of 16S rDNA fragments from microbial community samples.
Water samples:
E - epilimnium,
M - metalimnium,
H - hypolimnium,
S - close to the bottom sediment;
Sediment samples (from top to bottom): S0 - 0-2 cm.,
S10 - 10-12 cm.,
S20 - 20-22 cm.,
S36 - 36-38 cm.
Numbers from 1 to 10 indicate excised and sequenced bands.

Discussion

In summary, the results of this work suggest that a large number of previously "unknown" *Archaea* inhabit boreal habitats – i.e. humic soil layer in forest and pelagic water as well as sediment of a boreal forest lake, which has temperature amplitudes between 4 to 20°C and partial oxic/anoxic conditions over the water column. Sequences detected by the rRNA approach belong to members of the *Crenarchaeota* and *Euryarchaeota* branches of the domain *Archaea*.

The results show that *Crenarchaeota* are found in soils subjected to strong ecological and physico-chemical treatments such as clear-cutting and burning. Clear-cutting or clear-cutting together with burning of the ground seem to change the *Crenarchaeota* populations compared to soil in standing forest. Diverse representatives of *Crenarchaeota* seem to form a stable part of the boreal forest soil.

The existence of *Archaea* in the freshwater environment was expected, if we take into consideration the proven presence of methanogens in freshwater ecosystems. However, such large diversity and low 16S rRNA sequence similarity of the obtained new freshwater *Archaea* to the existing environmental sequences in pelagic interfaces as shown in this study was surprising.

The metabolic activity of *Archaea* in boreal soil and freshwater remains unclear except for the methanogens. The traditional objective of microbiological studies, a pure culture, seems inevitable in order to find out first the physiological properties of *Archaea*, and thereafter their place in the complex nutrition chains.

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About the future of meadows in the strict nature reserves of northern taiga

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Objectives

The problem of preserving meadows is a rather interesting scientific and practical problem for many Russian strict nature reserves. In accordance with the law, no human activities changing nature and natural processes are allowed on their territories. On the other hand, some of them have been protected as inheritance biocenoses, such as meadows and steppes, which without human interference are changing greatly and even disappear.

In 1979, in accordance with the results of forestry inventories there were 191 ha of meadows in the territory of the planned Kostomuksha strict nature reserve. In 1986, meadows constituted 88 ha or 0,2% of the preserved area. And though the last figure is not precise, as only patches more than 0,5 ha in area were taken into account, it is possible to say that during one decade the area grown up by meadows reduced significantly. So, the area covered by meadows is very small. Nevertheless, about half of the 395 vascular plant species registered in the Kostomuksha NR (Kravchenko 1997), including rare species, have been found in the meadows.

The meadows of Kostomuksha nature reserve have different background. Part of them is situated along the Kamennaya River, brooks (i.e. Munankijoki) and small forest ponds. They are formed on sedge mires that many years ago were used for mowing by Karelians who stored up hay for the cattle there. These poor wet meadows of small size are much alike mires. The vegetation of all of them is very common. In 1986, these river meadows along the Kamennaya River constituted less than 5 ha.

The other type of meadows has formed on the areas of abandoned Karelian settlements. These numerous hamlets and village Akonlahti were left by natives due to various reasons in different years, but mainly the population was removed from these places in late 1950s in accordance with the policy of enlarging of villages and removing them from the frontier region. These places of settlements grew up with verdant meadow vegetation, which differs greatly from the vegetation of meadows formed from sedge mires. These glade meadows among the forests are situated around the Lake Kamennoye (Kiitehenjärvi) and the vegetation of them differs from one another. Even small glades contiguous to each other have different vegetation. The reason of this variety seemed to be not only in the microclimate or direction of the slope but in the previous activities on each of the glades.

Study areas and methods

The territory of the Kostomuksha strict nature reserve, Russian part of the Finnish-Russian Nature Reserve Friendship, is situated in the northern taiga subzone. Its ecosystems are typical for the region. In 1986, a series of constant sample sites was created on its territory, including a sample site on the meadow of the previous Ehrimänvaara village (Кашеваров 1989). Its area is 110 m^2. The last mowing on the site took place in 1985, and before that the meadows were also mowed sporadically. There was no special cleaning of the meadows from bushes. Nevertheless, it seems to us that the process of growing the meadows with them was slowed by the mowing during the period of 1950s till 1986. A detailed description of the sample site was done, and the abundance of grass plants was determined in accordance with a system proposed by Drude (Фасулати 1971).

The monitoring of ground beetles (Carabidae) on the sample sites is conducted from 1986 also. Ten pitfall traps on every sampling site to study and monitor the litter dwelling beetles were placed at a distance of about 5 to 8 metres from each other. Glass jars of 70 mm diameter, 500-700 ml volume with a 2% formaldehyd solution as preservative, and metal roof protecting from precipitation, were used as traps. Trapping period started in the end of May and lasted till the end of September.

Results and discussion

During the period of investigation on the sample site, 57 grass plant species from the total amount of about 70 species of grasses and shrubs on this patch of meadow were registered (Adrianova 1997). Four Scotch pines *(Pinus sylvestris)* with the age more than 100 years old grow on it and around their trunks forest vegetation remained. Several juniper *(Juniperus communis)* and willow *(Salix phylicifolia)* bushes were growing also. The total area covered by these bushes was about 1%. Rather large area (10,7%) was grown up with raspberry-canes *(Rubus idaeus)* (Fig.1).

Secondary observations of 1998 showed that the area covered by meadow vegetation gradually reduced. The area covered by juniper and willow bushes grew up to 5,5% and the area of raspberry constituted 25,7%. Thus, the braky area increased three times and constitutes now about one third of the sample site (Fig.2). The process is alike the same one that was studied in sandplain grassland in Massachusetts (Harper 1995). Young stands of aspen *(Populus tremula)* and pine trees with the age of about 12-15 years appeared. Due to browsing aspens by mooses *(Alces alces)* and snowshoe hares *(Lepus timidus)* these stands have no ability to grow into normal trees.

Large structure changes happened in the grass cover (Table 1). It can be seen that some dominants were replaced, the abundance of some of them being changed greatly. It may be added that some species registered in the beginning of the studies are not found nowadays. They are *Dianthus deltoides, Dactylis glomerata, Lathyrus palustris* and some others. On the other hand, some new species were found.

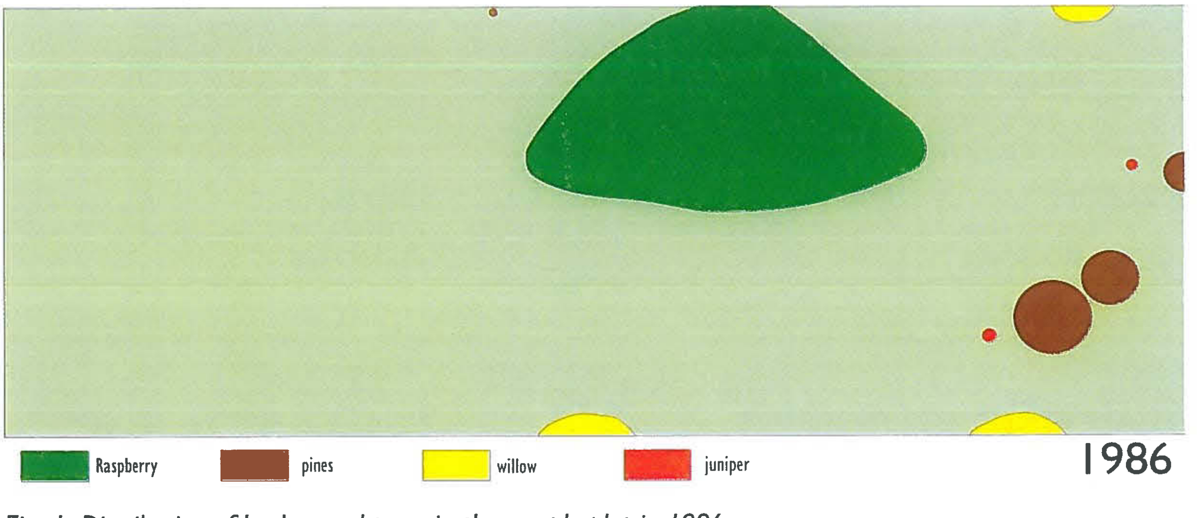

Fig. 1. Distribution of bushes and trees in the sample plot in 1986.

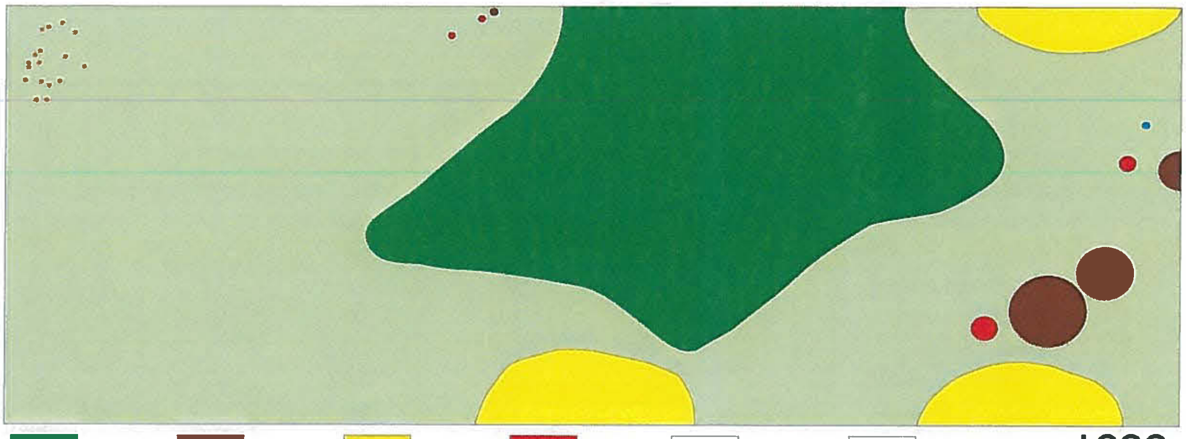

Fig. 2. Distribution of bushes and trees in the sample plot in 1998.

Table 1. Grass vegetation of the Ehrimänvaara meadow during 15 years

Species	Abundance	
	1986	2000
Equisetum		Sol
Anthoxanthum odoratum	Cop_2	Sp
Phleum pratense	Sp	Sp
Agrostis stolonifera	Cop_2	Sp
Deschampsia cespitosa	Cop_2	Cop_1
Deschampsia flexuosa	Sp	Sp
Dactylis glomerata	Sol	-
Poa sp.	Sol	Sp
Festuca rubra	Sol	Sol
Agropyron repens.	Sp	R
Carex spp.	Cop_2	Cop_2
Juncus filiformis	Sp	-
Luzula pilosa	Sp	Sp
Maianthemum bifolium	Sp	Sol
Urtica dioica	Sp	Sp
Rumex acetosa	Cop_1	Sp
Rumex sp. (?longifolius)	Sol	R
Rumex acetosella	Sol	-
Stellaria spp.	Cop_1	Sol
Dianthus deltoides	Sp	-
Ranunculus acer	Sol	Sp
Potentilla erecta	Sol	-
Alchemilla sp.	Cop_1	Cop_2
Trifolium pratense	Sp	Sol
Trifolium repens	Cop_1	R
Vicia spp.	Cop_1	Sp
Lathyrus palustris	Sp	-
Geranium sylvaticum	Cop_1	Cop_2
Viola epipsila	Cop_1	Sol
Viola tricolor	Sol	-
Chamaenerion angustifolium	Sol	Cop_1
Heracleum sibiricum	Cop_1-Cop_2	Cop_3
Anthriscus sylvestris	Sol	Cop_3
Vaccinium myrtillus	Sp	Sol
Vaccinium vitis-idaea	Sol	R
Trientalis europaea	Sol	Sol
Polemonium caeruleum	Sp	Sp
Myosotis cespitosa	Sp	-

Species	Abundance	
	1986	2000
Glechoma hederacea	Sp	-
Galeopsis speciosa	Sol	Sol
Linaria vulgaris	Cop$_1$	Sp
Veronica chamaedrys	Cop$_2$-Cop$_3$	Cop$_1$
Melampyrum sylvaticum	Sol	Sp
Melampyrum pratense	Un	Sp
Rhinanthus vernalis	Cop$_1$	Cop$_3$
Galium mollugo	Cop$_1$	Cop$_3$
Campanula rotundifolia	Sp	Sol
Achillea millefolium	Cop$_1$	Sol
Cirsium arvense	Sol	Sp
Solidago virgaurea	Sol	Sp
Centaurea phrygia	Sp	Sp
Hieracium spp.	Cop$_1$	Sol
Leucanthemum vulgare	Sol	Sol

Cop (copiosus)–very abundant, dominating (3 – 100%, 2 – 50%, 1 – 25%); Sp (sparsus) – scattered; Sol (solitarius) – solitary.

During the period of investigations, 24 species of ground beetles were registered on the meadow of Ehrimänvaara, some of them being registered nowhere else in Kostomuksha nature reserve (Table 2). The changes were noticed in the ratio of dominant species of beetles though the list of the most abundant beetles didn't change gradually. A decreasing of specific abundance of beetles preferring open biotopes (*Amara communis, Amara lunicollis*) (Жеребцов 1979) and, on the contrary, increasing of forest dwelling species (*Carabus glabratus, Calathus micropterus*) was noticed. Some species of open biotopes *(Calathus melanocephalus, Amara similata, Harpalus latus)* were caught only during the first years of researches. The changes of the abundance of *Amara nitida,* also from a group of species preferring open biotopes, had irregular character.

Table 2. Changes in Ground Beetles' *(Carabidae)* Assemblages of the Ehrimänvaara meadow during 15 Years

Species	Biotopes					
	1	2	3	4	5	6
Carabus glabratus	5,7	7,3	14,4	7,0	12,8	27,4
Cychrus caraboides	-	-	0,9	-	12,6	2,8
Pterostichus strenuus	4,1	20,0	9,0	15,6	-	0,4
P. oblongopunctatus	-	2,8	1,8		18,6	24,4
Calathus micropterus	3,7	8,7	18,9	4,1	46,5	49,2
Calathus melanocephalus	2,6	-	-	-	-	-
Amara brunnea	-	-	-	-	0,6	1,8
Amara communis	19,6	15,5	1,8	3,0	-	0,1
Amara lunicollis	55,7	24,2	24,3	42,6	0,3	-
Amara nitida	3,5	9,9	19,8	5,6	0,2	-
Trichocellus placidus	-	-	-	14,4	-	-
Harpalus latus	1,4	0,9	-	5,2	-	-
Species amount	18	16	14	11	13	14
Amount of Specimens	510	425	111	270	651	1376

1 – Ehrimänvaara meadow in 1986-90; 2 –the same in 1991-95; 3 – the same in 1996-99; 4 – Levävaara meadow in 1996-99; 5 – bilberry-moss pine forest; 6 – grassy birch forest.

The analyses of 5-year beetles' catches using a coefficient of biosenoses similarity (Вайнштейн 1976) was used. This analysis confirmed the trend of changing meadow ecosystem in the forest direction. The first 5-year catch of 1986-1990 yr. has the lowest similarity in diversity and abundance with the forests comparing with the catches of the proceeding ones. The similarity of carabs' assemblage of the same meadow in the beginning with its assemblages during the other periods is decreasing. The population of the Levävaara meadow which is on a distance around 100 km on the opposite side of the macro slope of the Maanselkä ridge (Finland) and which has the other history of exploitation differs also gradually from Ehrimänvaara material.

There were no special researches and analysis of other groups of animals. Nevertheless, our observations are the following: there are some changes in the bird assemblage connected with Ehrimänvaara meadow. During the first years wheatear (*Oenanthe oenanthe*), whinchat (*Saxicola rubetrera*), scarlet finch (*Carpodacus erythrinus*) were registered. During the latest 10 years the first two species are not observed on the meadow, and scarlet finch is encountered much rarer. Maybe, it is the result of the long-term changes of their populations, as they were never abundant.

Conclusions

Our observations show that a process of disappearing of meadows formed on the places of abundant settlements is going on, as it happened many years ago with the clearances after slash and burn agriculture. These places on the territory of the Kostomuksha NR are still noticeable by their vegetation and ground beetles' assemblages. The strategy of management of these areas in the taiga is not yet determined. Absorption of meadows by forests leads to the biodiversity decrease and the process is going on. On the other hand, the structure of vast virgin taiga forests is restoring. For sure, this process should be monitored in both cases.

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Hydrological problems associated with mire restoration

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Introduction

Drainage of peatlands has been very extensive in Finland, especially in the southern part, where 78 % of spruce mire area and 72 % of pine mire and treeless mire area is classified as drained (Virkkala et al. 2000). Also a great part of the area classified as undrained has suffered from ditchings in the catchment or e.g. loggings and subsequent preparations of regeneration areas. The total mire area has diminished about 9 % since early fifties according to National Forest Inventories, mainly due to ditching of thin peated areas. There are also drained areas in protected areas or areas belonging to protection programmes. For example, private landowners have drained about 50 000 ha of mires belonging to the National Mire Protection Programme (Aapala & al. 1996).

The use of peatlands for forestry and especially for agriculture is most profitable on the nutrient rich mire sites and, therefore, those have been the first ones selected for drainage. Spruce mires can often be found as narrow strips in the ecotone between forest and mire ecosystems and these ecotones are easily destroyed by a single ditch and even have often been left out of the conservation areas. The need for restoration is very high in spruce mires in hemiboreal and southern boreal zones, where less than 1% of them have been protected, and almost half of these protected spruce mires have been drained (Virkkala & al. 2000). Even worse is the situation with rich fens, both treed and open; less than one percent of the original area is left in southern Finland, largely due to early clearing for agricultural use.

The aims of restoration are diverse. The nutrient rich mires are most potential habitats of threatened peatland species and the endangered twenty-three mire site types are mostly nutrient rich and often demanding flowing water (Aapala & al. 1996). These are some of the most urgent sites to be restored, especially since changes in the mire vegetation and peat properties are most pronounced after disturbance in wet, base rich mires. The Principles of the Protected Area Management in Finland (1999) state that, as a rule, all the disturbed mires in the state-owned protected areas should be restored. These include areas with special landscape value; the natural mosaic of dense forests and open or sparsely treed mires should be returned. The ecotones of mire and forest vegetation are ecological hot-spots for biodiversity. In many cases, ditches in these ecotones divert waters from the seemingly natural mire area and affect its natural state. By restoration, natural development can be retaken. Peatland restoration aims to revitalise a self-sustaining, naturally functioning mire ecosystem, which in most cases accumulates carbon and retains nutrients from through-flowing waters. Also water quality management may be included to the aims of restoration (Vasander & al. 1998). Unprofitable drainages should be returned to their natural state, e.g. to promote wild berry production.

Methods of mire restoration

The prerequisite of a successful mire restoration is to restore the original flow paths of waters. This is aimed at by damming or filling in the ditches. Usually excavators are used. Hand made dams are very expensive and, even when constructed as voluntary work with many people involved, many failures have occurred due to insufficient dams. Whether the aim is to construct dams or to fill in the ditches completely, in both cases it is important create water-tight dams frequently enough to make it possible for the water level to raise to original level also in the areas between the ditches. For the dams to be watertight, several meters of tightly compressed peat, using old excavated peat originating from the ditches or fresh peat from artificial hollows dug to vicinity, is needed. As peat subsidence due to ditching is usually most pronounced near the ditches, extending the dams, as low banks, several meters away from the ditches is necessary. The frequency of these watertight dams is obviously dependent on the slope of the ditches. With a steep slope, very frequent damming, e.g. distance less than 10 m, is necessary.

Some kind of treatment of the forest stand is usually involved in the restoration of mires. If the original mire has been open, complete harvesting is the obvious treatment. In naturally sparsely forested mires, such as pine mires, partial harvesting is often plausible for both ecological and economical reasons. In peatlands which originally had a dense tree cover, particularly spruce mires, the whole tree cover is usually left intact during restoration (The principles....1999). If the tree stand is manipulated, typical characteristics of pristine spruce mires, as long continuity, trees of all sizes and ages, large amounts of dead wood and gap-phase dynamics (Hörnberg & al. 1998, Kuuluvainen 1994) should be taken into account. Restoring the hardwood component of the natural tree stand structure is usually not a problem since birch (*Betula pubescens* Ehrh.) as a pioneer tree species, readily recolonises mire habitats, which receive enough light.

Problems encountered in mire restoration

Difficulties in restoring original water levels and water flow paths

Drainage always changes the natural flow of waters, and drainage in one part of a mire ecosystem may also change the hydrology in the undrained parts. The uneven subsidence of peat surface after drainage may complicate the restoration of the natural water flow. Peat subsidence is most pronounced near the ditches already due to drainage, and both the excavators used when filling in the ditches and possibly also harvesting machinery are moving on the old ditch banks. This may exacerbate the subsidence. Since the physical properties of the acrotelm of the mire have changed due to drainage, fully controlled re-wetting may not be possible.

At a larger scale, peat surface subsidence is greatest where the peat layer is thick, originally wet, and nutrient level is high, especially near the main drainage channels due to their deepness (e.g. Minkkinen & Laine 1998 and references therein). Therefore, exact original water conditions are impossible to reach, and the result is even in an optimal case a mosaic of drier and wetter areas. Also the fluctuations of the water table are expected to increase, due to the increased bulk density of the surface peat after drainage (Minkkinen & Laine 1998).

In many cases, the dams in the restored areas have been inadequate. If water is flowing over the dams, they often eventually break up in the most critical points, where diverting water to the original direction would be most important. Also untight dams may become a problem, even if the leakage was minute. In the long run, underground watertracks may be created. During the growing season, there is very little runoff and waters easily flow to the direction of ditches. A common scene in especially early restored areas, before accumulated knowledge of, is a striped peatland. There is green rheophilous vegetation over the old ditches, slowly changing dwarf shrub vegetation in the area between ditches, originating largely from the period of forest drainage. In worst cases, the minerotrophic waters from the catchment do not meet the areas fed originally by them at all, at least during the growing season, but are diverted along a few ditches to entirely wrong areas. Successful restoration requires that right kind of water and right kind of peat meet - in right proportions especially in the growing season.

A large hydrological problem is created from land ownership. In many cases, mire protection areas are surrounded by ditches and these ditches divert water around the area, instead of reaching the mire as in the natural state (Aapala & Lindholm 1999). Technically it would often be very easy to restore the original flow paths adequately by dams, but at the same time, water levels in the surrounding forestry land would also rise. In very flat areas, considerable water-logging would be created, extending hundreds of meters to the lands of the neighbours.

Treatment of the tree cover

The tree cover can also cause hydrological problems. Dense healthy forest evaporates efficiently and may thus prevent the establishment of mire plants. The annual evaporation from forest land is, on average, approximately 40 - 80 mm greater than from waste land or poorly productive forest land (Hyvärinen & al. 1995). However, in minerotrophic mires with large watershed compared with the size of the mire, runoff from the surrounding areas easily overrules the evaporation due to the tree stand. The trees suffer from water-logging and evaporation is reduced due to natural processes as well. Excessive treatment of the forest stand may also create thickets of e.g. young birch, both from seeds and as saplings. Pubescent birch tolerates water-logging rather well especially when it is young.

Treatment of the forest stand may cause also visual problems. Peatland forests maintain their uneven-sized and -aged structure for quite a long time after drainage, but thinning operations level off the unevenness of the tree stand structure (Hökkä & Laine 1988, Päivänen 1999). Sometimes all the original larger mire trees have been cut just before drainage. The remaining trees have responded to drainage and trees typical to natural mires do not exist anymore.

