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Mires of Finland – Daughters of the Baltic Sea

Raimo Heikkilä, Tapio Lindholm and Teemu Tahvanainen (eds.)

Finnish Environment Institute

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Location of the mires presented in this book and the excursion route of the 12th International Mire Conservation Group field symposium in 2006.

Guide to the landscapes of Finnish mires from the Baltic Sea coast in different times of the Holocene

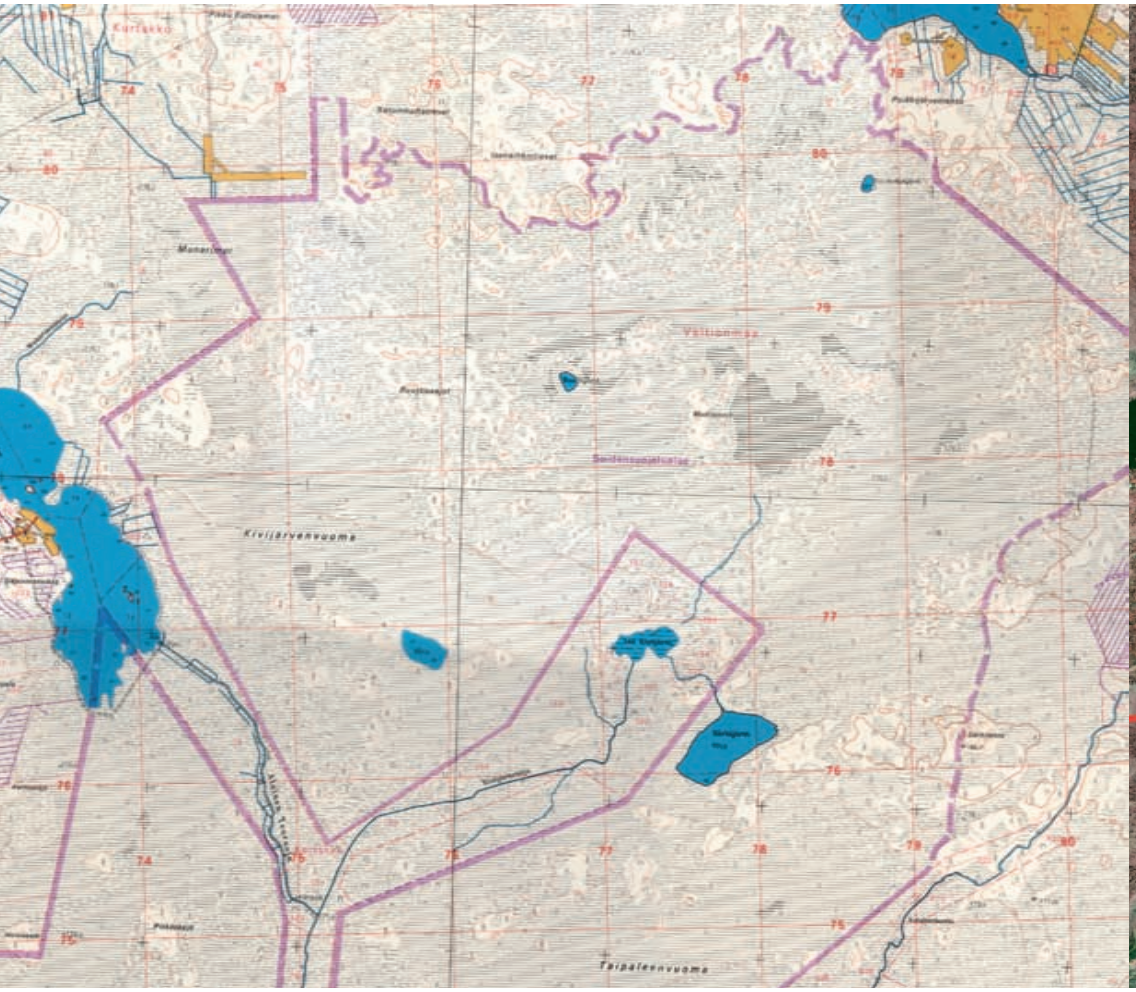
Raimo Heikkilä, Tapio Lindholm & Teemu Tahvanainen

This book presents a transect of Finnish mire nature from Forest Lapland in the north to the hemiboreal mires on the southern coast of Finland. It has been compiled in connection with the International Mire Conservation Group field symposium in Finland in July 2006, but the editors of the volume wish it to give a more general overview of the biodiversity of Finnish mires on mire system, massif, site and species levels as well as about the utilization, conservation and restoration of Finnish mires. A special topic is the primary succession of mires on the land uplift coast of the Bothnian Bay, which is a globally unique phenomenon in the boreal zone.