The excavators used when filling the ditches require space; in typical cases all the trees from the ditch banks are removed, and straight narrow clear-cuts are formed. The visual effects can be reduced, if untouched spots are left and the machinery alternates from bank to bank when moving along the ditches.

Very often some trees die due to the raised water table after damming of the ditches. If this is not to be expected, logs should be created by felling trees, since e.g. many insects and fungi are dependent on dead wood of different ages, typical to natural forested mires. However, sometimes very large and sudden tree deaths may occur, especially in topographically flat areas.

Water quality changes in recipient watercourses after restoration

The effects of restoration of drained mires have been monitored in the Seitseminen National Park, south-western Finland in 1997-1999 with co-financing from LIFE-Nature (Sallantaus 1999). This monitoring is still going on and new results from different restoration areas have been obtained. There are altogether five monitored catchments in Seitseminen. These are mostly dominated by oligotrophic or even ombrotrophic pine mires, some of which were nearly open before drainage. Also areas with hardwood and spruce mires are included. The treatments of the tree stands varied from almost complete tree removal to clearing just the tracks for the excavator, which blocked the ditches.

In all cases, concentrations of nutrients in downstream waters increased after restoration, as expected. However, the increase in phosphorus concentrations was unexpectedly high. In the two monitored lakes, total phosphorus concentration increased five-fold within one year, when all the drained mires in the catchments (25 and 38 % of the catchment area) were restored within a short period of time. Similar increases were observed also in the three monitored brooks, with similar degree of restoration. Although the mires were restored in late fall or early winter, the increase in phosphorus concentration took place late in the summer and in early fall, showing that biological processes are needed, directly or indirectly, to the phosphorus release. The poor oxygen conditions in the water-logged peat were demonstrated by the fact that the concentrations of sulphate dropped concomitantly with the increase in phosphorus.

Very high concentrations of phosphorus may occur especially during the low flow periods, up to more than 1000 μ/l. However, in the second year after restoration, the concentrations were already rapidly decreasing. Three years after restoration, average P concentrations in runoff seem to drop down to below 50 μg/l, but in some cases indications of a slower recovery were observed. The maximum annual phosphorus load due to restoration of a mire is on the order of one kg of phosphorus per restored hectare, based on the results of the catchments monitored in Seitseminen.

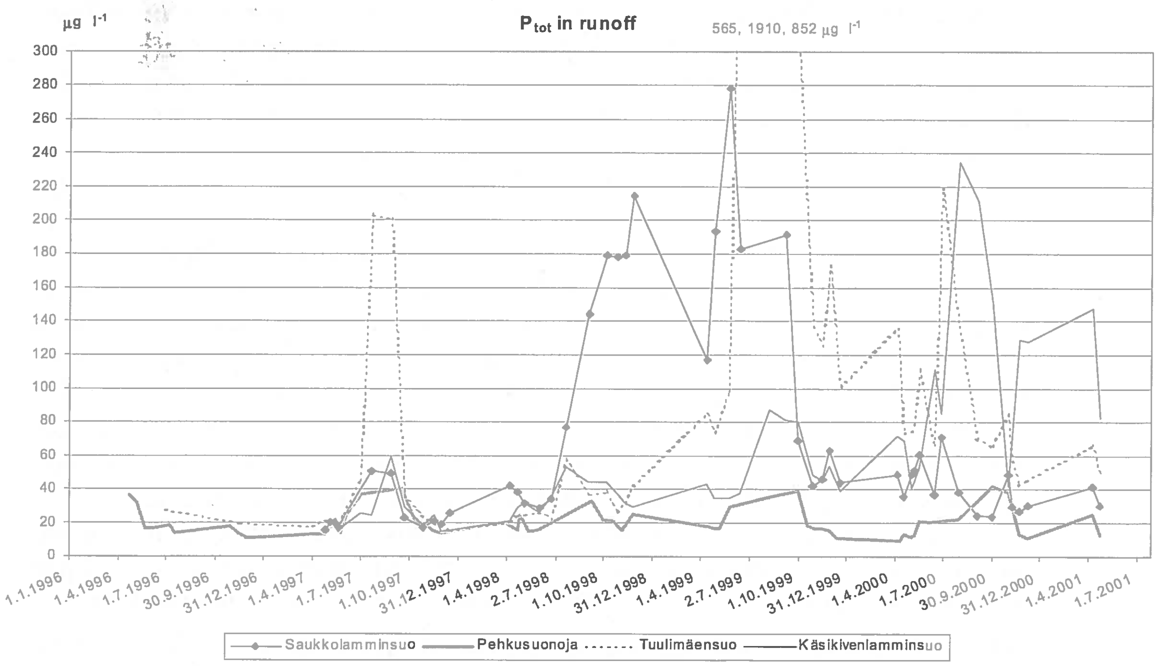

Figure 1. Total phosphorus concentrations in runoff waters from three catchments with mire restoration activities (30 - 40 % of the catchment area), and in a reference area (Pehkusuonoja). The restoration took place in the fall 1997 in Saukkolamminsuo, in the fall 1998 in Tuulimäensuo, and gradually in Käsikivenlamminsuo; small parts in 1997 and 1998, the main basin in 1999 and 2000.

The increases in concentrations of phosphorus and other nutrients after restoration were rather large, but not exceptional e.g. compared with the impacts of forestry practices in peat soils. Fertilisation of peatland forests with fertilisers containing some soluble phosphorus, used in Finland in a large scale still some 12 years ago, caused many-fold increases in concentrations and leaching and for a much longer time (Saura & al. 1995) Previous fertilisations of the drained mires may exacerbate the leaching of phosphorus due to restoration in the case of Seitseminen national park. Similar or even higher increases have been observed following clear-cuttings on peatlands, both in drained (Nieminen 1999) and undrained (Ahtiainen 1992) mires. In an area, which was previously a rich fen, outside Seitseminen, no greater increase in P concentration was recorded after restoration, in accordance with the results of Nieminen (1999) that many nutrient rich mires have a good P retention capacity.

Also other changes in water quality take place after restoration of drained mires (Sallantaus 1999). For example, leaching of dissolved organic carbon increases for some time after restoration, when increased amounts of water reach the changed, decomposed surface peat of the drained area. The higher concentrations of organic acids increase the acidity of runoff waters as well, and this may be the reason, why e.g. the establishment of brown mosses is very poor after restoration of sites where they thrived in the natural state. Also ammonium concentrations may slightly increase both in runoff waters and in the surface peat.

Conclusions

In spite of some draw-backs, the experiences of mire restoration are promising. The 5000 ha of mires already restored are, however, very young and many open questions still remain. Practical restoration projects should be closely linked with monitoring and research whenever possible (Heikkilä & Lindholm 1997). Monitoring enables to correct actions in order to better achieve the restoration goals (adaptive management, Walters & Holling 1990). Incorporation of research into management generates synergy benefits, e.g. by enabling to set up experiments at scales that are relevant both ecologically and for management. It also helps to ensure the formation of a knowledge basis about the long-term effects of restoration, which in turn can be used in planning future restoration efforts.

One of the most urgent questions today is the priority of the sites to be restored. High availability of nutrients favours rapid colonisers, but the succession of mire vegetation is still poorly known especially in the fertile sites. Restored habitats will be colonised by their typical species most likely if the patches are close to existing sources of potential colonists. Favourable objects are therefore those, in which wanted species still exist. The principles... (1999) include e.g. potential habitats of threatened peatland species and densely wooded nutrient rich peatlands to the priority category. The problems encountered with the restoration of these sites are not fully realised and, therefore, careful planning and monitoring are required - especially if potential damage can be made to nature values still existing.

The major adverse hydrological impact of restoration of drained mires is the increased leaching of phosphorus (Sallantaus 1999), although minor increases have also been reported (Vasander et al. 1998). It is still unclear how common this problem is, and whether it can be reduced or avoided. It is, however, a matter that must be taken into account when planning and conducting the restoration works in drained mires. Negative impacts in water systems may strongly affect the public attitudes towards restoration. Even in cases where there is no actual risk of harmful environmental impacts, the situation should be carefully demonstrated for the public.

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Forestry and lake restoration – a new perspective to this multidisciplinary problem

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Introduction

In modern forestry, the timber production capacity of forests is exploited through a multi-stage chain of procedures, whereby the growth of trees is promoted by a variety of measures throughout their life-span. These forest management procedures, however, affect the water and nutrient cycles of a virgin forest area so profoundly as to cause an environmental load that has effects on the waterways and, to some extent, also the soil, groundwater and atmosphere. The pollutant load on waterways caused by forest management is primarily manifested as changes in water quality, discharge, water level or the quality of lake sediments. Changes may also occur in the hydrobiology of water ecosystems, such as eutrophication, excessive algal growth, oxygen depletion and changes in the bottom flora and fauna due to sedimentation.

The environmental load is also reflected in economic values. The net profit accruing from timber production is not a direct indicator of the total profit to be derived from commercial forestry, because the environmental load effected by forest management causes costs that should be recognised in decision-making aiming to find a level of timber production optimal in terms of societal economy (fig. 1).

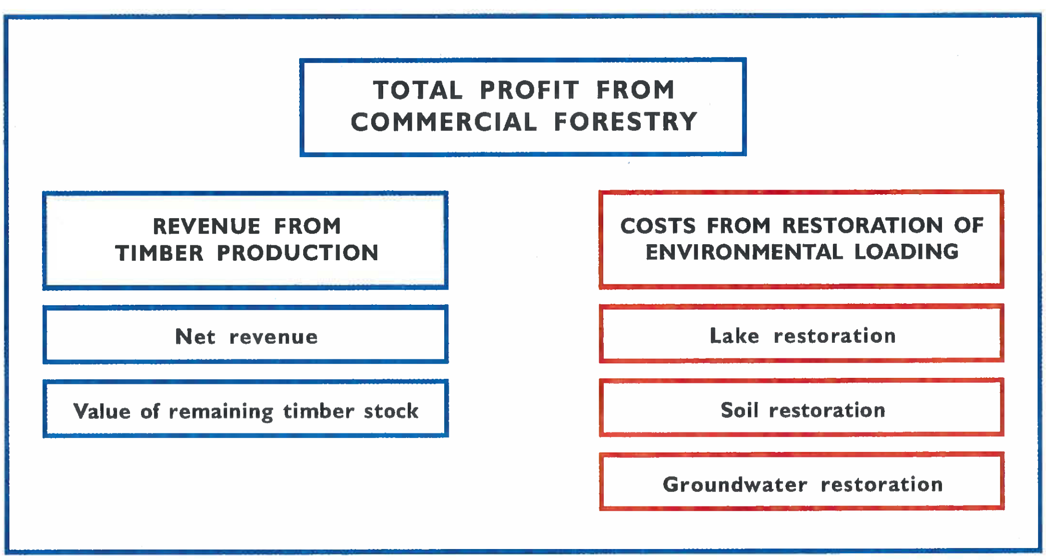

Fig. 1. The role of the revenue from timber production and the cost of environmental loading in the total profit to be derived from commercial forestry.

The aim of this study was to make an economic assessment of the costs of Lake restoration necessitated by commercial forestry using a unit cost method based on the surface area and volume of lakes. The scope was delimited to the costs of restoration occasioned by nutrients and solids discharged into lakes.

Material and Medhods

Literature review

A review of the literature concerning the effects of commercial forestry on waterways indicated that the assessment of hydrobiological impacts has gained an increasingly central role in forestry research. The findings obtained in different areas vary notably, highlighting the significance of local factors for the impacts of forestry procedures. One disadvantage of the research carried out so far is that the studies have covered only short periods in view of the real duration of the loading. Nor is it possible, based on the findings, to determine specific loading values for single procedures, as most studies have measured to the synergistic effects of combinations of different procedures. Based on the literature review, the following combinations of procedures were chosen for analysis: clear cutting, cultivation and ditching in peatland, clear cutting and cultivation in mineral soils, ditching in peatland, and fertilisation in peatland.

To determine the costs of restoration, a specific assessment model was drawn up to evaluate the impact of loading from a given managed forest area on the cost of restoration of a lake at a given distance using different methods. The assessment was limited to lakes. Phosphorus and solids were chosen as the loading parameters to be evaluated, because they are produced in significant amounts by commercial forestry and because there is technical and economic information available concerning the restoration measures affecting these loading components. The restoration methods employed were phosphorus sedimentation, removal of surface sediment, biomanipulation, mowing of aquatic plants and liming.

Model description

Lake

The impacts of forest management on waterways are greatest in the headwater lakes and brooks located in the immediate vicinity of the managed forest areas. These parts of waterway systems are typically shallow and infertile. Before the load caused by forest management, they have typically only been exposed to natural leaching (Kenttämies & Saukkonen 1996).

The range of variation of lake surface area included in the model was 0.005 – 5 km^2 and mean depth was assumed to be 2 m, which is common in small forest slakes. The mean volume of lakes thus ranges within 1000 m^3 – 10,000,000 m^3.

As the aim of the assessment model was to determine the costs of lake restoration caused by forest management, the state of the lake at the baseline before the loading was not considered and the contributions of other loading sources and internal loading to the deterioration of the lake were not evaluated.

Specific loading and distance from the managed area

Specific loading values have been defined for clear cutting, cultivation, ditching and fertilisation in different soil types. To simplify modelling, no other loading parameters except total phosphorus and solids were considered (table 1).

Table 1. Studied forestry procedures, loadings and soiltypes in model calculations

Procedure	Loading		Soil type	
	Total Phosphorus	Suspended solids	Peatland	Mineral land
Clear cutting, soil Cultivation and Ditching	+	+	+	
Clear cutting and Soil cultivation	+	+		+
Ditching	+	+	+	
Fertilisation	+		+	

The specific loading values of different forest management procedures have been multiplied by the distance factor in the model (table 2), to account for the distance between the managed area and the lake (e.g. Lakso & Viitasaari 1990).

Table 2. Distance as a factor of loading in model calculations.

Loading	Distance of forestry area from lake		
	0 km	1 km	10 km
Phosphorus	1,0	0,9	0,7
Suspended solids	1,0	0,8	0,5

Results and discussion

The results of modelling are illustrated by presenting the removal of the phosphorus load from a peatland-dominated forest area exposed to clear cutting, cultivation and ditching by means of chemical sedimentation. The load and its removal have been related to the size of the managed forest area and its distance from the lake (figures 2 and 3).

Table 3 shows an example of the calculated costs incurred in the process of removing the load leached from the 10-hectare managed area into the lake.

The significance of the costs of lake restoration necessitated by forest management can be evaluated by comparing them to the stumpage price of the timber that can be harvested from the managed area. Based on the statistics for 1986 – 1994, the mean volume of forest stands ready for regeneration cutting in northern Finland was 121 m^3 ha^{-1} (Metsäntutkimuslaitos 1998). Calculated on the basis of the percentage volumes of different kinds of timber (Tomppo et al. 1998) and the weekly mean stumpage rates in Northern Ostrobothnia in 1998 (Metsäntutkimuslaitos 1997), the minimum mean stumpage price per hectare for stands ready for regeneration in Northern Ostrobothnia was about 15,000 FIM. Based on these figures, the percentage of the costs of restoration out of the stumpage price of the timber to be harvested from the managed forest area ranges within 0.1 – 60.0 % (table 4). When the cheapest restoration methods, i.e. phosphorus sedimentation and surface sediment removal, are used, the costs are less than 1.0 % of the stumpage price of the timber to be harvested from the managed forest area. The percentage of restoration costs out of the stumpage price of the timber available for harvesting is highest when the restoration is accomplished by mowing the aquatic plants.

Generally speaking, we can conclude that the percentage of restoration costs out of the total revenue from timber production is small in view of the technically and economically feasible methods of restoration that can be used to remove the loading caused by forest management. The principal methods include removal of surface sediment and phosphorus sedimentation as well as biomanipulation in some single instances. This is a significant finding in view of lake restoration, for the major obstacle preventing restoration is often money. The calculated restoration costs were used to show that commercial forestry can, when necessary, reimburse part of the costs of restoration based on the "polluter pays" principle.

This study have been financed by EU (Interreg IIA Karelia-program) and Finnish Ministry of Environment.

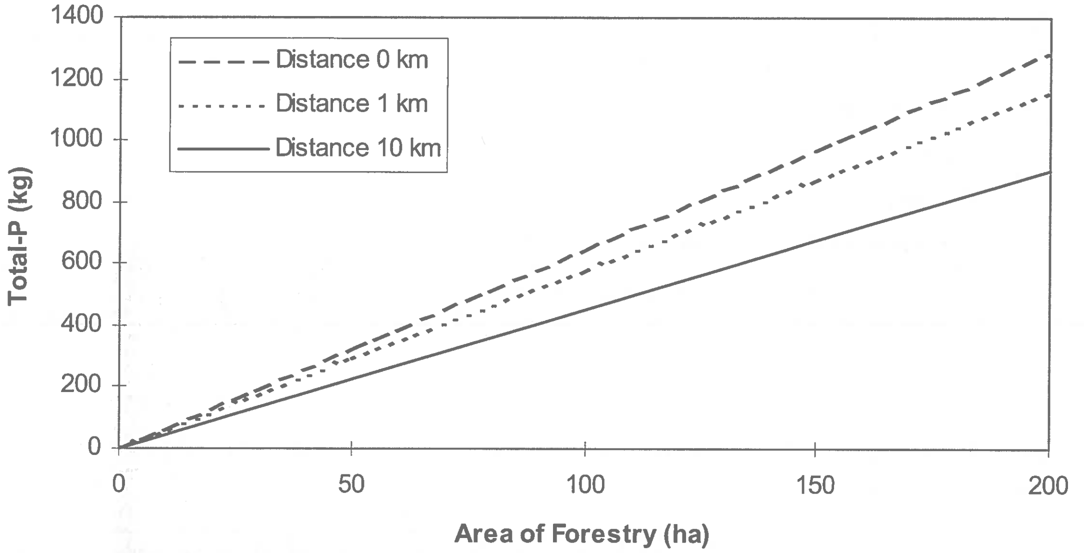

Fig 2. Total Phosphorus loading and its correlation to area size and distance to lake from clear cutting, soil cultivation and ditching area in peatland.

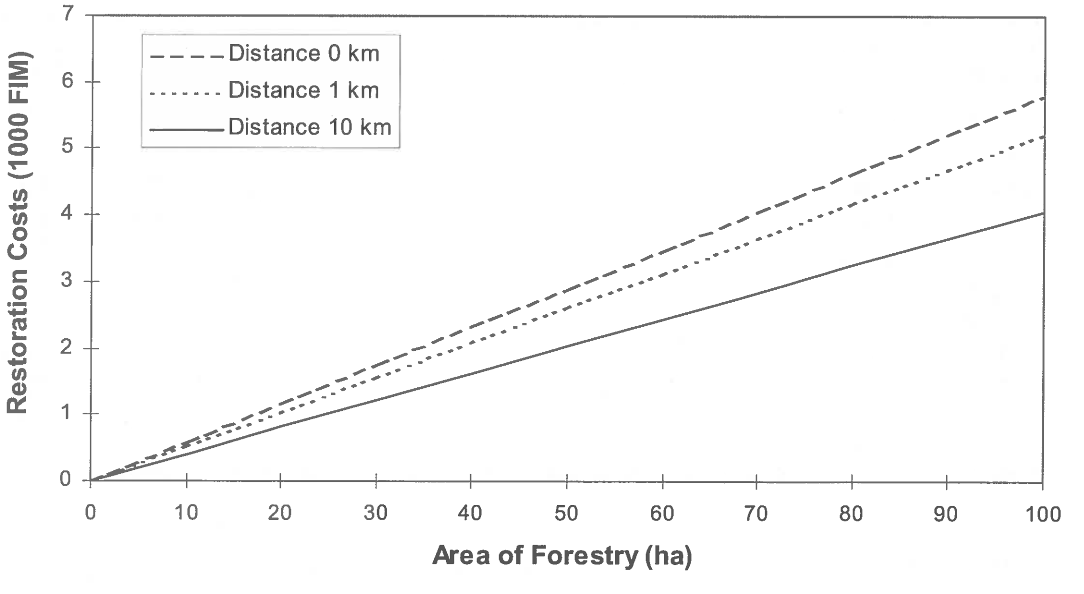

Fig 3. Lake restoration costs of Phosphorus sedimentation and its correlation to area size and distance to lake from clear cutting, soil cultivation and ditching area in peatland.

Table 3. Costs of lake restoration necessitated by the phosphorus and solid load leached from a managed forest area 10 ha in size in the immediate vicinity (distance 0 km) of the lake. The costs of the most typical restoration method for each procedure are shown underlined.

Restoration method	Costs of lake restoration due to forest management (10 ha) (FIM)					
	1)	2)	3)	4)	5)	6)
Phosphorus sedimentation and removal of surface sediment	1330	-	650	270	-	-
Biomanibulation and removal of surface sediment	6810	-	2420	1660	-	-
Clearcutting of aquatic wegetation and removal of surface sediment	49120	-	16070	12350	-	-
Phosphorus sedimentation	580	-	190	150	1080	540
Biomanipulation	6060	170	1960	1530	11280	5640
Clearcutting of aquatic wegetation	48380	1350	15600	12230	90000	45000
Removal of surface sediment	750	-	470	130	-	-

1) Clear cutting , soil cultivation and ditching in peatlands
2) Clear cutting and soil cultivation in mineral areas
3) Ditching in erosive peatlands
4) Ditching in non-erosive peatlands
5) Fertilisation with water-soluble phosphorus in peatland
6) Fertilisation with slowly soluble phosphorus in peatland.

Table 4. Percentage of the costs of lake restoration necessitated by forest management out of the stumpage price of the timber available for harvesting from the managed area.

Procedure	Percentage of the costs of a lake restoration necessiated by forest management out of the stumpage price of timber available for harvesting from the management area.						
	1)	2)	3)	4)	5)	6)	7)
Clear cutting , soil cultivation and ditching in peatlands	0,9	4,5	32,7	0,4	4,0	32,2	0,5
Clear cutting and soil cultivation in mineral areas	-	-	-	-	0,1	0,9	-
Ditching in erosive peatlands	0,4	1,6	10,7	0,1	1,3	10,4	0,3
Ditching in non-erosive peatlands	0,2	1,1	8,2	0,1	1,0	8,2	0,1
Fertilisation with water-soluble phosphorus in peatland	-	-	-	0,7	7,5	60,0	-
Fertilisation with slowly suluable phosphorus in peatland.	-	-	-	0,4	3,8	30,0	-

1) Phosphorus sedimentation and removal of surface sediment
2) Biomanibulation and removal of surface sediment
3) Clearcutting of aquatic wegetation and removal of surface sediment
4) Phosphorus sedimentation
5) Biomanipulation
6) Clearcutting of aquatic wegetation
7) Removal of surface sediment.

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Possibilities to assess economic values of biodiversity in Russian Karelia using Finnish data: A benefit transfer experiment

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Introduction

The need to find a monetary value for a public good, e.g. an environmental resource or a change of its quantity or quality, has been recognised as an important problem in society for a long time. The benefit transfer (BT) is a method that reuses existing results of valuation studies of non-market commodities in a new case or area (Brookshire & Neill 1992, Boyle & Bergström 1992). The use of old results, e.g. willingness to pay (WTP) figures, saves time and money.

The aim of this study is to assess conditions in which Finnish results can be used in valuation of environmental benefits of biologically valuable forests in Russian Karelia. According to BT terminology the valuation study of an original area is a "study site" and the area where the data set is applied, in this case Karelian forests, a "policy site". The study site in this case is Finland and the data set used here has been compiled in a contingent valuation survey "Public opinion on nature conservation in private forests" (Mäntymaa et al. 2000).

The BT has a great number of problems. On what ground it is permissible to transfer environmental benefits from one site to an another? On what conditions BT is a scientifically consistent method? One should remember that BT at best is as valid and reliable as the original study, in the worst case one could speak about bias transfer if the original data set has not been collected in proper way. On the other hand decision situation influences on quality of required information and benefit estimations need not always be equally accurate (Brookshire & Neill 1992). According to Desvousges et al. (1992) and McConnell (1992) the use of BT will increase considerably in the future. Decisions can be made more rabidly if the use of old data is sufficient for instead of a new survey.

A BT study can be made whether by transferring a data set or a whole demand function. The oldest form of the data transfer is an estimate based on professional guess (Loomis 1992). In practise, the data transfer uses official tabulated values or average WTP figures calculated especially for each special case.

As experience and knowledge increased the method was started to develop to theoretically more justified direction. Many researchers, e.g. Loomis (1992) and Desvousges et al. (1992), advocate the transfer of a whole demand function. The function transfer uses the demand function of a study site at a policy site so that the original function form is used with a new data set. Using benefit estimates of a travel cost study Loomis (1992) shows that the transfer of a utility function produces less biased estimates than a corresponding data transfer.

This study can even not implement a data transfer while there is not enough information for this kind of experiment. Here instead, starting points and conditions of the BT will be presented. In addition, the study will assess what kind of transformation coefficients are essential in the BT between Finland and Karelia and to what direction Finnish benefit estimates should be changed in order to get corresponding Karelian figures.

Survey and the data set

The data for the study was collected by a mail survey, sent out in spring 1999 to a random sample of 800 persons among the Finnish population aged 18-75 years over the whole country. The sample was divided into two sub-samples of 400 individuals to which the conservation projects were stated in slightly different ways, as will be described below. The questionnaire elicited a total of 381 replies, a response rate of 47.6 %.

The survey described three separate projects including 155.000, 430.000 and 705.000 hectares of protection in addition to the set-aside area according to the Finnish Forest Legislation (i.e. 120.000 hectares). The first group of people was asked to give the WTP for the first two projects, i.e. 155.000 and 430.000 hectares and the latter group for 430.000 and 705.000 hectare projects. This means that each respondent was asked to answer two contingent valuation questions for two projects. Furthermore, if respondents were uncertain of the WTP they were encouraged to give two sums of money for the both projects the first being the sum that they certainly are willing to pay for the project and the second the sum being the absolute maximum for the project. This format of the question gives upper and lower bounds of the WTP (for more about the survey, see Mäntymaa et al. 2000).

Table 1 shows the mean annual WTP per household of both sub-samples for the three preservation projects. As said above the larger project of sub-sample 1 is the same as the smaller project of sub-sample 2. The third column of the table is the mean WTP at the lower bound, the fifth column at the upper bound and the fourth column the mean WTP calculated using the observations at the both bounds. The sums vary from FIM 159 to FIM 468 depending logically on the volume of conservation, i.e. the larger is the area to be set aside the more people are willing to pay for preservation.

Table 1. Willingness to pay of households for conservation projects of commercially managed forests.

Sub-sample	Additional conservation	Mean willingness to pay FIM/household/year		
		at the lower bound	on the average	at the upper bound
Sub-sample 1	155.000 ha	159	224	288
	430.000 ha	194	289	384
Sub-sample 2	430.000 ha	221	321	422
	705.000 ha	291	380	468

Benefit transfer criteria

According to Desvousges et al. (1992) the following conditions should be realized in order to get reliable results with the BT method:

1. The data set of a study site should be of good quality so that proper scientific methods have been used in its collection. The data set by Mäntymaa et al. (2000) fulfils these criteria.
2. The presumed change of quality or quantity should be of the same size both at the study site and policy site. While there is no information of potentially protected areas in Karelia this criteria will be left out of the analysis.

3. The study should include regression results that describe WTP as a function of socio-economic factors. It would be possible to construct a linear regression model using the data set of the study site. The criterion is not used here because corresponding data are not available and function transfer will not be applied in this study.
4. The study site and policy site should physically be similar. This criterion holds true quite well.
5. Markets should be similar. This is not true since markets differ substantially. In applying this criterion in this experiment one should take into account
   a) differences in recreational use of forests,
   b) direct benefits of households from use of forests,
   c) differences in availability of substitutes,
   d) differences in industrial use of forests and
   e) proportion of the available income of households between countries.

Based on the criteria above the BT coefficient will be constructed or the sign of the coefficients will be assessed (Table 2).

Applying the benefit transfer criteria

Income criterion

In order to take into account differences of available income of households two alternatives will be presented for income coefficients (OECD 1997a, OECD 1997b and Tilastokeskus 1999). As an approximation, although inexact, of difference of income the ratio of the gross national products (GNP) per capita between countries is used.

GNP per capita in Russia 1996 (USD) / GNP per capita in Finland 1996 (USD) = 2977 / 24235 = 0,12

or

GNP per capita in Russia Karelia 1996 (USD) / GNP per capita in Finland 1996 (USD) = 2 222,2 / 24 235 = 0,09

If only this coefficient is used the WTP of the Russian people is 12 % and the Karelian people 9 % of the Finnish figures (see Table 2).

Quality criterion

Since more Karelian forests have still been preserved from commercial use their natural state and better biodiversity should be weighted in the BT. For this purpose the coefficient of environmental quality will be created where the numerator is the share of old growth forests of Karelia and the denominator the corresponding figure of Finland. There are several estimates of the former figure, but this study will use the figure by Myllynen & Saastamoinen (1995) (35 – 50 %). According to Finnish Environmental Centre the corresponding Finnish figure is 8,7 %.

Old growth forests in Karelia (%) / old growth forests in Finland (%) = 35 % / 8,7 % = 4

According to this Karelia has four times more old growth forests than Finland. Since old growth forests are an abundant resource in Karelia it should decrease the WTP of consumers for additional protection.

Criterion of prevailing market

In order to apply the criterion of the prevailing market in the BT one should take into account differences in recreational use of forests, direct benefits of households from the use of forests, availability of substitutes and industrial use of forests. With respect to this criteria a single coefficient will not be constructed but different factors and the direction of their effect will be analyzed only.

Recreational use of forests and its increase are seen as a possibility of future development since beautiful nature tempts tourists. Better possibilities to recreate in old growth forests increases WTP for protection.

Direct benefits of households from the use of forests include benefits that people get from berry and mushroom picking, fishing and hunting. The non-timber products have traditionally had a great importance in Russia and their high rate of utilization increases WTP for forest preservation.

People's valuations are also influenced by the fact how easily a commodity can be replaced with a similar or some other commodity. Easy availability of substitutes decreases the uniqueness of commodities and reduces the WTP for its preservation. This factor is partly taken into account with quality criterion.

Forest industry is the most important industry in Karelia and timber is the most common export good being 61 % of the total export in 1995 (Haapanen & Eskelinen 1996). Decrease of logging has increased unemployment and reduced incomes especially in Karelian countryside (Ulkoasiainministeriö 1999). This tends to lower WTP for forest protection. On the other hand, the preservation of old growth forests also gives an advantage in competition in international markets. Thus the effect of forest industry on WTP is both positive and negative.

Table 2 gives a summary on the factors that should be taken into account when Finnish WTP figures are applied for assessing of a preservation value of Karelian forests. The weighting of the criteria depends, of course, on political selection of values.

Table 2. Factors that should be taken into account when Finnish willingness to pay figures are applied for assessing of a preservation value of Karelian forests.

Criterion	Direction of the effect of the factor on WTP	Approximation of the coefficient or other effects to be taken into account
Income coefficient	- -	0,09 (Karelia) or 0,12 (Russia) inflation a critical factor
Quality coefficient (biodiversity coefficient)	- -	More than 4
Criterion of prevailing market:		
recreation of households	+	property rights have an influence on the protection of forests
direct benefits of households	+	
substitutability of the commodity	-	
forest industry	- / +	

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Current state of the surface water in Kostomuksha reservoir and surrounding territory

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Introduction

In 1977-1985 the town of Kostomuksha and the Kostomuksha Ore-dressing Mill were built in the northwest of Karelia. The town and the mill appeared in the northern taiga zone, where the natural resources practically had not been used and had stayed virgin. Upon completion of the building process when the mill started working the anthropogenous effect on the environment increased. It was connected with gaseous and solid emissions of the mill, domestic sewage waters disposal in the river Kontokki system (the river Kamennaya basin) and the technogenous waters in the river Kenti system (Lake Sredneye Kuito basin).

Before the natural resources development in this region in 1976-1980 a detailed study of surface waters of the Kostomuksha Ore-dressing Mill was conducted at the Northern Water Problems Institute of the Karelian Research Centre of the Russian Academy of Sciences. The state of water bodies and precipitation in the Kostomuksha region have been monitored since the onset of the works at the mill. Since 1992 these objects have been included in the monitoring program of the water environment of Karelia and monitored annually (Current state… 1998).

The joint hydrochemical investigation of lakes in the Kostomuksha reservoir was made by the Northern Water Problem Institute from Russia and Kainuu Regional Environment Centre from Finland. Lakes of Kalevala region, Kenti- and Kontokky lake-river systems were included too. The main anthropogenic factors, which have an impact on the surface water, are the emissions of Kostomuksha ore-dressing mill and sewage water (return system of the mill water supply and domestic sewage from the town Kostomuksha.

Objects and research methods

Since 1991 collaborative studies of the water bodies state and precipitation in the Kostomuksha region have been conducted at the Northern Water Problems Institute and the Kainuu Regional Environment Centre. The work is being done on the water bodies directly affected by anthropogenous factors (the rivers Kenti and Kontokki system, Lake Sredneye Kuito) and located in the air-pollution impact zone (the lakes of the Kostomuksha nature reserve and the Kalevala region).

Precipitation monitoring was conducted during maximum snow accumulation period (late March B early April). Snow samples were taken 3, 10, 24, 40, 60 km from the ore-dressing mill. The chemical analysis of water samples from surface water bodies and the analysis of melted snow were conducted by using the same methods.

The majority of chemical analyses were performed simultaneously in the Kainuu Regional Environment Centre and Northern Water Problems Institute. The Li, Al and heavy metals determination was conducted in Kainuu, and the determination of O_2, NO_2-, BOD_5 (biochemical consumption of oxygen), oil and Fe^{2+} in Petrozavodsk. For the majority of the components the results obtained in both the laboratories were highly comparable.

Results and discussion

One of the factors of anthropogenous influence on the water bodies in the Kostomuksha region is the chemical fallout of pollutants with precipitation due both to the local sources and transboundary transport. The basic source of air pollution in Kostomuksha is the ore-dressing mill, where the most part of emissions are represented by sulphur dioxide (53-38 thousand t) and solid matters (5.3-6.4 thousands t).

It should be mentioned that the greater part of the emissions of the dioxide of sulphur, as well as solid matters, starting from 1997 occur mostly in Kostomuksha in comparison with the other industrial centres of Karelia. At the same time, in comparison with such metallurgical plants as Severonickel and Pechenganickel, located in the Kola peninsula, the emission of SO_2 in Kostomuksha is only 20-30% of the emission of each of the specified mills.

Gaseous and solid emissions of the Kostomuksha Ore-dressing Mill influence the chemical fallout of $S0_4$, K, Ca, and also Fe, Al, V and Ni, and their impact is substantial within the range of 10 km from their source. The fallout of strong acids in this area is insignificant. Over 10 km away from the mill the fallout of strong acids reaches 0.5 mmol m^{-2} mth^{-1}, which is almost half of the mean values in Karelia (0.9 mmol m^{-2} mth^{-1}) observed in 1989-1992 (Lozovik & Basova 1994).

The lakes of the Kostomuksha nature reserve and the Kalevala region

The study of the water bodies of the Kostomuksha nature reserve and the Kalevala region in the vicinity of the border suggested a character of the chemical composition of the water similar to the natural water characteristics for this region. The examination of the lakes of the Kostomuksha nature reserve and the neighbouring territory of the Kalevala region in the winter period 1997-1999 showed that the majority of the lakes was characterized by low mineralization and alkalinity (0.04-0.34 mmol l^{-1}). Judging by the organic matter content, 25 of the 46 lakes, which were examined, belong to the mesopolyhumic water class, 15 to mesohumic and 6 to oligohumic. 14 lakes can be classified as low acid ($pH < 6.0$, alkalinity 0.04-0.06 mmol l^{-1}). As a rule, they are characterized by a small watershed and a significant amount of atmospheric supply delivery. Lake Devitchia Lamba is characterized by a high acidity level. The values are close to those of the precipitation (pH 5.2). In comparison with similar water bodies of South Karelia the acidity level in the Kostomuksha region lakes is lower.

Oxygen supply in the surface waters of all the lakes is quite sufficient (60-90 % in winter). At the same time in mesopolyhumic low acid neutral lakes the deficit of O_2 at the bottom level ranged from 70 to 100 %, which is connected with the oxygen consumption by bottom sediments during the organic matter mineralization processes. Due to oxygen deficiency near the bottom high concentrations of Fe and Mn (Fe up to 3.3 mg l^{-1}, Mn up to 1.2 mg l^{-1}) were also observed, while on the surface their concentrations were 0.15-0.70 and 0.03-0.06 mg l^{-1} accordingly).

The P_{total} content in the majority of the lakes did not exceed 10-12 µg l^{-1}, which is characteristic for low productivity oligotrophic water bodies. A higher content of P_{total} is observed in the lakes Latvajärvi, Srednyaya Vazha, Saarikkojärvi, Kovalampi and Lyttä (14-22 µg l^{-1}) and these lakes presumably belong to the mesotrophic type.

The content of all forms of nitrogen is rather low, and it is typical of small low productivity lakes, with a small drainage basin, particularly when there is no sewage waters inflow, and it actually characterizes the natural level of these lakes for the specified region with NH_4 - 0.015, NO_3 - 0.07, N_{total} - 0.4 mgN l^{-1} on the average.

Trace elements concentration, including heavy metals, was rather low in all the lakes and its value corresponds to the background values:

B 1.4-2.7, Cr < 0.1-0.9, Pb < 0.03-0.3, Ni 0.05-0.3, V 0.03-0.7, As 0.16-0.29, Li 0.34-1.2, Be < 0.15, Co 0.04-0.08, Sr 0.6-0.21, Sb 0.02-0.03, Ba 7.3-8.6, Cs < 0.04, Al 56-83, Cd < 0.03 , Cu 0.3-0.8, Se < 0.4, and Zn 1.2-1.5 µg l^{-1}.

There are 6 types of geochemical classes according to the alkalinity of water and organic matter content. The most representative is the mesopolyhumic low acid neutral class of water (19 of the 46 lakes in the research). The number of the lakes belonging to each type is basically the same. The only lake of the acidic oligohumic type is Devitchia Lamba. According to the classification adopted in Finland, the water quality of the majority of the lakes is satisfactory (33 lakes), good (7), high (5) and poor (1) (Vesi-ja ympäristöhallitus 1988) (Fig. 1 and 2).

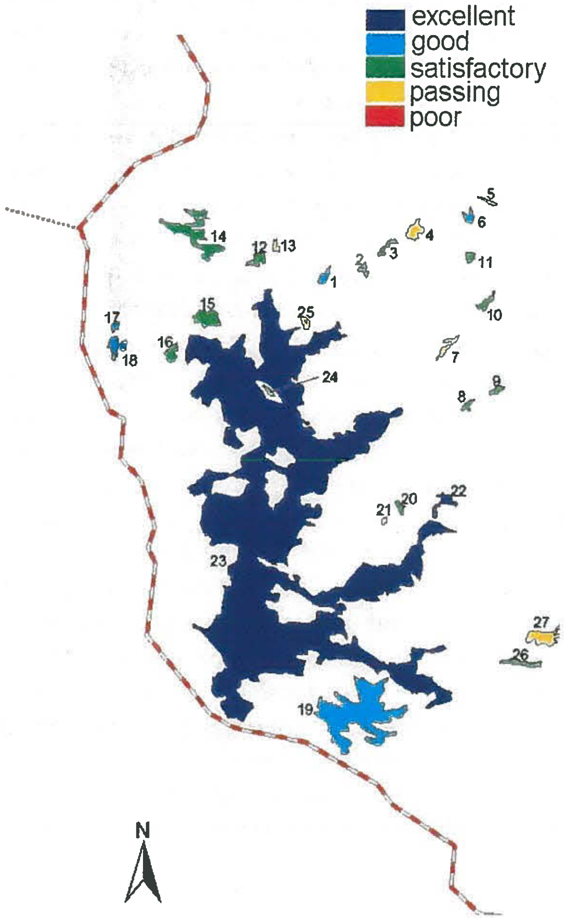

Fig. 1. The Classification of Lake Water Quality in Kostamus in 1998.

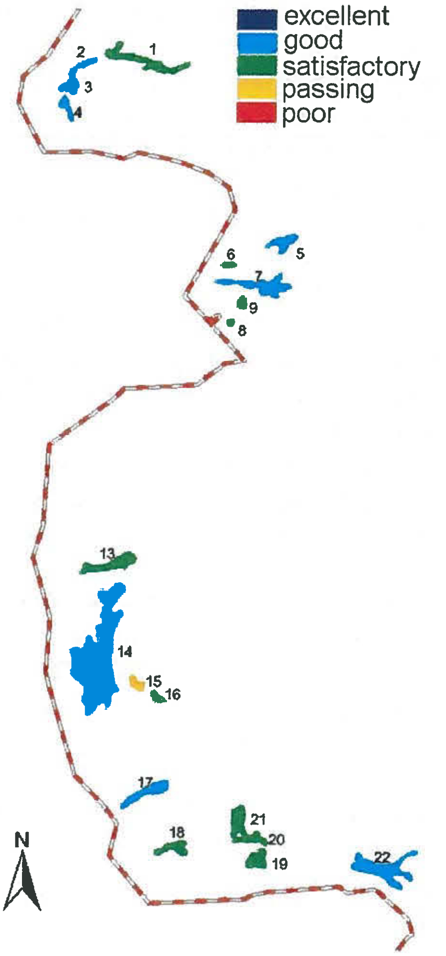

Fig. 2. The Classification of Lake Water Quality in Kalevala in 1999.

The Kontokki-Nogeus river system

Domestic sewage waters of Kostomuksha (annual amount about 5 million m^3) exert a negative influence on the Kontokki river, and it manifests itself mostly through the increase of nitrogen and phosphorus compounds concentration ($N\text{-}NO_3$ - 1200 $\mu g\ l^{-1}$, P_{tot} B 340 $\mu g\ l^{-1}$). The latter causes increased loads on the lower lakes Luvozero and Kimasozero and accelerates the eutrophication process, which is confirmed by the values of the mineral and organic substances, and nutrient content in the Nogeus river flowing out of Lake Kimasozero.

The Kenti lake-river system

Of all the water bodies of the Kostomuksha region the most significant anthropogenous changes have taken place in the Kenti lake-river system, due to the impact of the technogenous waters of the ore dressing mill. Since 1994, the water from the waste storage has been disposed in the lake B river system annually. Depending on the annual amount of water inflow their annual amount makes 9-22 million m^3. Besides, drainage canal waters flow into the lakes Okuniovoye and Poppalijärvi. Technogenous waters composition differs considerably from that of natural waters of this particular region. In mine waters alongside with their high mineralization (about 1.5 $g\ l^{-1}$) there is a very high content of nitrous matters (NH_4 B 48 000, NO_3 B 64 000, N_{total} 100 000 $\mu g\ N\ l^{-1}$), manganese up to 3000 $\mu g\ l^{-1}$, nickel -140 $\mu g\ l^{-1}$. They are disposed directly in the waste storage and they are the main source of nitrogen compounds in its water alongside with the inflow from pulp in the course of ore processing.

The waste storage waters are characterized by very high potassium and sulphate content, and an abnormal ratio between potassium and the other main ions, which generally do no occur in natural waters. The filtration waters are close to the composition of the waste storage waters. They contain less nitrous matters, but more calcium and sulphates, what is connected with the leaching of gypsum from the lock. Drainage canal waters characteristics differ from those of the natural waters, and they also pollute the river Kenti system. In all technogenous waters, and first of all in mine water, the increased content of lithium, chromium, nickel and cobalt is observed in comparison with the natural waters. Technogenous waters inflow into the river Kenti system resulted in mineralization increase of 5 B 20 times from the lower lakes of the system to the upper ones, potassium concentration - 25-250 times and sulphates - 2-60 in comparison with the 70-s. Now a considerable increase of nitrates and N_{org} concentration, exceeding the potassium concentration to a great extent, and also the decrease of oxygen content in water at the bottom in the winter period have become the other peculiar feature of the hydrochemical regime of the river Kenti system. Increased concentrations of Ni, Cr, Co, Mn and Li enter the lakes of the system with technogenous waters, and it shows in the excess of background values of these elements in the upper and central lakes Koivas and Kento, but the values observed do not exceed the maximum concentration limit for fish husbandry basins. In 1999 the concentration of lithium was: in Lake Poppalijärvi 19 $mg\ l^{-1}$, in Lake Koivas 12, 7.7 B in Lake Kento, 9 B in Lomozero and 6.6 in LakeYlijärvi. The nickel content changed from 2.5 to 0.31 $\mu g\ l^{-1}$, and chromium from 3.0 to 0.42 $\mu g\ l^{-1}$.

Conclusion

On the whole, analyzing the water bodies state of the Kostomuksha region, it should be noted that beyond the area of the direct influence of the Kostomuksha Ore-dressing Mill technogenous waters no significant changes in the regime of the lakes were detected.

A slightly higher acidity level was observed in the lakes with a small watershed, which may be due both to the local emissions of sulphur dioxide from the ore-dressing mill, and the transboundary transport. The most significant changes are observed in the river Kenti system. The basic technogenic influence on its hydrochemical regime is the increase of mineralization, potassium and lithium concentration, and natural cations ratio disbalance. Nitrous matters pollution, nitrates first of all, deterioration of the oxygen regime in the winter period - all these factors exert a highly negative influence on the ecosystem of the lakes.

The eutrophication of the Kontokki river and the lower lakes Luvozero and Kimasozero is the consequence of domestic sewage waters disposal in Kostomuksha.

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Surface water pollution with nitrogen compounds in the ore-dressing mill impact zone

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Introduction

The aim of the study was to estimate nitrogenous pollution of water bodies in the Kostomuksha area influenced by industrial sewage from the ore-dressing mill (ODM).

The Kostomuksha ore-dressing mill "Karelsky okatysh" stock company, was built in the second half of the 1980's within the framework of co-operation between Russia and Finland. In order to provide a better insight into the problem let us consider the process of sewage supply to the nearest bodies of water, and the sources of their pollution with nitrogen compounds.

Sewage generated by the ore dressing process is reused after sedimentation in lake Kostomukshskoje which was turned into the mill process reservoir used to store tailings (the so-called tailings dump). Discharge canals through which most waters from the Kostomukshskoje lake drainage basin flow directly to the downstream water bodies have been constructed around the tailings dump. Nevertheless, the tailings dump area increased more than 6 times since 1994 and the volume more than 20 times as compared with the initial values as a result of precipitation and industrial sewage supply. As the tailings dump got filled with sewage the need emerged to discharge the sewage directly into the downstream water bodies of the Kenti river system. The first controlled sewage discharge was performed in 1994 and amounted to 9.56 mln. m^3. In 1998 it was about 23 mln. m^3. Besides, water bodies of the Kenti river system receive 2 mln. m^3 of water seeping through the dam facilities (seepage). The main sources of anthropogenic impact on the Kenti river aquatic ecosystem are seepage, water from the tailings dump, as well as mining (quarry) water which is in fact the main source of nitrogenous pollution since it carries explosives disintegration products (ammonium nitrate, trinitrotoluene, polyacrylamide, etc.). In the winter of 1999 some 1,500 m^3 of mining water were discharged directly into the system.

The Kenti river system that flows through 10 lakes and empties into lake Srednee (Middle) Kuito belongs to the Kem river drainage basin (Fig. 1).

Materials and methods

The programme of research on the ODM sewage impact on the river system comprised the following water objects: lakes Okunevoje, Poppalijarvi, Koivas, Kento, Lomozero, channels connecting lakes Okunevoje and Kurojarvi, Jullajarvi and Alajarvi, Verkhnee Kuito and Alajarvi, as well as lake Srednee Kuito. In addition to this, water from the tailings dump, seepage, mining water and water from the discharge canals were studied. Sampling took place biannually in the winter and summer periods. Chemical analysis of total, ammonium, nitrite and nitrate nitrogen followed the techniques commonly accepted in hydrochemistry. Monitoring over water quality in the Kenti river system started in 1970, i.e. before the ODM construction and operation began.

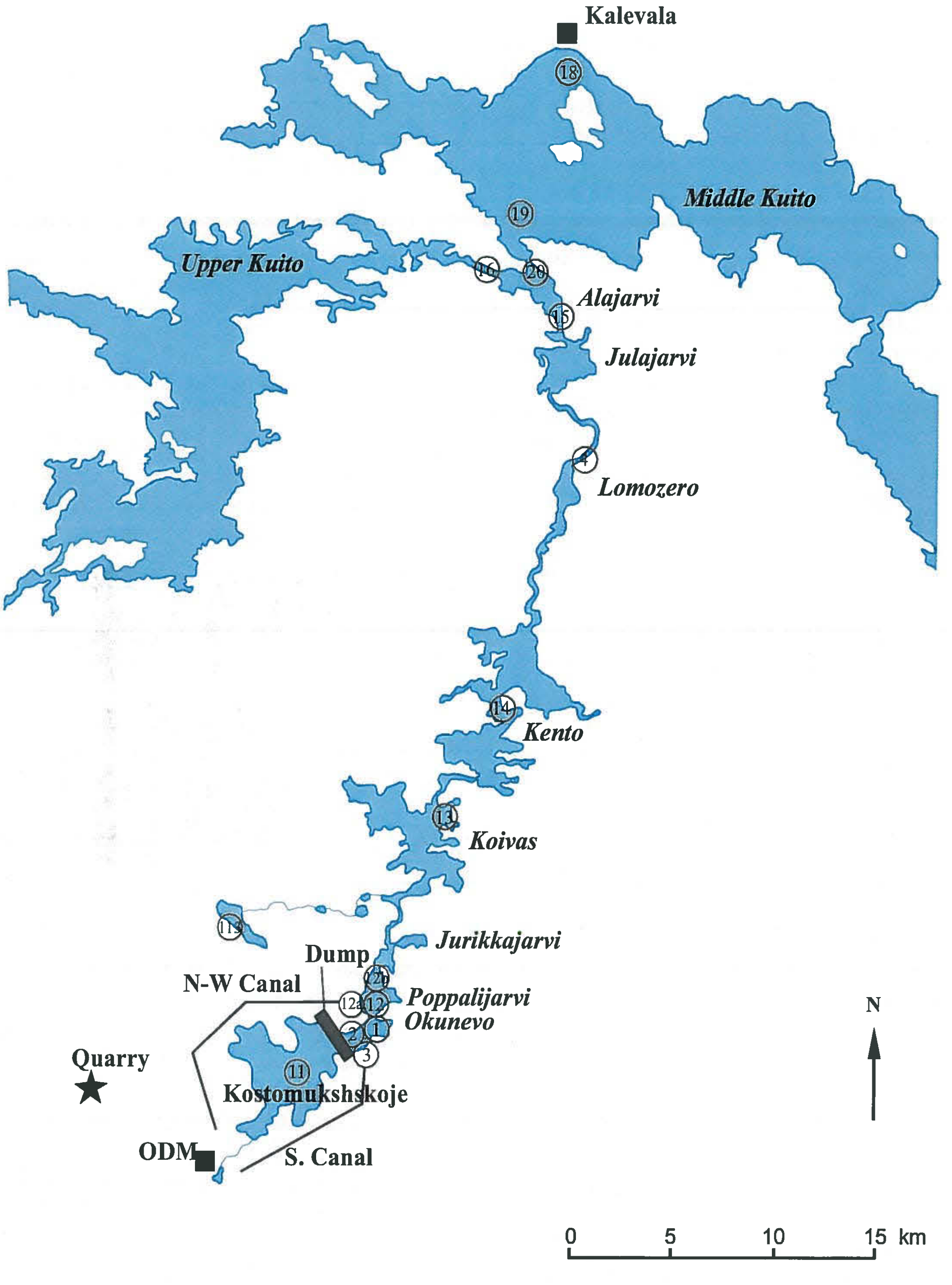

Fig. 1. Kenti river system (water bodies of the Kostomuksha area)

Results and discussion

Before the mill started operating nitrogen compounds in lakes Kostomukshskoje (here tailings dump) to Apajarvi were represented primarily by the organic form (N_{org}), whereas the nitrate form was as a rule absent (no more than 0.1 mg N/n). The oxygen saturation conditions were favourable for aquatic organisms and fish fauna.

Later investigations revealed man-induced modifications in the water chemical composition in the lakes of the drainage basin.

Pollution of the Kenti river system can be regarded as purely mineral pollution. The heaviest anthropogenic loads on the system water bodies in the latter years were those of potassium and nitrates. We are speaking here about pollution with nitrogen compounds.

Analysis of the Kostomuksha ODM process sewage showed it to contain considerable amounts of nitrogen (N). Particularly high N concentrations were recorded in mining waters as a result of blasting. Explosives contain organic nitrogen compounds (TNT, PAA) that disintegrate down to inorganic compounds upon ignition.

Concentrations of 87-170 mg N/n total nitrogen, 49-83 mg N/n nitrate nitrogen, 2.8-4.3 mg N/n nitrite nitrogen and 23-72 mg N/n ammonium nitrogen were recorded in the mining water. These concentrations were more than 100 times greater than in samples from lake Srednee Kuito that can be regarded as background for the water bodies.

The biogenous elements composition in the tailings dump was also found to include considerable concentrations of nitrogen compounds, primarily nitrates. In 1999 their concentration reached 6.7 mg N/n.

As has already been said a source from which various nitrogen forms are supplied is the mining water pumped out of quarries.

Biotesting was used to reveal the toxicity of the process-generated water. It demonstrated that the tailings dump water and seepage did not produce any effect on the survival of *Daphnia magna*, and the LT_{50} value (concentration at which 50% of the animals die) for *Simocephalus serrulatus* was between 12-72 hours in the tailings dump water and 12-96 hours in the seepage water. Twenty-time dilution resulted in a harmless concentration.

Mining water caused intoxication in both crustacean species. LT_{50} for *D. magna* was 96 hours and for *S. serrulatus* 6 hours, which suggested the conclusion about heavy toxicity of the water.

Process-generated water inflow to the Kenti river system tells first of all on small upstream lakes: Okunevoje, Kurojarvi, Poppolijarvi and Jurikkajarvi. Further downstream the concentrations of pollutants, including nitrate and organic nitrogen, decrease due to dilution (Fig.2)

The general trend of the curves reflects an increase in nitrate concentrations in all water bodies of the system caused by elevating discharge volumes and partial accumulation of the pollutants in the lake system.

At present the nitrogen compound composition is dominated by nitrates. Their concentrations range widely enough from 0.41 in Jullajarvi to 6.39 in lake Okunevoje. Nitrites in concentrations from 0.024 mg N/n in the upstream to 0.002 in the downstream lakes were recorded (1999 data). The concentrations of total nitrogen (0.42-0.53 mg N/n) downstream from lake Kento are typical (background) for light-coloured lakes in their natural state.

Nitrate content that in the tailings dump water remained practically the same as in the previous year grew 2-3-fold in the Kenti river system lakes. The steep increase of nitrate concentrations in the upstream lakes of the system was caused primarily by emergency mining water discharges not through the tailings dump but directly into the system in 1994, 1997 and 1999 (Fig.2).

A general tendency towards a year-to-year increase in the content of nitrogen compounds is observed. Even in lakes like Koivas and Kento, where pollutant concentrations are generally not high owing to dilution, nitrate (NO_3) content was found to have increased lately.

Considerable oxygen deficiency has been observed lately in the lake bottom layers in the winter period. In the winter of 1999 water saturation with O_2 was 31% (minimum) by the bottom of lake Okunevoje, and 49% (maximum) in lake Kento. One of the possible reasons for the unfavourable phenomenon is an increase in organic nitrogen content. Reduced dissolved oxygen content drastically deteriorates the water quality and induces a situation critical for aquatic organisms (Fig.3).

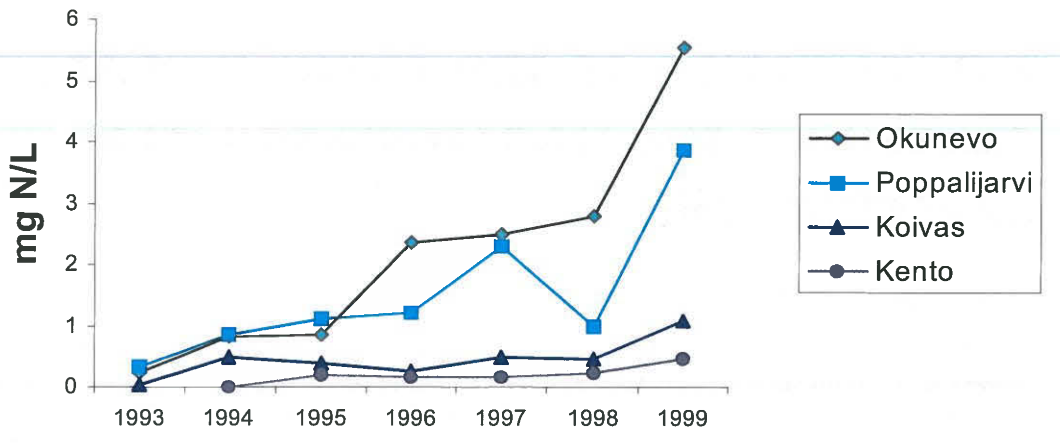

Fig. 2. Annual means of nitrates in Kenty system lakes

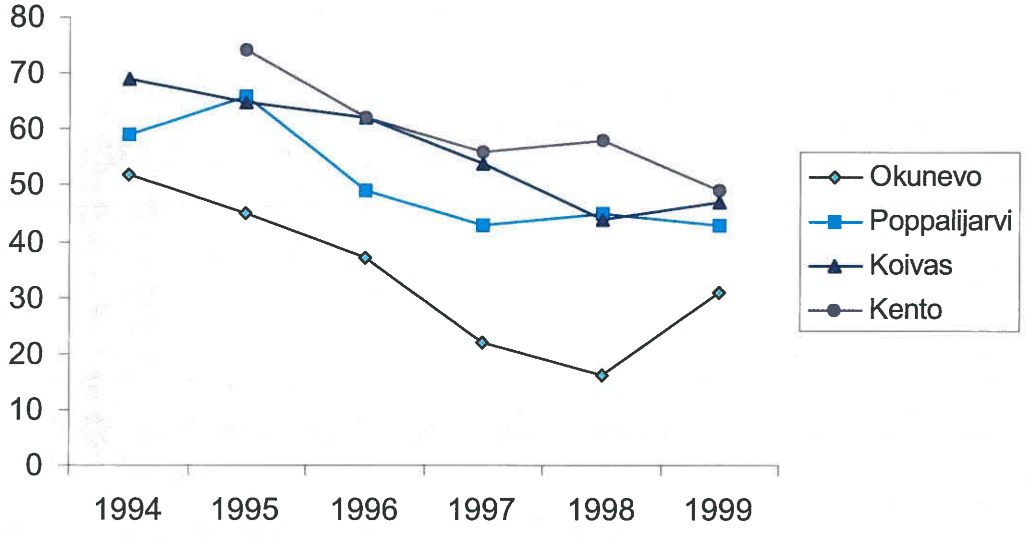

Fig. 3. Oxygen in lower lays of Kenty system lakes (% saturation)

Conclusion

1. Current anthropogenic load on the Kenti river system lakes is comprised of discharges from the tailings dump, as well as pollutants from non-point sources carried by seepage, mining and discharge canal waters.
2. One of the main consequences of industrial load on the hydrochemical regime in the water bodies belonging to the system in question is pollution with nitrogenous substances, primarily nitrates.
3. Generally, nitrate concentrations in the tailings dump and some upstream lakes are continuously growing, and may reach maximum permissible values in the coming 2-3 years, whereupon effluent discharges will have to be controlled with respect to nitrate concentrations.
4. Increased N_{org} content appears to be related to the emerging tendency towards growing oxygen deficiency in the bottom water layers of the lakes.

Air pollution of the environment caused by the Kostomuksha Ore-dressing Mill

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Introduction

The basic source of air pollution in Kostomuksha is the emissions from the ore-dressing mill, the most part of which are sulphur dioxide and dust (Table 1).

Table 1 Emissions of pollutants in Kostomuksha from 1993 till 1998 (thousands of tons).

Year	Dust	SO_2	CO	NO_x	Total
1993	5,30	53,0	0,60	1,60	61,60
1994	6,40	48,0	0,60	1,50	57,50
1995	4,96	44,59	0,55	1,26	52,24
1996	6,36	47,42	0,52	1,19	55,57
1997	5,99	32,24	0,89	1,51	40,85
1998	6,42	37,68	0,91	1,56	46,79

It should be mentioned, that the greater part of the emissions of the sulphur dioxide , as well as dust starting from 1997, occur mostly in Kostomuksha in comparison with the other industrial centers of Karelia (Fig. 1, 2).

At the same time, in comparison with such metallurgical plants as "Severonickel" and "Petchenganickel", located on the Kola peninsula, the emission of SO_2 in Kostomuksha is 20-30% of the emissions at each of the specified mills.

Materials and methods

Precipitation monitoring was conducted during maximum snow accumulation period (late March - early April). Snow samples were taken 3, 10, 24, 40 and 60 km away from the Kostomuksha Ore-dressing Mill north - northwestwards, and also north - northeastwards towards Kalevala (3; 7,5; 10; 15; 25; 45 and 60 km), southwestwards (40 km from the ore-dressing mill on Lake Kamennoye), south-eastwards towards Lake Nyuk (3, 10, 20, 40 km) and around Kostomuksha.

The results of the research of the chemical composition of precipitation, conducted in the laboratory of hydrochemistry of the Northern Water Problems Institute in 1993 - 1998, are reported in this paper, and those conducted in 1993 with the assistance of the Kainuu Regional Environment Centre.

The snow samples were delivered to the laboratory, where they were thawed at room temperature. The chemical analysis of the snowmelt water was performed by using methods similar to those used for surface water sources samples.

The amount of chemical deposition with snow was calculated according to the formula Dm = Cs30Ws/ Dt, where

Dm - monthly fallout, (mg/l)

Cs - concentration of a component in snowmelt water, (mg/l)

Ws - water content in snow, (mm)

Dt - time of fallout, (day).

In 1994-1998 the water content in snow was not determined during sampling, therefore there are no observations for this period, Ws was assumed to be equal to the mean value of water content in snow in 1993 (191 mm).

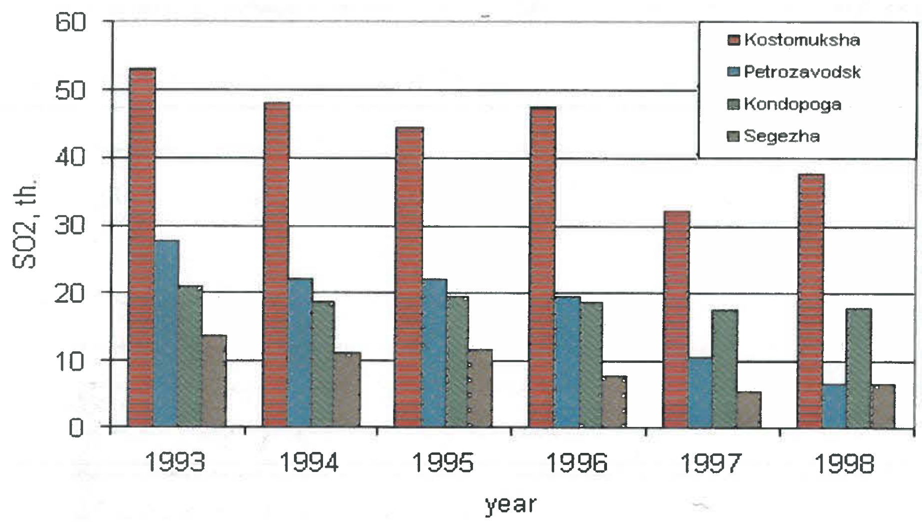

Fig. I .So_2emission from industrial centers of Karelia.

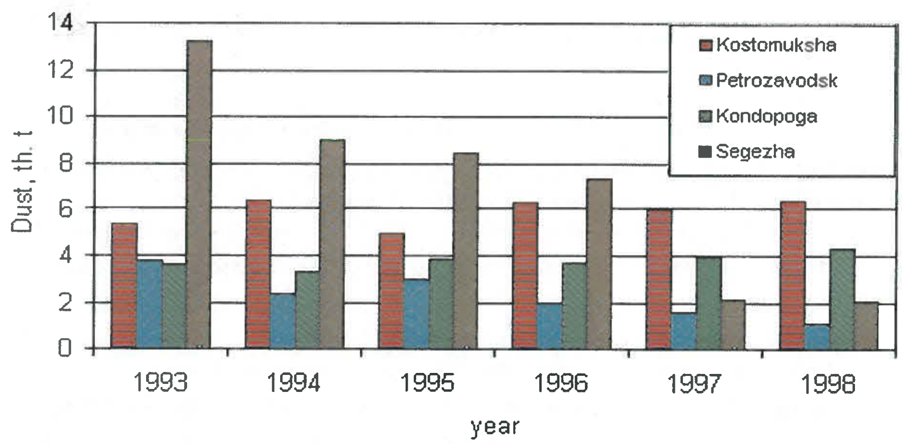

Fig.2. Dust emission from industrial centres of Karelia.

Results and discussion

The ionic composition of snowmelt water in the vicinity of the ore-dressing mill is characterized by a high content of Ca (up to 2,7 5 mg/l) and K (up to 7,0 mg/l) ions. On the average the concentration and the amount of fallout of these elements make 0,94 mg/l (36,9 mg/m^2 per month) and 2,05 mg/l (80,4 mg/m^2 per month) accordingly. In the samples collected at a distance from the mill, the content of these substances is lower, and on the average it makes Ca - 0,37 mg/l (Dm - 17,9 mg/m²per month), K - 0,15 mg/l (Dm - 13,4 mg/m² per month) (Fig. 3), which, however, exceeds the mean values in Finland Ca - 8,0; K - 3,4 mg/m² per month

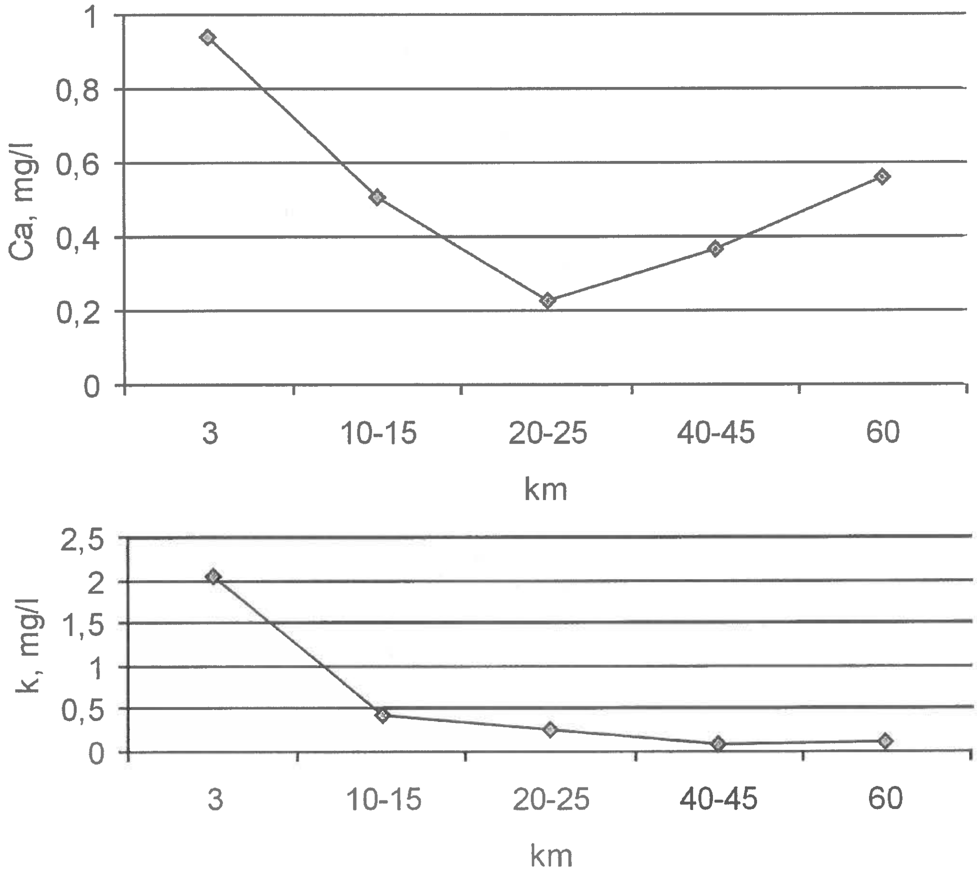

Fig. 3. Ca and K contents in atmospheric precipitation.

The high concentration of hydrocarbonates (up to 5,2 mg/l) corresponds to the high concentration of potassium. It is determined by the influence of solid pulp exhausts which occur during the alluviation on the dam. On the average the amount of HCO_3 - fallout is 197 mg/m² per month In the rest of the samples the hydrocarbonates are not to be found, what is also confirmed by the acidic quality of the precipitation (pH < 5,0).

The Mg (up to 0,45 mg/l) and Na (up to 0,8 mg/l) content in snow samples is rather low, irrespective of how far from the mill the samples were collected.

The value of pH in the majority of snow samples is below the equilibrium value for precipitation (5,6), and on the average it makes 4,91, which is close to the mean value in Karelia (4,8). Higher pH values are observed in the samples collected within the 3 km range from the mill (northeastwards 6,93, southeastwards 6,0 and northwestwards 5,77) (Fig. 4).

Strong acids fallout around the mill makes only 0,005-0,07 mmol/m² per month, while beyond the 10 km range it goes up to 0,5 mmol/m² per month The latter values are close to the mean values in Karelia. It appears to be impossible to specify in particular the fallout of strong acids, connected with the emission of oxides of sulphur and nitrogen from the Kostomuksha Ore-dressing Mill and their fallout caused by transboundary transport. In any case, in the vicinity of the mill the environment is affected by

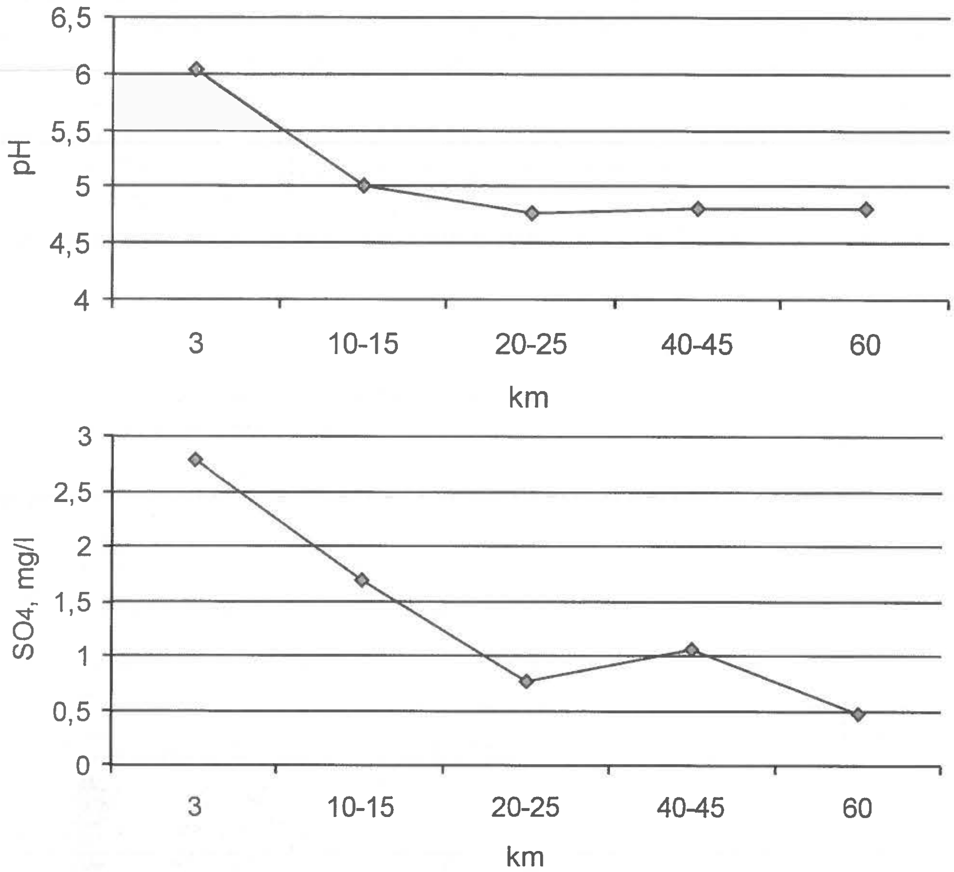

Fig. 4. pH and SO_4 content in atmospheric precipitation.

acidity to a much smaller extent than at a distance from it. And this fact is contrary to the situation at the plants in "Severonickel" and "Petchenganickel", where the precipitation acidity is most intensive in the impact zones.

The content of sulphates varies broadly (0,3-8,04 mg/l), and their greatest concentrations are found in the samples collected around the mill, where pH values are increased (Fig. 4). The average content of sulphates in this area makes 2,79 mg/l, the amount of fallout 109,4 mg/m^2 per month The fallout of sulphates as salts here reaches 98 %. At a distance from the mill the tendency of decrease of the contents of sulphates as salts and an increase of their contents as acids is observed, and the amounts of fallout make 19-66 mg/m^2 per month

The concentration of chlorides in snow is moderate and on the average it makes 0,55 mg/l, the amount of fallout - 21,3 mg/m^2 per month, what is close to the mean values in Finland (19,6 mg/m^2 per month).

In the distribution of nitrous matters the dominant form in precipitation is represented by nitrates, the content of which makes 0,24 mgN/l. It is followed by ammonium (on the average 0,094 mgN/l). The nitrite content is rather insignificant (on the average 0,002 mgN/l). The N_{org} content is lower, than the sum of its mineral forms (on the average 0,014 mgN/l). And the concentration of all mineral forms of nitrogen were lower than the average values in Finland ($N\text{-}NO_{2,3}$ = 0,351 mg/l, $N\text{-}NH_4$ = 0,196 mg/l).

The concentration of P_{total} in most samples did not exceed 50 mg/l. However, it exceeded the mean values in Finland P_{total} = 18,7 mg/l.

No significant variance in the distribution of nutrients in the vicinity of the mill and at a distance was detected.

Of trace elements the tendency of Fe_{total} contents increase is observed. Its highest concentration is detected in the samples collected in the vicinity of the mill, especially north-eastwards 1,14; 1,36 mg/l and south-eastwards 0,75 mg/l, and on the average it makes 0,71 mg/l (the fallout value - 27,8 mg/m² per month). These values exceed by far those determined earlier in 1987-1990. The amount and value of iron fallout at a distance from the mill make 0,09 mg/l and 3,53 mg/m² per month (Fig. 5).

According to the data of 1993 in sample collection points located near the mill increased concentrations of aluminum (160 mg/l, Dm - 6,4 mg/m² per month; as well as in Kamalahti - 240 mg/l, Dm - 10,9 mg/m² per month), nickel (3 mg/l; 123 mg/m² per month), and vanadium were detected. The contents of the latter in snow (0,14-9,1 mg/l) and the amount of its fallout (3,31 - 405 mg/m² per month) increase sharply in the direction of the mill.

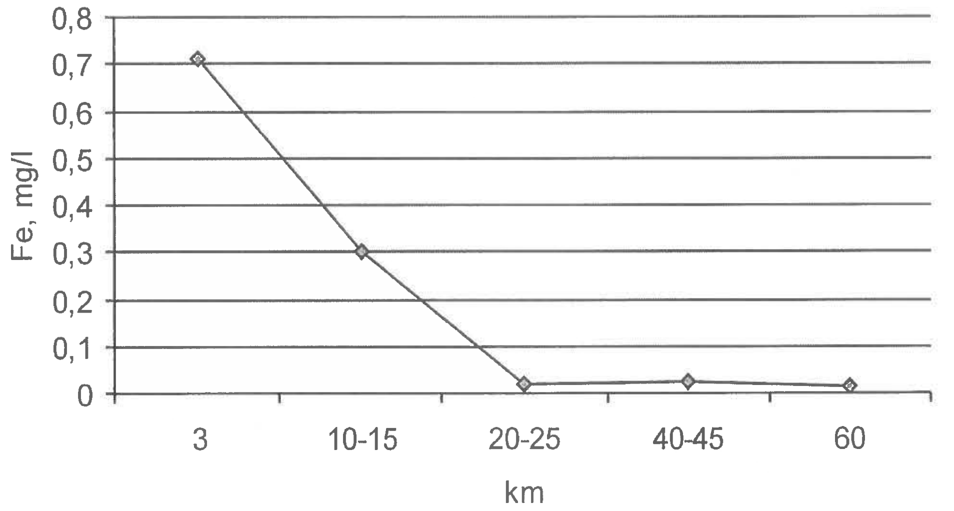

Fig. 5. Fe content in atmospheric precipitation.

Conclusions

In conclusion it can be stated that in snow samples collected in the vicinity of the ore-dressing mill, high concentrations of Ca, K, sulphates as salts (with high pH values), and also Fe total, Al, V, Ni are observed. A higher content of sulphates (with low pH values) at a distance from the mill is due not only to sulphur dioxide exhausts from a local source, but also to the transboundary effect.It is difficult to distinguish between their contributions. As a result, it is possible to state that the influence of the Kostomuksha Ore-dressing Mill shows within the 3 km range, and up to 10 km north-northeastwards, and it is basically due to the fallout of the salt forms of elements, but not acid. The fallout of sulphates is 1,2- 4 times higher than the maximum load values (0,3 g/m² per year), adopted for Northern countries, and at a distance of over 60 km away from the mill they do not exceed the critical load value.

Estimation of the stability of the development of birch (Betula pubescens) as a component of an integrated estimation of a natural complex

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Introduction

Different approaches can be used for the assessment of environment quality. Thus, basic information on any global and local environment changes, and on the content of various pollutants in different components of ecosystems is required. But it is necessary to take into account that the number of pollutants and other type of influence on environment is quite large (thousands of names) and continues growing. In such situation obtaining integral information about the quality of environment under any influence seems to be very important. To reach this purpose is possible by means of the living beings state assessment necessary for obtaining information about environment health.

Defining the environmental health degree deals with the health of an ecosystem, that is to say the health of all its components – different kinds of living beings (Захаров et al. 2000a, b). The offered system of biological monitoring presents different approaches to the assessment of the state of various populations under the influence of both natural and anthropogenetic factors (Захаров et al. 2000a, b). Efficiency of physiological processes is a fundamental parameter of such state. Violation of physiological processes shows after-effects, which can be assessed according to the degree of fluctuating asymmetry.

Plants are extremely important and interesting objects for defining environmental health; they assimilate substances and undergo the direct effects of both soil and air.

Specific character of plants makes definite demands for choosing species. Thus, the following features should be taken into account:

- wood plants are better to be used for the assessment of major terrains;
- possible difference in stability of the development of hybrids and initial forms should be taken into consideration;
- for a matter of convenience while assessing the value of fluctuating asymmetry, species with definitely asymmetrical leaves should be avoided.

Materials and methods

Proceeding from the above set criteria as object of research, *Betula pubescens* is chosen. The species under review is widely spread in the territory being explored and the five-mark scale was empirically developed for it.

There are no principle limitations for choosing characteristic features to be investigated. The only requirement is the simplicity of their definition. Reliable results can be obtained while using not only one, but several characteristic features.

The following five bilateral measurements of a leaf-blade appeared to be the simplest and the most convenient way of obtaining large amount of data (Захаров et al. 2000a):

· half-leaf width (the measurements were taken in the middle of a leaf-blade;

· length of the second nerve from the base of a leaf of the second order;

· distance between the bases of the first and second nerves of the second order;

· distance between the ends of these nerves;

· angle between the main nerve and second (from the base) nerve of the second order.

For the assessment of stable development violation the five-mark scale was used (Table 1.), number 1 being the conditional norm, and number 5 being the critical value (Захаров et al. 2000 a, b).

Table 1. Five-mark scale of an assessment of a condition of an organism on size of an integrated parameter of stability in development for a birch.

Number	Value of a parameter of stability of development
1	<0,040
2	0,040 – 0,044
3	0,045 – 0,049
4	0,050 – 0,054
5	>0,054

Asymmetry degree of every plant was defined according to measurements. Population assessment is expressed by the arithmetical mean of those asymmetry degree. The statistical importance of differences between samples is defined according to the T-criterion of Student.

1. The relative size of asymmetry for every characteristic feature is calculated when difference between left and right measurements is divided by the sum of these measurements;
2. By summing relative degrees of asymmetry for every characteristic feature of each leaf dividing them the number of those characteristic features, the degree of asymmetry for every leaf is calculated;
3. By computing the arithmetical mean of all asymmetry degrees for each leaf, the integral index of stability of development is calculated.

In July-August 2000 field material was collected in seven sample sites (Fig. 1). 1) 4 km to the south-west and north-east from the Kostomukshski ore dressing combine and concentrating complex (SS 6 and 7). 2) In the boundaries of the Kostomuksha town (SS 3-5). 3) In the territory of the Kostomuksha Nature Reserve (SS1 and 2).

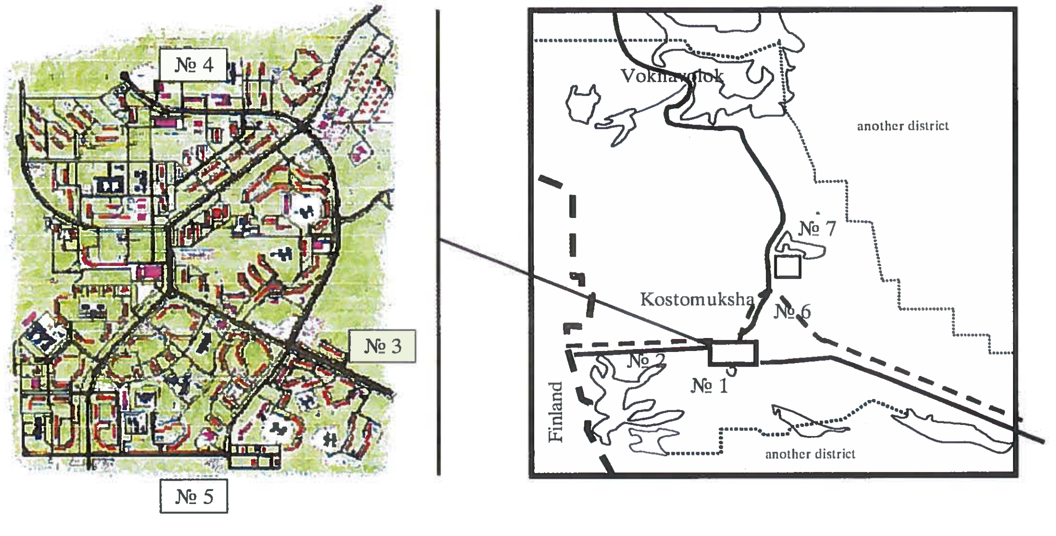

Figure 1. Location of the sample sites

100 leaves from 10 trees (10 leaves from every tree) were taken in each sample site. In whole 800 leaves were gathered.

Results

The leaf blades asymmetry analysis showed the largest asymmetry degree of the plants (on the average > 0,054) growing in the immediate proximity to the dressing combine (Fig. 2.).

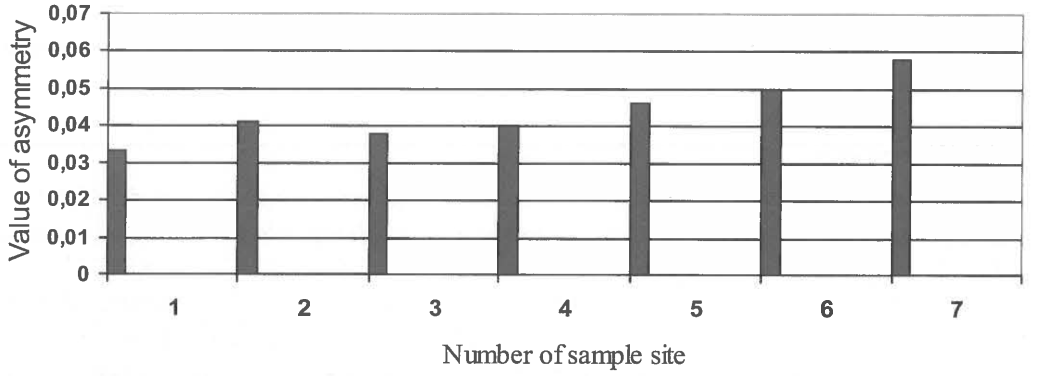

Figure 2. Values of asymmetry in different sampling sites.

Within the boundaries of Kostomuksha town the degree of the stable development violation considerably decreases, that means slight and average degree of depression (on the average 0,043 - 2 points). But sometimes (in radius, approximately, 1 kilometer) stability of degrees varies from 1 to 3 points. In the territory of Nature Reserve the asymmetry of the leaf blades appears to be slight – SS1 – 0,034, SS2 – 0,042, insignificant increasing of the last index can, probably, be explained by influence of the transport exhaust.

Thus, the pollution degree in the immediate proximity to the dressing combine can be defined as strong. On this stage of influence the violation accurately and quickly defined with the present method of biological testing of an environment. This method is very simple and is effective, particularly for assessing the pollution degree in the large territory.

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Hierarchy levels of biological systems and principles of biological indication

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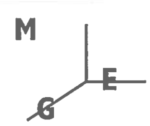
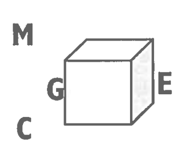
Introduction

The application of systems approach in ecological investigation has shown the most essential value within the methods of delimiting of biological systems. In the nature only the organisms are really substantially observable. They can be integrated to populations, communities and other of the overorganism systems in the subsequent analysis. A solution of a problem of the biological systems' hierarchy be intimately connected to a problem "What kind of principles can be used for the overorganisms systems delimiting for a solution of practical problems?".

As against inert substance, the biological systems have differentiation of the energy balance mechanisms' stabilization (homeostasis), extrinsic choronomic and intrinsic of environment (Ленинджер 1976, Джанколи 1984). This feature determines the differentiation of biological species on a sex (Геодакян 1987), even for some bacteria.

This feature determines general four-dimensional structure of a phase space of biological species in general hierarchy of material systems. Formally it can be presented by the way of mathematical description of linear space, or algebra (numerical series Fibonacci) and geometric (locomotion of a point in different frames of axes) interoperation (Table 1).

Table 1. Phenomenology of biology levels.

Hierarchy level	Type of correlation	Geometric interpretation	Algebra interpretation
Organism (Шмальгаузен 938)	**G**enomic: **M**orphogenetic, **E**rgontic		3
Population	**G, M, E +** **C**ommunicative		5 (4+1)
Community	Spectrum	?	8 (7+1)

Шмальгаузен (1938) proposed 3 types of correlations (genomical, morphogenetic and ergontic) (Table 1). These 3 types of correlations define an organism as a whole in individual and historical development. They correspond to three fundamental physical types of interactions. But in a population the organisms are differentiated on sex and age. Therefore, there is a fourth type of correlation, which is similar to gravitational force of interactions. This communicative type of correlations has the inductive nature (as it is gravitational force of interaction) and dominates on a population hierarchy level. The community level is probably similar in nature to a spectrum and is presented by a more complex form of correlative interactions. All four types of correlations determine various functional levels of the hierarchy of biological systems.

The biological hierarchy can be considered as function (Энгельгард 1994). It is utilizing the logic of fundamental forces of physics interaction. For each level biological hierarchy it is possible to define a small number of signs that determine its as a whole. These signs can be used as indicators (Table 2).

Table 2. The signs of biotest in accordance with the hierarchy levels of biological systems.

Biological level	The sign
Organism	Asymmetry of bilateral features or phenetic signs
Population	Sex-age structure
Community	Structure of contacts between biocenotic groups

The analysis of small mammal fauna state is based on physical principles of biological systems organization at different levels of their function hierarchy.

Material and methods

In 1987-98, a series of biocenotic groups of small mammals were investigated in Kostomuksha Nature Reserve: 1) in the area with agri-technogen influence (Sample Sites 1, 5 & 7); 2) in undisturbed forests (SS 2, 4, 6 & 8) and in the area of agri-recreational influence (SS 3).

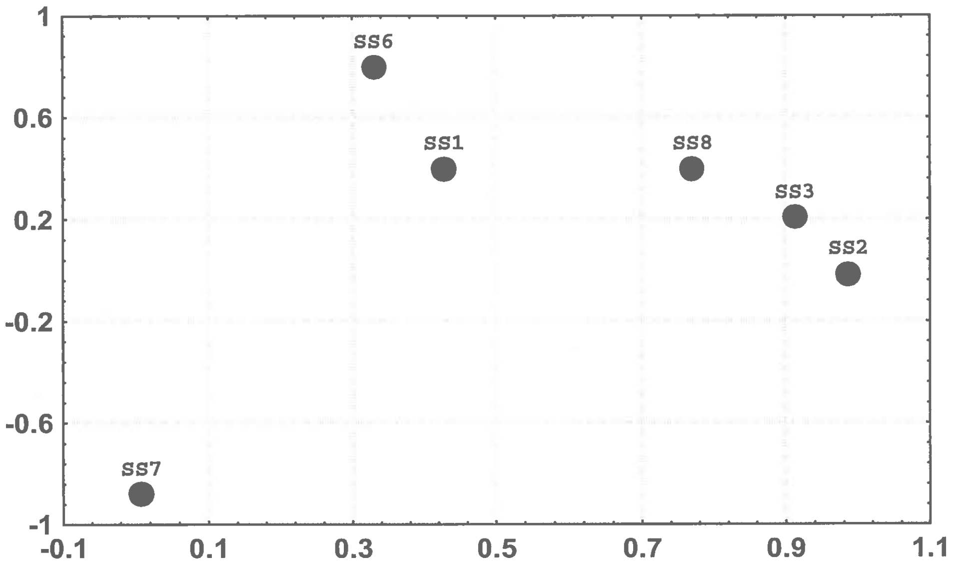
Data on species composition and number were collected by means of standard methods: line traps (25 traps every other 3 - 5 m) and ditch trap (20 m length with 2 cones) (Кучерук & Коренберг 1964). Some of the material was obtained from the soil traps (Фасулати 1971). On every sample site animals were caught in bilberry and lingonberry pine forests, in bilberry and green-moss spruce forest, in birch forests and swamps. Traps of SS 1, 3 and 5 were on a meadow, and traps of SS 2 were in pine *Ledum* forests. The distance between the first and the last lines on every SS was from 1,5 to 4 km.

Biocenotic distribution of animals, and breeding of the bank voles was analysed with the method of principal components. Relations between their biocenotic groups were assessed with the help of algebra logistic methods.

Results

The analysis of the distribution of the phens of bank vole on SS 1 – 3 and 6 – 8 (Fig. 1) shows that in the industrial pollution zone of the Kostomuksha ore dressing plant (SS 7 4 kms north-east), the number of voles with signs 3 and 7 is higher. At other SS, where pollution was weak or absent, the number of individuals with signs 1 and 2 was higher.

The analysis of the sex-age structure and breeding of bank vole populations at four SS (Fig.2.) has shown major differences between SS 1, SS 4 and SS 5 (distance between them does not exceed 6 kms). In 1994, the pollution level was higher than background on SS 5. The difference was absent on SS 2 and 4 of undisturbed forest zones, although the distance between the sites is 22 km.



Note:

NN	phen	Factor I	Factor II	Description of bank vole phens (for a tail)
1	111	1,77	-1,24	**1 – short**
2	112	0.97	0.64	**2 – lengthy**
3	**121**	**-1.01**	**-0.89**	**1 – thin**
4	122	-0.61	0.30	**2 – thick**
5	211	0.37	1.88	**1 – naked**
6	212	0.16	-0.36	**2 – fluffy**
7	**221**	**-0.76**	**-0.65**	
8	222	-0.89	0.30	

Fig. 1. The distribution of phens in the populations of bank vole on sample sites 1-3 and 6-8 in Kostomuksha Strict Nature Reserve and Kostomuksha area in 2000 (organism level).

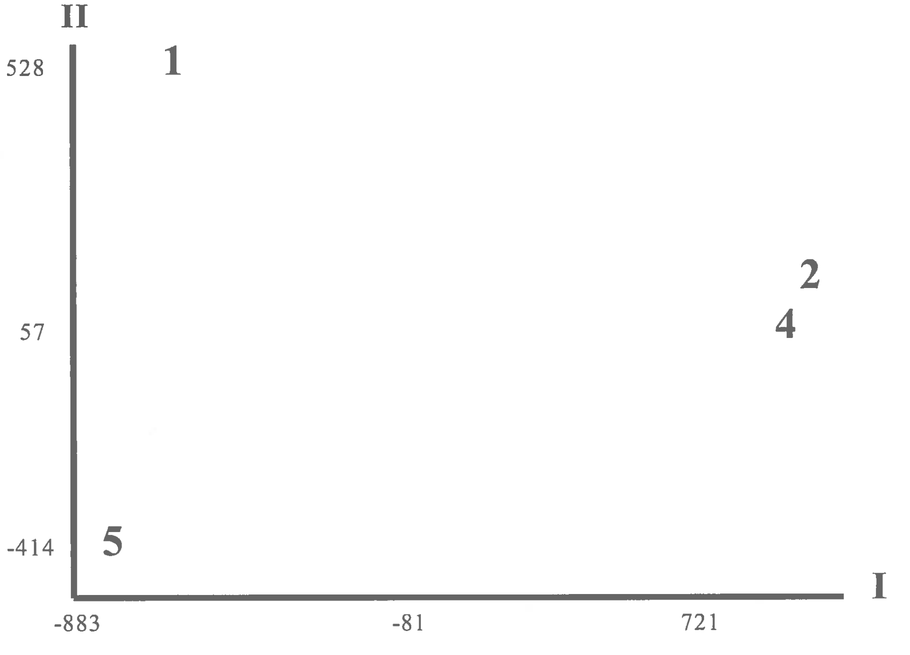


Fig. 2. The breeding of the bank voles in four areas of the Kostomukshski Nature Reserve in 1994 (population level). Sample sites 1 and 5 are from the human disturbance zone, and sites 2 and 4 from the undisturbed forest zone.

In a community it is possible to define species, which are poorly resistant to the effect of a complex of environmental factors (Table 3, Fig. 3, Factor III). Analysis of the species composition and numbers of populations of SS 1-3 and 5 shows: on SS 1 and 5 (the agri-technogen infringements' zone) the greatest suppression was shown by a population of masked shrew (3) (Fig. 3). On SS 2 (undisturbed forest zone) the environment was pessimum for the population of lesser shrew (5) (Fig. 3). In spite of the fact that in 1996-97 on all the territory of the Russian-Finnish Friendship Reserve the large-scale breeding of wood lemming (8) (Fig. 3) was observed. On SS 5 its number, however, remained low, as well as during the suppression years. The latter fact, probably, is explained by a longer process of populations' restitution of small mammals after industrial pollution observed on SS 5 in April 1994, than in undisturbed forests. In agri-recreation areas (SS 3) the field vole (4) and root vole (9) (Fig. 3)could resist the environment very poorly. In fact, in the spring and summer of 1999 18 and 39 field voles were caught in SS 3, respectively. In the autumn, the number of field voles caught was only **7.** So the population became **5.6** times smaller. These species can be considered to be qualitative indicators for assessing the environment of the whole community.
The structure of a small mammal community (species composition and number of populations) is closely related to the common infrastructure of landscape's area, the degree of its transformation by human activity.

The results obtained suggest that the populations of species located in a constantly depressed state on the part of integrated action of the environmental factors can be used as indicators of industrial pollution.

Table 3. The number of the small mammals in biocenoses in 1995-98 on SS 1, 2, 3 and 5. I, II and III are complex environmental factors. 1 - bank vole (Cl. g.); 2 – common shrew (S. a.); 3 – masked shrew (S. c.); 4 – field vole (M. a.); 5 – lesser shrew (S. m.); 6 – graves shrew (S. i.); 7 – large-toothed redbacked vole (Cl. rf.); 8 – wood lemming (My. s.); 9 – root vole (M. oe); 10 - water shrew (N. f.).

	SS1	SS2	SS3	SS5	SS1	SS2	SS3	SS5	SS1	SS2	SS3	SS5
	Factor I				Factor II				Factor III			
1. Cl.gl	-0,146	0,783	0,823	-0,55	0,933	0,233	0,034	-0,02	0,058	0,465	0,296	0,624
2. S.a	0,153	0,837	0,407	-0,53	0,567	0,271	0,874	0,136	0,16	-0,06	0,209	0,624
3. S.c	-0,41	0,107	0,718	0,244	-0,14	0,76	0,175	-0,78	-0,79	0,612	-0,18	-0,13
4. M.a	0,284	0,153	-0,37	0,142	0,927	0,85	-0,3	0,088	-0,13	0,033	-0,67	0,922
5. S.m	0,113	-0,17		-0,9	-0,3	0,156		0,021	0,666	-0,95		-0,1
6. S.i	-0,971		-0,08	-0,85	-0,07		0,957	0,126	-0,09		-0,08	0,177
7. Cl.rf	0,971	-0,27		0,367	0,073	-0,82		0,638	0,094	0,247		-0,47
8. My.s	0,071	0,788	0,972	0,053	0,79	0,233	0,068	-0,83	-0,47	0,313	0,088	-0,31
9. M.o	-0,305		-0,61	-0,11	0,555		-0,15	0,21	0,674		-0,72	0,856
10. N.f	0,971	-0,64	-0,29		0,073	0,431	-0,17		0,094	0,44	0,793	
Expl.Var	3,23	2,484	2,906	2,36	3,108	2,37	1,86	1,8	1,81	1,843	1,768	2,732
Prp.Totl	0,323	0,31	0,363	0,262	0,311	0,3	0,23	0,2	0,18	0,23	0,221	0,304

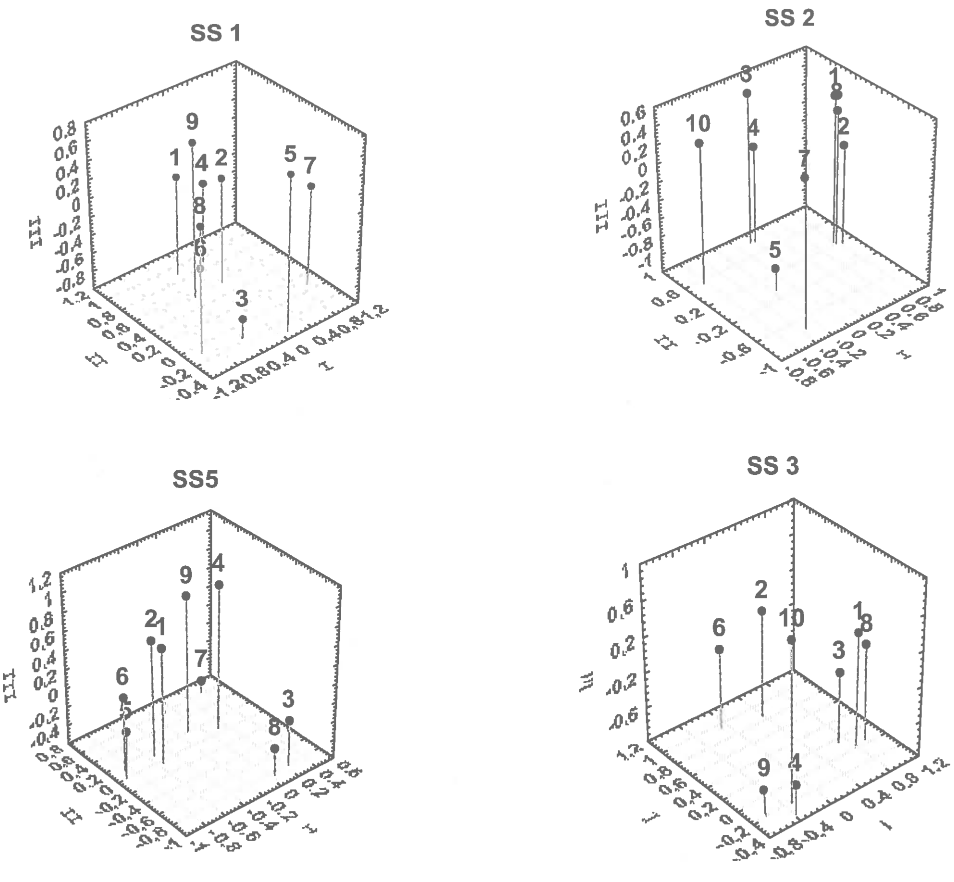


Fig. 3. Biocenosis distribution of small mammals species (1 – 10) on SS 1, 2 and 3 in Kostomuksha Strict Nature Reserve in 1995 – 98. 1 bank vole; 2 common shrew; 3 masked shrew; 4 field vole; 5 lesser shrew; 6 graves shrew; 7 large-toothed; 8 wood lemming; 9 root vole; 10 water shrew

The comparative analysis of the structure and number of species in biocenotic groups of small mammals at three sample sites in the Friendship Reserve in 1995 - 1998 (Table 4) is presented by a series of examples illustrating the lowering of animals' level of life.

Table 4. The biotopical difference of the environmental quality in the various natural reserve zone (community or landscape level).

SS 1) (the agriculture zone): *meadow > birch forest > green-mossy spruce forest* > bilberry spruce forest > bilberry pine forest > mire > lingonberry pine forest

SS 3) (the agriculture zone): *meadow > birch forest > green-moss spruce forest* > bilberry pine forest > bilberry spruce forest > lingonberry pine forest > mire.

SS 2) (undisturbed forests zone): *birch forest > bilberry pine forest > ledum pine forest* > bilberry spruce forest > green-mossy spruce forest > lingonberry pine forest > mire

Biocenotic rows are organised in accordance with the degree of habitats aggravation. The analysis of these rows shows that in agricultural areas biocenoses of anthropogenic parentage (meadows and birch forests) and slightly disturbed grassy spruce forests have the greatest importance in the formation of the population

Other biocenoses are less significant. Nature complex of undisturbed forests, especially light coniferous and deciduous forests, ensures stability of existence of small mammals' populations. Because of human invasion into nature complexes of the North European taiga different communities choose different habitat conditions ensuring their stability. In anthropogenically influenced areas soil cover protected from precipitation seems to be a factor of priority. In undisturbed taiga ecosystems the role of such priority factor plays habitats insulation.

Conclusion

Each hierarchic level of the biological systems has a small number of it as signs, which occur for the first time at this level and characterise functionally as a whole. These signs can be utilised as integrated bioindicators of environmental health. The more differentiated the system, the smaller the number of such signs it includes. The hierarchic level of the biological systems has a small number of it as signs, which occurs for the first time at this level and characterizes functionally as a whole. These signs can be utilized as integrated bioindicators of environmental health. The more differentiated the system, the smaller the number of such signs it includes.

As such integrated signs, probably, it is possible to consider the following:

- *organism* – asymmetry of bilateral morphological features (Захаров et al. 2000) or frequency of occurring of organisms with different phens in a population;
- *population* - sex-age structure of population;
- *community* - structure of contacts between biocenotic groups.

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Finnish-Russian co-operation in environmental education

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The idea of environmental education is to increase the level of ecological, social and cultural sustainability. One of the aims of Finnish-Russian co-operation in environmental education is to make people understand that nature does not know any borders. It is also work to lower prejudices between nations.

Fig. 1. Heads of the cooperation partners, Ms. Merja Väisänen from Metsähallitus and Mr. Sergei Tarhov from Kostomuksha Nature Reserve.

When the Nature Reserve Friendship was established, the co-operation was on a rather abstract level, mainly meetings of directors and making plans for future actions. Now we have stepped to more concrete work.

Part of the co-operation is financed by both organisations, Metsähallitus and Kostomuksha Nature Reserve, but main financiation comes from the Finnish ministry of the Environment from the budget for cross-border co-operation. This extra budget has made it possible to expand the common activities.

For four years we have made a written plan for co-operation between the Friendship Park and the Kostomuksha Nature Reserve. This plan can be clearly divided into four sections: development of co-operation, environmental education, management plan and development of ecological tourism. In the field of environmental education the common works are divided into visits of school groups, participation in the March for Parks -happening, creating relationships between the Finnish and Russian schools and development of the methods of environmental education. Environmental education is, however, included in all co-operation. It can not be separated from other concepts.

On Finnish side of the Nature Reserve Friendship environmental education is mainly dealt with in the Kainuu Nature Centre according to the principles of education in Metsahallitus. In our work the presence of the Research Centre of Friendship park is a great help and support. By combining the forces of these three organisations - Metsahallitus, Kostomuksha Nature Reserve and the Research Centre of Friendship Park - we have been able to do much more than any of these would have done alone.

During only a few years this work has received many forms. Some examples:

March for Parks

Already four years the Friendship Park has participated in the March for Parks -happening in Kostomuksha. Finnish school children have sent their drawings, stories and other works to Kostomuksha and joined the competitions and exhibitions. For three years now the best parts of these works have been collected into a booklet, which every participant gets and which will remain as a concrete remembrance for future times. So far Finnish school groups have not attended the main festival, but the staff of Frienship park has joined it several times. It can already be seen that slowly this world wide happening is coming familiar also in Finland.

Fig. 2. The logo of the March for parks event.

Groups

In the Kainuu Nature Centre and Friendship park we have had numerous visits of Russian school groups and specialist of environmental education. These groups come not only from Kostomuksha, but all over Russia to get to know both Finnish and Russian side of the Nature Reserve Friendship. In Kuhmo we have had visitors from more than 15 National Parks and Zapovedniks in Russia. Like Kostomuksha Nature Reserve is working as a window to the west, Friendship park is becoming a window to the east. As we are told, the results of these visits are becoming visible since in many places around Russia they are now building visitor centres of their own utilising the experience and knowledge they got in the Kainuu Nature Centre.

Fig. 3. A group from Vodlozerski National Park visiting Lentua Nature Reserve in Kuhmo

Camp school

In autumn 2000 the first camp school of Finnish school children in Kostomuksha was organised. Organising this pioneer camp was a result of common planning work of four sides: Kainuu Nature Centre, Kostomuksha Nature Reserve, Kontio school from Kuhmo and Kostomuksha school no. 3.

The Finnish group visited their friendship school, where Russian pupils had organised different programs together with their teachers first to get to know each other. Then the groups spent three days together and managed very well without a common language. The pupils visited the Kostomuksha Nature Reserve. They were told about the beavers living in the area, about the nature of the area, about the traces of Ice Age, about history, culture and so on. They got information about Kostomuksha town and its surroundings, and they learned a lot about travelling abroad. This camp school was a success, which no doubt will have successors now that the biggest planning work has been done.

Fig. 4. A camp school group.

Seminars

Together with the Russian partner we have organised common seminars for Finnish and Russian teachers both in Kuhmo and in Kostomuksha. The main idea of these seminars is to create contacts between schools and to hear how environmental education is dealt with in both countries and also to get some new ideas for practical work. We have created materials and programs for environmental education for different age groups to be used in nature, in the protected areas and in schools, and we help teachers in their realisation.

In environmental education both sides have something to give and something to receive. Maybe the biggest difference is that on Russian side people, also children, know more about species and have more exact information about nature, whereas on Finnish side we are dealing with wider objects like ecological sustainability.

Fig. 5. Finnish-Russian seminar of environment education for school teachers in 2000.

Training

Since environmental education is not meant only for young people, but for everyone, we have organised different training courses, for example on ecotourism for Russian and Finnish enterprises on how to use protected areas in ecotourism. We have studied nature together on both Finnish and Russian sides, we have done common field work in the landscape ecological planning, we have organised training in customer service and guiding etc. All this is also a part of environmental education.

Fig. 6. Excursion to Kostomuksha in 1999.

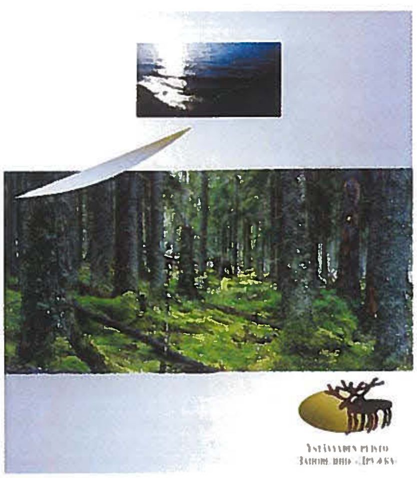

Fig. 7. The cover of the brochure of the Finnish-Russian Nature Reserve Friendship.

Information materials

Different information materials support environmental education. For example, in co-operation we have done a brochure of the Nature Reserve Friendship, we have worked out badges with the emblem of the Nature Reserve, we have internet pages and some small publications. Together we have planned and built exhibitions in the Kainuu Nature Centre, and now in the office of the Kostomuksha Nature Reserve there is a newly built exhibition

We have also set direct contacts to the Russian Environmental Education Centre "Zapovedniks" and as a result of this we have had their exhibition in Kuhmo Arts Centre during the 10 years anniversary symposium of the Nature Reserve Friendship. Co-operation with the Ecocentre "Zapovedniks" has only begun, but undoubtedly the centre will be a part of our co-operation in future.

Visits

The least part in co-operation do not play the visits on both sides. To know the culture and history helps us and all people from different countries to understand each other better. It also helps us to understand why nature has developed and changed as it has, it helps us to realise what has happened and why. It is our duty to spread this information and prepare the soil more favourable to nature protection.

These are a few examples of what we have done in co-operation so far. On the other hand we have done a lot, but on the other hand this is only the beginning. There is a lot to be done and new ideas come up all the time. One of them is that we have participated in a project of Finnish and Karelian Ministries of Education to organise an ecological forest travel seminar for young European people. The idea is to make it a yearly event, which will increase knowledge of our areas and work we have done for nature protection and environmental education.

The co-operation in environmental education between the Friendship Park and Kostomuksha Nature Reserve is on a higher level than anywhere else in Finnish-Russian cross border co-operation. It is our privilege to be the initiators in this work, but we hope that in future this will not be only our work but will spread and become wider and more popular in other parks as well.

Fig. 8. Akonlahti, Kostomuksha Nature Reserve in July 2000.

Development of ecological culture among teenagers

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A man is between a wild animal and an angel.
Which to become depends on education.
Thomas Mann

Introduction

Education is an element of human culture, that is why it should contribute to natural development of a child, that is to say development in accordance with nature. At first the idea of natural education appeared in works of antique philosophers Democrete, Platon and Aristotel, and was developed by Komenski, Russo, Pestalozzi and Disterweg. Disterweg thought that education should be in conformity with current socio-historical conditions of life, in accordance with nature and culture. The nature and the man are two cultures, each being "social" in its own way, each having own "rules of behaviour". And they meet on the basis of morality. These two cultures have historical roots. Human culture has been developing under the influence of nature since the beginning of mankind. One culture - Nature - can exist without the other, but Human Culture can not do without nature. But nevertheless there was a balance between the nature and the man during the past centures. (Лихачев 1988, 150)

The Latin word "cultura" means " cultivation, growing, development". In modern times "culture" is thought to be a degree of a person's development, this person being a member of society. (Словарь иностранных слов 1997, 165-166). Ecological culture as well as environmental education are considered to be a part of human culture. Dmitry Likhachev was the first to single out two parts in ecology - biological and cultural, and he called ecological culture of a person a systematizing factor that forms a real cultured, educated and civilized person.

Environmental education leading to obtaining ecological culture should not be substituted by a theoretical school course. Studying ecological terms and principles will not teach how to love nature and how to take care of it. That is why strictly protected nature areas having the nature stock, value of which cannot be stated, join in environmental education, that is a priority direction of their activity.

Activities in the Nature Reserve Friendship

Friendship Park has been conducting environmental programmes for some years. These programmes develop children's and especially teenagers' ecological culture. Lessons not in classrooms but in nature can help and do help to change children's attitude towards it.

Environment Education Centre " Zapovedniki" from Moscow, World Wildlife Fund and their project "Public support for protected nature areas and environment education" was carried out in 1998 as a socio-psychological research "People's attitude towards nature and protected nature areas". The research was held in 4 reserves. In Kostomuksha more than 700 children took part in it. The research showed that teenagers are very pragmatic towards nature, it is only the place of natural resources for them.

In Russia, from pedagogical and psychological points of view, children aged from 10 to 15 are called teenagers. It is the most complicated period in a child's life, it means transition from childhood to maturity, it means formation of a personality. That is why we choose this children's category to participate in programmes correcting the attitude to nature. The transition period forms moral and social principles, attitude towards own personality, people, society and nature. Self-cognition, self-expression and self-confirmation are the main motives of this period.

All programmes held in the Reserve take into account children's peculiarities caused by the age. Boys and girls understand that nature is not specially made for them, it is not an object for their activity. A man and nature are two subjects in this world.

Faster and faster urbanization and techno-pressing more and more holds us away from nature even in such a small town as Kostomuksha. I taught Ecology at school during three years.Year by year I asked my pupils to draw a favourite often visited place. The following three-year data were obtained among pupils of the 6-th year of education, school 6, the town of Kostomuksha.

In 1996 all 30 drawings contained nature objects, 27 presented Karelia, 3 presented nature objects of the country.

In 1997 27 drawings were made, 17 depicted nature corners of Karelia, 6 showed other nature objects, 4 pupils drew man-made parks and gardens.

In 1998 29 pupils presented their works, 18 of them drew Karelia, 6 depicted other man-made objects, parks and gardens, 5 works showed the central square of Kostomuksha.

The psycho-analyst Erich From noticed in modern attitude to nature signs of necrophilism, that is to say people go away from every living thing, from nature and turn to death, to machinery-everything created by people.

The main forms of work with teenagers in the territory of the Nature Reserve have become ecological camps and short (no more than 2 days) ecological expeditions.

The experience shows that specific way of life in ecological camps and expeditions creates pedagogical techniques and methods capable of using advantages of field conditions..

An ecological expedition programme helps children not only know but feel knowledge obtained in the Reserve. These programmes are useful on condition that they do not substitute or repeat school courses, but widen and supplement them. If people,especially teenagers, do all their best to understand the truth, it becomes of tremendous value for them, it is like a discovery (Сухомлинский 1979, 48).

Watching children more and more clearly shows that healthy sound children take pleasure in personal developing, moving ahead and acquiring new skills and abilities. (Маслоу 1997, 47).

When children spend their time in ecological camps, it is nature that is in the centre of activity. The surroundings - natural and social - are new, that is why children at first are fearful and mistrustful. Some Saint-Petersburg ecologically oriented schoolchildren, when on practice in the territory of the Vodlozerski National Park, were given psychological tests. The questionnaire showed that nature appeared to be hostile to children at the first time (O.A. Drugovejko, oral presentation, Sankt-Petersburg 1995).

To avoid these fears ecological games developing children's knowledge and abilities are made the basis of educational activity in ecological camps and short expeditions. The main idea of our correction programme is to influence children's feelings.

Ecological games let a child be not a passive observer in the world but a participant in all its processes. Playing children can imagine themselves as migrating birds, or mosquitos, the disappearing of which can cause the changes in food chain. Children become a part of nature not the top of it. They can see nature in its own being and start thinking that nature exists not for people but for itself. Playing helps children not to look at nature as a playground constructed especially for them.

What do children think about programmes in the Reserve?

Ecological expeditions, 1998
Dasha N., 12 years old: This year I have been to the Kostomuksha Nature Reserve. I liked it very much. We came to a conclusion that we should take care of our nature and first look at ourselves and only then at others.

One-day ecological programme " On a visit to the New Year Tree", 1999
Sasha G., 11 years old: It is the best day in my life.
Olya N., 11 years old: After such a New Year Celebration we will love our forests and take care of them.

Hiking along the ecological route, 2000
Ira R., 13 years old : We were on the route a little over an hour. And we knew about our region more than on many lessons at school. Karelia turns out to be a very interesting land.

So environmental education nowadays needs paying more attention than ever before. It is an aim and a systematizing factor not only for the system of education but for the whole society. This will help to form a child's ecological way of thinking and ecological culture.

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Protected areas and opportunities for ecotourism in Latvia

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Introduction

In Latvia similarly to elsewhere, nature based tourism and nature protection have closely evolved. For instance, Gauja River valley with sandstone outcrops became a famous destination place for travellers already at the beginning of the 19th century. German travellers who compared it to the Elba in Saxony and to the "Switzerland of Saxony" called it the "Switzerland of Livland". In 1920s the first three areas of Gauja valley obtained the status of protected areas, and in 1930s a National Park of 375 ha was created there. During the first period of independence in the first half of 20th century Latvia had a powerful tourism industry. Income from tourism was almost twice the income from our main export product - bacon. Already in the 1930's tourism was regarded as an essential component of regional development, which succeeded in stimulating economic development, maintaining the traditional rural landscape and also playing a role in public education about history and nature. Unfortunately, during the mid 1900's Latvia was once again embroiled in war, and incorporated in the Soviet Union. As a result it was isolated behind the "iron curtain" and therefore still is a "blank spot" on today's European and World tourist maps. Nowadays Latvia similarly to other Eastern European States in post-communist transition period is looking for new ways to strengthen national economy. Tourism is one of the areas with greatest potential for development. According to the Government Declaration one of main priorities for tourism development is rural tourism as well as ecotourism in protected and coastal areas.

The aim of this study was to evaluate the resources of nature-based tourism in Latvia paying special attention to the current use of protected areas, the keystones of ecotourism development (Boo 1994).

Materials and methods

The study was based on both questionnaire data and summaries of different published materials for tourists. The questionnaires launched in 2000 were directed to tourism managers at administrative district level as well as to some tourism entrepreneurs who have received the "Green Certificate" of the Latvian Country Tourism Association "Lauku celotājs . Tourism managers working mainly in Tourism Information Centres were asked to give data on nature areas or monuments serving as tourism attraction in their administrative district. Data including availability of information (signs, guidebooks, maps etc.) and services (guides, tourism equipment rent, catering, accommodation etc.), their access as well as opportunities for open-air activities (walking, cycling and horse riding paths, sight platforms and towers, camp sites, possibility for fishing etc.) were requested in order to evaluate the preparedness of sites to entertain tourists. Responses were received from 21 of 26 administrative districts. Information from different guidebooks was used for the evaluation of the remaining five districts. Countryside tourism entrepreneurs were asked to give data both on sites of natural and cultural heritage serving as tourism attraction in the vicinity of their houses to find out how well informed about such sites respondents are. Responses were received from 15 tourism entrepreneurs. Additionally, administrations of protected areas were inquired about their management staff.

The data received were critically assessed. Some nature sites were excluded from the lists if they could be classified only as potential or insignificant tourism attractions, e.g. bogs that need special arrangements to become accessible for visitors. The reported legal status of sites listed was also checked. Availability of resources for nature-based tourism was analysed both on administrative districts level and level of four historical regions of Latvia. The SWOT (strengths, weakness, opportunities and threats) analysis regarding the use of nature-based tourism resources in Latvia was carried out, too.

Results and discussion

Diversity of ecotourism resources

While neither World Wars nor the communist regime spared the lives of people, nature has returned to many places they had to leave. Therefore Latvia's natural environment nowadays is surprisingly rich and diverse. There are not many countries, especially in Europe, whose territories are more than 50 percent covered by ecosystems that are relatively untouched by man: forests, mires, lakes, and rivers. Latvia's competitive advantages for tourism, especially ecotourism development are diverse, mosaic type landscapes; high biodiversity including unique biotopes; relics and natural monuments; numerous populations of wildlife species threatened in Western Europe, wide system of protected areas, as well as rich cultural heritage including outstanding monuments of history, architecture and archaeology; living customs, traditions and folklore; ancient annual festivals and intense contemporary culture life. Fewer opportunities are for adventure type tourism activities.

When analysing questionnaire data it was revealed that a quite wide spectrum of nature objects were used as main tourism attraction sites. Most of them (24%) are lakes. They, as well as rivers (12%) are used mostly for active recreational purposes: boating, fishing and swimming. Together with other recreational areas (e.g. nature parks) these sites make almost half (44%) of all nature based tourism attractions. Rather popular are different interesting biotopes: natural forests, coastal meadows, fish-ponds, coastal lakes and mires (mainly as birding sites), etc. comprising 12% of all sites. Approximately of the same number are different geological monuments: cliffs (outcrops of primary rocks), caves, springs, boulders, etc. The Seacoast with 9 sites or 5% of all is among the most popular tourism attractions. Nature trails (currently 6% of all sites) gain increasing number of visitors and popularity.

Abundance and distribution of ecotourism resources

Distribution of natural and cultural tourism resources in Latvia is rather uneven. The questionnaires revealed that the number of nature sites currently used as main tourism attractions is ranging from 3 to 17, or 8 sites in average, per one administrative district (2500km^2). The number of these sites depends both on natural heritage including protected areas and tourism traditions in each administrative unit. For example, Southern Latvia is mainly agricultural region. There are few nature areas (including protected areas) and therefore few nature based tourism sites. At the same time an area rich in cultural monuments including manor houses with parks is located there. The Eastern part of Latvia is richest in lakes. There are also quite many protected areas, but the number of nature-based tourism sites per administrative unit usually does not exceed the average.

According to the data of Countryside Tourism Association, in 2000 the second largest amount of visitors has been accommodated in Cēsis district (NE part of Latvia) - an administrative unit having the highest number (17) of nature tourism sites. 13 of them are located in the Gauja National Park covering almost one third of the district's area. Moreover, these are only the most popular tourism sites. Additionally several hundreds of different geological objects alone are located in the area of the Gauja NP: outcrops of primary rocks, caves, karst swallow holes, springs, waterfalls, valleys, glens, boulders and mires. Beside nature sites, Gauja NP is also rich in cultural monuments, total number of which reaches 547 in the territory of the Park and its close vicinity. Churches, castles and their ruins, castle mounds, manor-houses, Medieval graveyards, objects of national construction – farm-houses and yards, scattered buildings, granaries, threshing barns as well as cult places, border-stones, sign-stones and ancient battlefields are among them. Typically, such culture-based ecotourism resources can be found almost in every larger protected nature area of Latvia. When analysing the list of State protected cultural monuments it can be noticed that in every administrative district there are approximately 100-300 such potential tourism sites. Some of them, for example, cult trees and sign-stones might be regarded both as cultural and natural monument. Inquiry of countryside tourism entrepreneurs revealed that they also know better cultural monuments situated in vicinity of their houses than nature tourism sites.

A special case is Latvia's seacoast. For 50 years after the World War II almost 2/3 of it were erased from the rest of Latvia's territory. This territory was considered to be the near bordering zone of the former USSR with limited freedom of movement and economic activity. As a result, very many residents left the area and the environment remained untouched. There is no other place in Europe, where sandy beaches without any cottages, hotels, restaurants and crowds of people would cover almost 300 km (of Latvia's 500 km long coast). Coastal areas host also important bird habitats and wetlands of great significance, representing unique biotopes rarely found in Europe. On one hand all it provides the necessary pre-requisites for the development of eco-tourism, on the other hand there are no tourism traditions. Many local people are not only inactive but also opposite to any changes. Therefore several ecotourism development plans (e.g., Stræde & Gamborg 1995, Metsähallitus 1999) have been already prepared to stimulate the development of "soft" tourism in the area as an alternative to alternation of natural seacoast into conventional cottage area.

Network of protected nature areas

The questionnaires revealed that about 70% of all nature tourism sites have the status of protected areas or are situated either entirely or partly in a larger protected area. At the present, the protected nature areas cover 8,53% of the state territory (Table 1). In addition, there are also two areas having the status of State protected cultural historical territories. Both are either part of a larger protected nature area or are partly overlapping with such area. Besides, Latvian Parliament has ratified Ramsar Convention and designed 3 Ramsar Sites to preserve natural wetland habitats ensuring successful movements of migratory species. Along the Latvian seashore 4 internationally important marine areas are designated by HELCOM. There are also 206 nature monuments – separate, single natural formations like trees, caves, springs, rocks, boulders etc. with scientific, cultural, aesthetic or ecological value.

Table 1. Protected Nature Areas of Latvia.

Category of protected areas	IUCN management category	Number	Total area (ha)	% of total State area
Nature Reserves	Ia	4	24525	0,38
National Parks	II, V	3	158927	2,46
Restricted Nature Areas	Ib, III, IV	211	170448	2,64
Nature Parks	-	22	68944	1,07
Protected Landscape Areas	V	6	152018	2,35
	total		550918	8,53
Biosphere Reserves	-	1	474447	7,35
	total		1004762	15,56

Protected areas as tourism destination sites

According to the Law On Specially protected Nature Areas, mainly National and Nature Parks, Protected Landscape Areas as well as nature monuments are designed for tourism development. Nature Reserves and corresponding functional zones in other protected areas generally are closed for visitors. The Law says that each area can be visited in line with general and individual regulations on the protection and use of protected areas as well as management plans for particular area. Up to now only 1/6 of all nearly 250 protected areas have their individual regulations or management plans (approved or under preparation). Inspection of visiting is responsibility of corresponding administration of protected area or regional environmental board. Examining all protected areas, only National parks, Nature reserves and Biosphere Reserve have their own administration (Table 2). In fact, visiting of most of the other protected areas remains more or less uncontrolled. According to the Law, management of protected territories is the responsibility of the their administration or, in the absence of such, the owner or user of the land. The relevant municipality manages protected territories designated by municipalities. In fact, visitor management or/and management for protection of biodiversity is carried out only in areas having administration (Table 2) and in few areas having individual managers. Several NGOs have been established at some of Protected areas to encourage their management. Except the park rangers of Gauja NP, most of them have a little experience in visitor management as authorities for other protected areas are either recently established or have not been dealing with visitor management at all, e.g. in Nature Reserves.

Table 2. Staff of the largest protected areas in Latvia.

Protected areas	A	B	C	D	E
total area (ha)	28 763	42 790	475326	91 745	21 962
total number of staff members	25	18	8	64	25
environmental inspectors	7	9	1	25	6
scientists, experts	5	4	4	9	7
forest managers	5	1	-	4	1
visitor managers	-	1	-	2	-
of them, nature guides	3	6	3	4	4

A - Slitere Nationl Park, Grini and Moricsala Nature Reserves

B - Kemeri National Park

C - Ziemelvidzeme Biosphere Reserve including 1 nature park and 16 restricted areas

D - Gauja Nationl Park

E - Teici and Krustkalni Nature Reserves

Obstacles for development of nature-based tourism

Lack of management plans and funds as well as the absence of appropriate control in most of protected areas leads to degradation of natural values. For example, construction of nature trail in one of Nature Parks was done parallel to removal of dead wood in a forest. Several cases are known when management plans for protected areas have been worked out to facilitate tourism development not securing further conservation of certain species, e.g. in lakes with Lobelia-Quillwort aquatic plant complexes. Destruction of certain habitats, e.g. dunes, and geological monuments, e.g. sandstone rocks, due to too intense recreational activities is also observed. Common management is bothered by high percentage of private lands in protected areas, especially large ones (except Nature reserves) with agricultural areas.

Undeveloped infrastructure including low-grade roads, deficient number of road signs, marked nature trails and bikeways as well as lack of maps for hikers and lack of guidebooks on protected areas and wildlife are main direct obstacles for the development of nature-based tourism. The growing intensity of forest management, overgrowth of abandoned agricultural areas, prevalence of private interests over public interests are indirect threats for tourism development.

The number of protected areas having own administration or single manager should be regarded as insufficient. Among all park rangers few are those directly dealing with nature tourism, especially with visitor management (Table 2). There are no professional nature guides at all, as guiding in general is adjoining profession not only for park rangers. Overall network of nature guides should be arranged in the country. Quantitative and qualitative up-growth of the park ranger service in the country should be regarded as crucial point of encouraging the ecotourism.

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Present state and prospects of development of ecological tourism in National park Vodlozerski

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Not so long ago in the Soviet time Karelia was very popular among the tourists.

In 1989 more than 1.5 million people visited the republic. Its main attraction was the abundance of crystal clear lakes and fast rivers, pristine taiga forests and remarkable monuments of culture, history and northern architecture.

With the collapse of the Soviet empire many traditional ties between the regions were broken. Economic problems, low living standards of people and other well-known factors, including the unwise state policy in the sphere of tourism, brought disastrous results. The tourist traffic reduced ten-folds. Revival of tourism industry had to be started from zero in the absence of any state support. Analyzing the situation the administration of National park Vodlozerski has come to the conclusion that it needed to work out a concept of the tourism development in a specially protected nature territory and modern methods of its implementation. In spite of the lack of experience of such work by 1994 the Park had prepared the basic document: "Organization and development of tourism in National park Vodlozerski", which served as a sound foundation for working out of a concept of tourism development in the Park. Oleg Chervjakov – the director of National park Vodlozerski – was the chief driving force in that effort.

The selected strategy was further elaborated in the General plan of development of tourism in National park Vodlozerski and in the Business-plan of tourism development. These documents envisaged three stages of development of tourism and its infrastructure till 2010:

- Organization (1996-1999)
- Building-up (1999-2001)
- Development (2002-2010)

The first stage is being finalized at present. It includes planning and organization of the tourism structure, training of personnel, creation and marketing of the Park's tourist products.

Today the Park has two tourist camps, several stations, dozens of special camping sites, a summer field centre on Kolgostrov island which arranges summer ecological camps for children. There is a sufficient stock of tourist equipment and transport vehicles, including snowmobiles "Lynx", vans, motorboats and rubber boats. The Park's special pride is a motorized sailing boat – a replica of traditional Russian boat of 17^{th} century – custom-made at Petrozavodsk wharves. The Park has built the first in the northwest Russia visitors' centre equipped with modern appliances and interesting exhibitions, which can provide extensive information about the Park. Thousands of local citizens and guests of the republic have already visited the visitors' centre. Similar centres will be commissioned soon in Vodlozerski and Onezhski branches of the Park.

The Park is already offering various types of tourism: rafting, hiking and skiing trips, tours on snowmobiles, vacationing on Vodlozero, fishing and educational tours. Scientific research and various forms of ecological education in the wild nature have become very popular in the Park.

There is a stable tendency of growth of the number of visitors in the Park: from 400 in 1994 to 600 in 2000. New interesting tours are commissioned each year. For example, a 40-km hiking trail along the ancient pilgrim road to the White Sea is being completed.

The Park has a license for international tourist business, and the Park's tours have state certificates.

Lack of trained staff was one of the serious problems. To resolve it, 4-month courses for guides to work in National park Vodlozerski were organized in 1996 in Petrozavodsk state university with two weeks of field training before exams. The courses were very popular and free of charge: more than 200 students graduated. The State committee for employment of the republic of Karelia financed them.

In the result of the courses dozens of specialists are now available in the summer to work in the Park. Several students after summer field practice were permanently enrolled.

Since 1997 National park Vodlozerski in cooperation with Kuru Forest school (Finland) and Harpury (UK) organize annual international courses for specialists in ecological tourism. During the study period from August to June the students get advance level professional training to work in the wild nature and an international certificate permitting to work in tourist firms and various ecological and nature protection organizations. In the course of training the students get practice in tourist companies in Finland, UK, in National park Vodlozerski, Lapland and Wales. They get skills of guides, orienteering, rafting, first aid, driving, etc. The courses are very popular in Russia and abroad. The courses provide free education, accommodation, scholarship of 200 euro and other benefits.

During the last two years the Park was also sending trainees to special educational institutions: Petrovski college, tourist school and Academy of tourism. In 2000 National park Vodlozerski together with Petrovski college has started a 2-year course for specialists to work in the specially protected nature territories in the northwest Russia. Negotiations are going on with Karelian pedagogical university to start a special course in ecotourism at its faculty of physical training.

Another important task is marketing of the tourist product. National park Vodlozerski is one of the few tourist organizations in Karelia which have state certification to provide services to tourists in its territory. Actually the Park almost from its inception was participating in the bigger annual tourist exhibitions – fairs, both domestic and international. It has concluded agreements with reliable tour operators. Today we can state that the Park has proved itself as a reliable partner. The traffic of visitors from Moscow, St. Petersburg and abroad is constantly increasing. The park has built an attractive image in the mass media in Russia and abroad. For that purpose it has arranged autumn tours for journalists of Karelia and Russia to the territory of the Park. Much attention is given to the publishing of booklets, postcards, calendars, newsletters, video films and CD-ROM. Press-conferences and briefings are a custom. The Park is a constant participant in the domestic and international conferences and seminars on ecotourism, where exchange of ideas and new solutions to common problems and development strategies take place. A good example of it is the participation of the Park in the activities of the Association of nature reserves and national parks of the northwest Russia.

Now we have started the implementation of the next phase – building up of the tourist infrastructure in the Park.

It envisages reconstruction of the existing facilities, such as tourist camps "Ohtoma" and "Novguda", completion of the tourist shelters in Koskosalma, Pilmasozero, construction of new ones in Ragunovo and Luza. At this stage, the construction of a tourist village in Varishpelda and a stationary field camp on Malyi Kolgostrov will be finished. Restoration work in Iljinski Pogost – a historical and cultural monument of wooden architecture of the 18^{th} century will be also finished. It is also planned to complete the construction of a hiking trail Varishpelda – Luza and some other projects, like establishing of a commercial entity, possibly with a foreign partner, to service tourists in the Park. We hope to attract large investments in the Park's tourism business and create domestic market of products and services. Much is expected from the implementation of a large-scale program of state support of National park Vodlozerski in 2001-2005.

The ultimate goal of this phase is the creation of the necessary prerequisites for sustainable growth and development of the Park.

Tourism co-operation between Kostomuksha State Nature Reserve and Matka-Kos Tourist Company

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Matka-Kos Tourist Company and Kostomuksha State Nature Reserve began their co-operation in 1994. An agreement on co-operation in the field of tourism in the territory of the Reserve was signed. The idea of creating a tourist company resulted from numerous (during more than 30 years) water, ski and hike travels round Karelia and Russia. Practically all most popular tourist regions in Russia were visited. Very often we travelled round the reserves, where sometimes we fulfilled calculations of animals and birds. Deep inside we were glad to see the beauty of virgin nature of those places but at the same time we were sorry as other people have no possibility to look at it in reality, only at photographs in booklets. Luckily the situation in the country changed for the better, not only in the field of politics but in ecology as well. Sustainable ecological tourism in reserves was permitted. And nowadays people can admire nature objects seeing them with their own eyes. Matka-Kos Tourist Company and Kostomuksha State Nature Reserve started their co-operation at that very time.

The most interesting in the territory of Kostomuksha Nature Reserve are untouched forests characteristic of the north taiga subzone where all typical fauna species were preserved. All this can be watched along ecological routes. Tourists can hike round the reserve, or they can undertake water or ski travels. Having visited the Reserve tourists from Finland and Europe said that they had not seen such pristine forests in their own countries before. It is the fact that attracts tourists to the Reserve.

In the territory of Kostomuksha Nature Reserve water, ski and hike travels were organized. They were preceded by huge cartography and field work. The most popular route is along the Kamennaya River. Places for rest were built there at the distance of 8-10 km from each other. There are also special places for making fire and log houses (20-25 square m) for 4 persons, where travellers can dry their clothes. In the lower course of the river there is a large wooden house (about 80 square m) for 12 travellers. Near some log houses and near the large wooden houses there are saunas.

The most picturesque places are the Kamennaya River, Kamennoye Lake and the cayon called Kamennye Vopota. All routes follow in the direction of those beautiful nature objects. Recreation activities influence about 5% of the total Reserve's area. Yearly surveys of ecological routes show that recreation activity along the routes is too slight to produce any influence over nature. On the contrary, plant cover, which has been damaged before establishing the reserve, is restoring now.

While taking part in seminars on tourism I am used to saying that joint tours should be created, one part of the tour shoud be held in Finland the other in Russia. It appears to be an additional motive for attracting tourists from Europe, who can be acquainted with the nature and culture both of Finland and Russia during one tour. Russian-Finnish Reserve Friendship, Kostomuksha State Nature Reserve being the part of it, is the most suitable territory for conducting such tours.

Co-operation between Matka-Kos Tourist Company and Kostomuksha State Nature Reserve is mutually beneficial. Matka-Kos finances a tourist licence, advertising compaign, provides tourists with necessary equipment, board and organizes different activities when on a route. The Reserve receives entrance fee, lodging and transport payment.

The Tourist Company takes part in different tourist exhibitions in Russia and Finland. Owing to it, Kostomuksha State Nature Reserve is known among hundreds of tourist companies in Russia, Finland and Europe. In Karelia the winter tourist season finishes in April but in the North of Russia and in Murmansk region and in the Polar Urals it continues. Our tourist company organizes ski tours to these regions. The Director of the Company is a ski sport candidate, with the aim of qualification improvement he undertakes yearly sport water and ski travels in different regions of Russia.

Everybody is invited to take part in travelling round Kostomuksha State Nature Reserve, Karelia and Russia.

Fruitful co-operation between Matka-Kos Tourist Company and Kostomuksha State Nature Reserve exists now and will go on in future, because the development of ecological tourism is necessity of present times.

Forest in the traditional beliefs of the Russian population of Vodlozero land

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The material collected by the author in 1994-2000 makes it clear that the forest in the traditional understanding of the Russians who lived in the Vodlozero area, is not a territory covered by wood. They perceive it as an animate media. The people of Vodlozero in their charms call it "holy wood". According to their cosmology the forest is one of the four elements of the universe (the others are the earth, water and air). The wood tzar rules the forest. Sometimes it also called "father-wood". The ultimate ruler of the humans and nature, according the beliefs of Vodlozero people, is the Holy Father, whereas the devil and his servants inhabit the underground world. A human soul is sent either to hell or to heaven, whereas the dead keep living on the territory within the cemetery walls. Therefore, the wood groves on cemeteries are ruled by the dead but not by the holy father or wood tzar. The same applies to the islands turned into cemeteries, like Kingostrov (XV century) or Ilamostrov (XVIII century).

The ruler of forest element (wood tzar) is immortal. He commands over all other wood spirits and goblins. According to Poljakov (1991), in XIX century the people of Vodlozero also believed in water-nymphs, which appeared on the tree branches in hot afternoons. "Lembois" (much similar to Karelian "karu") were forgotten by mid-XX. Tales about "wood old men" (analogue of Karelian "heine" – a devil with a small bell) are still alive in the Vodlozero area like in all other lands of the Russian north. It is believed that the goblins lure the children to the wood by ringing the bell. They keep the kids, feed them, warm in the night and protect from mosquitoes, until a sorcerer throws chip crosses on foot trails.

It is believed that the wood goblins live in monogamy families. Each family inhabits its territory, with water systems and large mires serving as natural boundaries. The goblins on their territory are the owners of trees, birds and animals. Whereas the plants of the lower level, as well as most of berries and mushrooms, belong to the "earth tzar", "mother-earth" and their servants (like "masters" of islands, meadows, etc.). That is why the Vodlozero people, when entering the forest to pick berries, address two nature rulers: "Father-wood, Mother-earth, permit us to pick berries". The waterfowl, according to local belief, is not commanded by wood goblins. The witches in Vodlozero, when praying for successful hunting on geese or ducks, charm the spirits of the water but not the wood masters. The mires were not completely owned by wood goblins either. Even today it is believed that a man is drowned in a mire by "kikimoras" but not by a wood goblin. They are promised a pie if the man escapes the bog and returns safely home. The wood goblins rarely come out of the forest to a village. Appearance of it in a village (always at a sunset or in twilight) is an omen of death. People avoid building houses on goblins' property. It is thought that settling in such a house would cause death of one or even three inhabitants.

Wood goblins, according to Vodlozero people, are mortal creatures, but live much longer than humans, a 180-year goblin is considered a broom, old age is 580-600 years. A goblin can be a widower. A man can kill it with a silver bullet or a with a button with a "cross" made by 4 holes and stitched in that way to the clothes.

It is believed that the wood goblins do not appear in their true form so as not to scare the humans out of their wits. Only the witches may see them in their true appearance at the moment of communication. They can turn into a hare or a bear to help to steer the cattle. A goblin in the image of a man is usually accompanied by a black dog, the size of a fox. Barking of such a dog in the forest is a sign that the man would soon get lost. It is believed that the face of a goblin is darker than that of a human and the eyes are big and shining. As a rule they remotely remind some acquaintance or a long-dead one. Sometimes description of a goblin is similar to that of Yeti in popular fiction ("Big-foot" of the north-taiga zone): naked and hairy all over. The height of goblins can vary from that of the tallest tree to that of a mushroom. They can change their height and run in the tree tops with terrible noise and whistle, bending the trees to the ground. Sometimes the goblins remain invisible. They fell trees in windless weather, pinch people from behind (usually girls and women) to make fun of them. Allegedly, they are afraid of hunters with rifles, seldom try to tease them or divert from the right way.

The hunters may meet goblins only in wood cabins if they occupy them without asking permission. Very often it may happen if a hunter forgets to make a fire in the stove or at least to stir the old ashes. In that case the intruder may be terrified by appearance of the wood spirits and even have to fight them. As a rule, the man wins the fight but would have to keep a knife or an axe stuck in the door. Mortal outcomes of fights are also known. According to A.I.Pimenova, her four cousins were surprised by goblins in a cabin. One died with a broken neck, another had his back broken, the rest two were bitten and roughed but wounded the creature with knives and gun shots before it escaped.

According to Vodlozero people, the goblins avoid wood roads and trails made by humans. They keep to their own trails which look like runs made by wild animals. A man or an animal on such a trail would invariably lose orientation. After a while the man realizes that he is lost and goes through a simple ritual: all clothes are taken off, shaken, turned inside-out and put back in reverse order. It is thought that after this the goblin can not see the man and loses control over him. It can also help to beg the "wood masters" to let out of the wood and show the way home. Reciting of orthodox prayers may also help.

It is thought not very dangerous to mistake a goblin for a human and to get into the "first degree" contact with it. It would be enough during such intercourse to remember the first word said by the "unholy" one. The contact is then immediately discontinued and the goblin, uncovering in one way or another his true origin, disappears. The same happens when the name of God is somehow mentioned in the talking. The Vodlozero people also believe that the same reaction is caused by strong odor from human footwear, dirty socks or puttees. But the same factors do not help that unfortunate who has been cursed by a spouse or a close relative when going to the forest or the one who boasted to come back in a short time. Such people become hostages of the evil spirits and stay in the wood until special people with magic craft interfere. After special rituals it may be possible to find such unfortunates, dead or alive. Much depends on the strength of the curse and closeness of keen to the one who made the curse. The same may happen to the cattle when letting it out to graze.

The witches appeal to the goblins to help find the cattle or people lost in the wood, to make spouses love or hate each other. The latter is done by appealing to the spirit through the smokestack in the house after midnight. All other cases, according to the Vodlozero witches, require contacts with wood spirits in a forest on a trail or road crossing. The spirits are called by cutting of three trees at such crossing, by thrashing the crossroads with a twig or by drawing of crosses on the ground with a ring finger. A gift has to be left on the crossroads in the form of a boiled egg, pies, small silver change of uneven sum or a silver rouble.

The Vodlozero people believe that with the start of concentrated clearcutting the number of the wood goblins has significantly decreased. The spirits left the slashed areas. It is to some extent true even in respect of the territory of national park Vodlozerski, where the forests remain mostly untouched.

Some of the traditional rituals of Vodlozero people, concerning communication with the wood spirits and wood elements, have become forgotten. Thus, the hunters do not sacrifice to the forest the first kill of the year. The concept that the wild animals possess a part of what is called "the soul" in humans is preserved only as a cultural superstition: the head of killed bear and eyes of elk are left as gifts in the forest. The concept of the tree's soul is almost forgotten, although the rituals connected with cutting of trees, transportation of them to the village, using of timbers for construction, splitting of wood and burning of fuel wood are still observed. For instance, the trees marked for construction of a house are preferably felled in winter, when the "wood" and trees "sleep". Before cutting, permission is asked from the "wood hosts" and one crosses himself. The first tree to be cut has to be touched with a palm to beg absolution. The felled trees are transported root first as dead men, otherwise a relative may die. The first 40 days the timbers are debarked but not cut into frame. It is though that during this period the trees mourn their demise but the tree soul is keeping close like a human soul. An axe should not be stuck into a tree unnecessarily for fear of a vengeance. For the same reason an axe should not be left stuck in a stump used for splitting wood. It should be put alongside on the ground with the edge towards the wood (or towards the future log cabin). The tree soul may be still living in it after physical death of a tree. Therefore axes are not stuck in walls of even very old cabins and half-burnt wood from the stove is not thrown out in the yard but first put in a water bucket and burnt the next day to finalize in cremation the tree's death.

It is obvious to the author that the traditional beliefs of Vodlozero people related to the wood elements and the tree soul do not permit this folk group to treat the forest as inanimate resource which can be wasted thoughtlessly.

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On a new type of stone structures on Kiitehenjärvi in the Kostomuksha Nature Reserve

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Introduction

In the summer of 1995 in the Kostomuksha Nature Reserve piles of stones were found, tentatively defined as a burial mound. Some of the piles were closely spaced and structurally complex. Archaeological investigation was done in July 1999 by a joint team formed by the Institute of Geology and the Department of History, State University of Petrozavodsk.

The group of stone structures lies about 1 km from the northeastern shore of Kiitehenjärvi on the southwestern slope of a hill gently sloping toward the Kamalahti Bay. The site covers a total area of 100x50 m.The group consists of not less than 30 piles of two types distinguished in terms of size and structure:

1. Nine 0,4-0,8 m high piles varying from 2 to 6 m in diameter. They are rounded in plan view, and are formed by 2-4 rows of boulders 30-60 cm across. Their inner parts are filled with smaller stones (Fig. 1).

2. About twenty smaller piles that are rounded to elongate in plan view, cone-shaped or semi-spherical in profile, vary in size from 0,4 to 1,5 m across, have a height of 0,3 to 0,5 m, and are composed of medium-sized boulders (up to 30 cm diameter).

It is hard to estimate the precise number of stone structures because they are small and are buried under a thick moss cover.

In the western part of the site lies a round grass- and moss-covered glade about 12 m in diameter. Several piles of stones, defined as type 2, were found on the margin and in the centre of the glade. The cross-section shows that the glade was cleared and the podsol was partialy removed and then was covered with sand.

The northeasternmost pile in the group, was taken to pieces. When the moss was removed, a hill, 3,6 x 2,8 m in size and 40-60 cm in height from the soil surface, was exposed (Fig.2). Its margins are formed by 2-3 rows of big boulders that constitute the vertical walls of the structure. The internal part of the structure is filled with smaller stones piled up to the edge of the external walls or slightly below. However, one cannot say that the upper stone layer was not built carelessly. The northern half of the pile was first dismantled. After fixing the transverse profile of the structure the pile was completely removed, so that a depression, sub-oval in plan view and saucer-shaped in cross-sectional view, was exposed. The depression is 3,2 x 2,6 m in size and up to 15 cm in depth. Its long axis is oriented approximately SW-NE.

In the northeastern part of the hollow the stones that constitute the margin and internal portion of the pile rest on a 2-3 mm thick film formed by decayed organic matter which resembles a piece of skin. Pieces of coal and small amorphous coaly patches, up to 1 cm thick, occur beneath the decayed organic matter. West of the re-

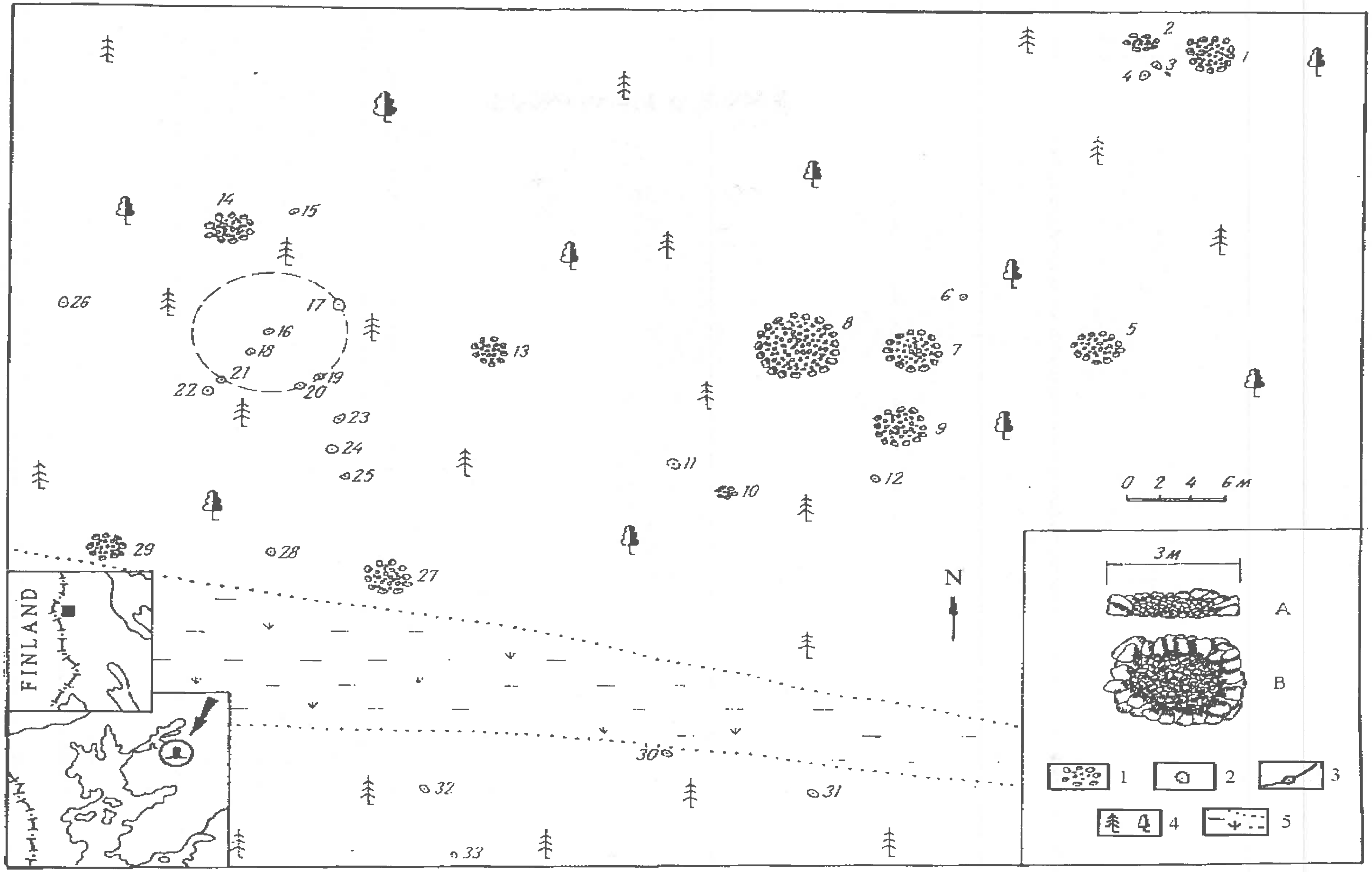

Fig. 1. Plan of the Kamalahti complex: 1 – Piles of stones (I type), 2 – Small piles of stones (II + type), 3 – Grass and moss covered glade, 4 – Secondary mixed forest, 5 – Ravine

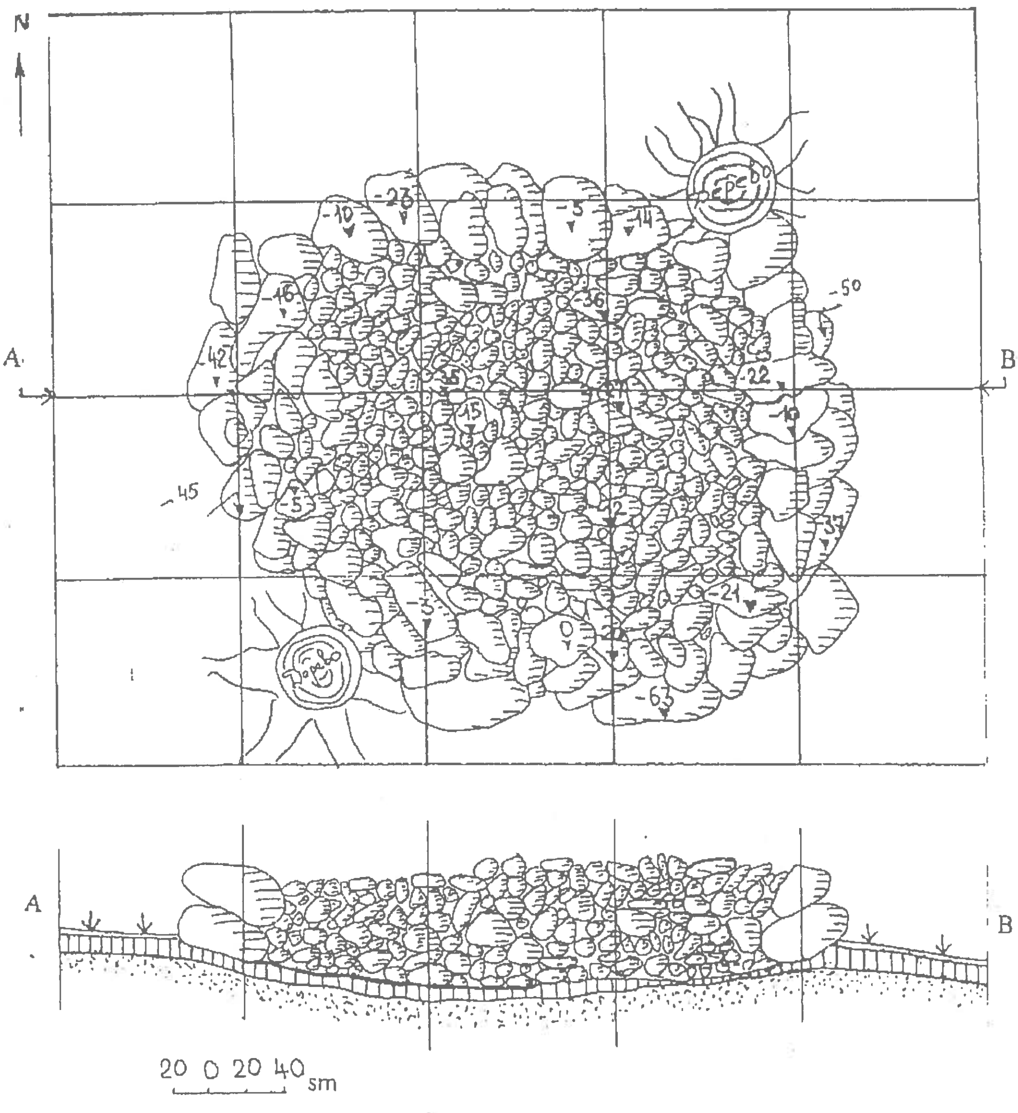

Fig. 2. Cairn I upon removal of moss .

mains described, indistinct traces of 1.8 m long log or executioner's block oriented approximately N-S were found. Cleaning the site surface on the continental podzol level revealed no traces of excavation. It should be noted that podzol layer is thinner in the depression under the stones than at the site adjoining the structure.

The absence of findings or clear indications of burial in and under the pile of stones makes it difficult to estimate the age of the structure sololy by archaeological methods. Samples of decayed organic matter and charcoal were collected for radiocarbon and phosphate analyses. Their results are expected to facilitate the dating of the stone structure and provide additional evidence for its interpretation. The quality of the samples collected for 14 C dating is fairly poor because they were taken near the day surface.

Discussion

The cultural significance of the complex in general and the stone structure in particular can be evaluated by comparing them with similar sites. In Karelia, however, stone cairns have seldom been studied archaeologically, so that available data are scanty (Манюхин 1996). Sites, similar to the Kamalahti complex, are unknown in Karelia.

In adjacent Finland, piles of stones with external walls composed of big boulders and smaller stones in between are unknown either. Structurally simpler "Lapp cairns", referred to as "Lapinrauniot" in Finland, are encountered in North Pohjonmaa and Kainuu. Some of them are interpreted as graves back from the Bronze and Early Iron Ages (Huurre 1983), but the age of the "Lapp cairns" found in inland Finland is still uncertain (Taavitsainen 1987) . The cairn we have studied together with eight similar piles revealed in the Kamalahti complex are most similar structurally to stone burial mounds built commonly in central and South Ostrobothnia in the Bronze and Iron Ages (Ýðÿ-Ýñêî 1990). However, excavations have not shown the Kamalahti stone cairns to be burial mounds. Besides, they can hardly be compared with geographically remote farmlands cultivated by peasants in South Ostrobothnia in the first millenium A.D., although some structural similarities are obvious.

As regards possible analogues in Northwest Russia, attention should be given to several stone cairns in the Karelian Isthmus and on the Kola Peninsula. They show a geometric pattern, have thick vertical walls and a flat top. Recently, a research team from St. Petersburg (Кирпичников et al. 1992) tried to interpret these sites based on evidence for Lapp family credence altars referred to by Sheffer in his famous description of Lapland (1671-1673), they assumed such flat-top stone structures to be altars (sacrifice tables) on which seid idols were placed prior to rites and sacrifices.

This interpretation seems to be applicable to the Kamalahti complex, although the above hypothesis is poorly supported by available evidence on individual sites spaced over a thousand kilometres apart most of which have never been excavated.

Let us assume that the complex discussed is a Lapp site of cultural value, remembering that Lapps used to settle over large forested areas in East Fennoscandia and that in the 19th century local population commonly interpreted piles of stones and other structures known as Lapp sites. I.V. Juvenius, who visited Russian North Karelia in 1888 to collect data on Stone Age sites and Lapp antiquities (Juvenius 1889), noted: "Lapp stone cairns have been reported from Point Pekanniemi, Mount Vintavaara, Kelonaho Glade, and Mount Kukkarovaara near the village of Kivijarvi". Karelians told Juvenius about "Lapp holes" at Kivijärvi. Other findings are "reindeer graves" on the western lake shore indicated on a map made by Juvenius. We are not sure whether the above evidence is directly related to the Kamalahti complex, but the fact in the area stone structures are commonly thought to have been erected by Lapps is demonstrative.

In any case, the Kamalahti group of stone cairns has shown once more how difficult it is to study this type of sites. Stone cairns should be investigated more thoroughly. The primary goal in this connection is to develop methods to search for and study such sites.

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Abstract	The publication is based on the presentations and posters of an international symposium in Kuhmo, Finland 16th to 19th October, 2000. Altogether there were 140 participants from eight countries in the symposium. The publication consists of 63 articles, which deal with the biodiversity and conservation in the boreal coniferous zone, especially in the so-called Green Belt along the Finnish-Russian boundary. In addition, a few articles give information about history, environmental education and ecotourism. The articles about natural sciences deal with bedrock, soils, forest, mire and water ecosystems as well as flora of plants and fungi, and fauna. As a synthesis of these topics nature conservation principles and practices are treated.	
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Julkaisun nimi	Biodiversity and conservation of boreal nature – Proceedings of the 10 years anniversary symposium of the Nature Reserve Friendship	
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Tiivistelmä	Julkaisu perustuu Kuhmossa 16.-19.10.2000 pidetyn kansainvälisen symposion esitelmiin ja postereihin. Kaikkiaan symposiossa oli 140 osanottajaa kahdeksasta maasta. Julkaisu sisältää 63 artikkelia, joissa käsitellään pohjoisen havumetsävyöhykkeen, erityisesti Suomen ja Venäjän rajaseudun ns. vihreän vyöhykkeen luonnon monimuotoisuutta ja sen suojelua. Lisäksi muutamat artikkelit esittelevät historiaa, ympäristökasvatusta ja luontomatkailua. Luonnontieteelliset artikkelit käsittelevät kallioperää, maaperää, metsä-, suo- ja vesiekosysteemejä sekä kasvi-, sieni- ja eläinlajistoa. Synteesinä näistä aiheista tarkastellaan luonnonsuojelukysymyksiä periaatteellisella ja käytännön tasolla.	
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Название публикации

Биоразнообразие и охрана природы бореальной зоны лесов – Обсуждение материалов международного симпозиума, посвящённого десятилетию заповедника «Дружба»
Biodiversity and conservation of boreal nature – Proceedings of the 10 years anniversary symposium of the Nature Reserve Friendship

Вид публикации *	***Финансирование*** **Министерство Окружающей среды**
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Резюме
Настоящая публикация основана на материалах международного симпозиума, организованном в г. Кухмо с 16 по 19 октября 2000 г. В симпозиуме приняли участие 140 человек из восьми различных стран. В настоящую публикацию входит 63 статьи, в которых описывается многообразие и охрана природы северной бореальной зоны хвойных лесов и в особенности природы Зелённого пояса, расположенного на приграничной территории Финляндии и России. Дополнительно к ним, несколько статей представляют историю, экологическое воспитание и экологический туризм. В научных статьях рассматриваются древние коренные породы, почвы, лесные, болотные и водные экосистемы, а так же видовые составы растительности, грибов и животных. Синтезом выше перечисленных тем является обсуждение вопросов охраны природы на принципиальном и практическом уровне.

Ключевые слова	Бореальная зона, природоохрана, флора, фауна, экосистемы.		
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Sammandrag	Publikationen är baserad på föredrag och poster som presenterades vid ett internationellt symposium i Kuhmo 16.-19.10.2000. 140 personer från 8 olika länder deltog i symposiet. Publikationen innehåller 63 artiklar över biodiversitet och dess skydd i den boreala barrskogszonen, speciellt in den sk. Gröna bältet i gränsområden mellan Finland och Ryssland. Därtill några artiklar presenterar historiet, miljöuppfostran och ekologisk turism. De naturvetenskapliga artiklarna omfattar berggrunden, kvartära formationerna, skog-, myr- och vattenekosystemer, och fauna och flora i olika grupper av djur, växter och svampar. Som en syntes finns det artiklar om naturskydd i princip och praktik.	
Nyckelord	Den boreala zonen, naturskydd, flora, fauna, ekosystem	
Publikationsserie och nummer	The Finnish Environment 485	
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The Finnish Environment

NATURE AND NATURAL RESOURCES

Biodiversity and conservation of boreal nature

Proceedings of the 10 years anniversary symposium of the Nature Reserve Friendship

140 scientists and nature conservation authorities from 8 countries gathered in Kuhmo, eastern Finland 16th to 19th October 2000, to take part in an international symposium dealing with the biodiversity and conservation of boreal nature. The symposium was arranged to celebrate the 10 years anniversary of the Finnish-Russian Nature Reserve Friendship. On the basis of the presentations and posters of the symposium, this publication containing 63 articles has been compiled. In addition to articles covering various disciplines of natural sciences, also nature conservation principles and practices, environment education and ecotourism are dealt with.

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