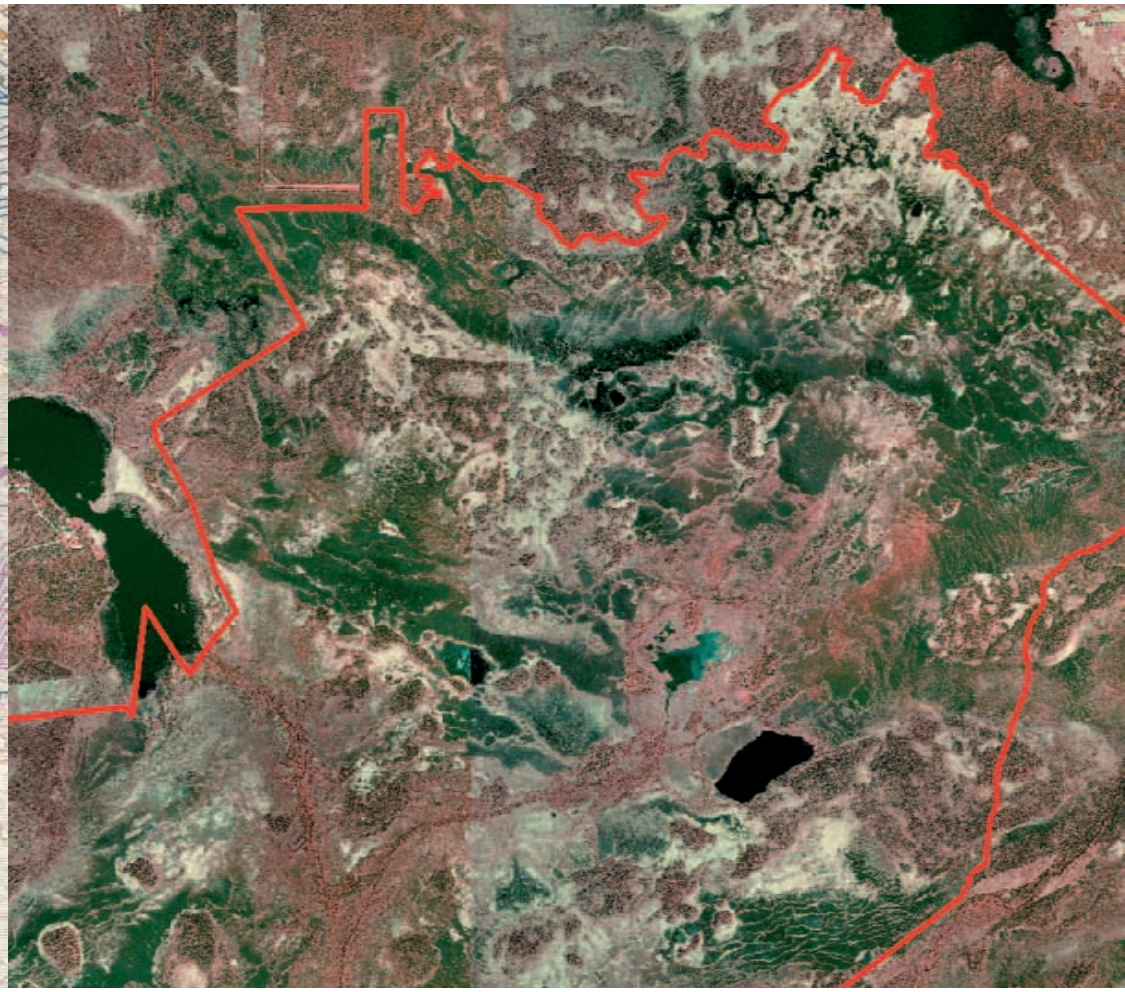
The mires described in this book cover a wide range of mire massifs from northern flark aapamires to sedge aapamires and eccentric bogs in central Finland, concentric raised bog in western and southwestern Finland, and the plateau bogs in the southern coastal area. There are successional series of the development of young aapamires and bogs from shallow coastal waters in the land uplift coast near Oulu town, and recent mire succession due to the lowering of the water table of lakes. Mire site types in the mires cover a wide ecological range from bogs to rich fens, spring-fed mires and flooded swamps. Almost all mire plant and bird species recorded from Finland can be found in these mires.

Most of the mires presented here are protected as national parks, strict nature reserves or mire reserves. Thus this book gives a positive view over Finnish mires. We must remember, however, that about 75 % of Finnish mires have been destroyed by forestry drainage, agriculture, peat mining or reservoir building. Therefore, it is essential to continue the work to protect the remaining pristine mires, especially in southern and central Finland. One aim of this book is to emphasize the great diversity and high conservation value of Finnish mires.

During the compiling of this book it was revealed that despite a long mire research tradition and intensive inventories conducted in nature reserves recently, we know surprisingly little about our mires. Even though the examples described in this book belong to our most famous protected mires, the knowledge about site types, plant species and development history of them is very scattered. For example, we found pollen diagrams for only two of the mires, and there were several, for which there was no knowledge about peat deposits at all. Macrosubfossil studies revealing the development of the mire itself were also very scanty. The knowledge about birds covers mainly land birds, for which line censuses are suitable, but information about waterfowl was hard to find, even though mires host a rich fauna of it. Knowledge about other animal groups was almost lacking. Some mires have been well studied for hydrology and ecology, but from most of them there is no concrete data. All this emphasizes the importance of mire research in Finland – land of mires.



Topographic map of Teuravuoma mire reserve. Each grid square is 1 km².



False-colour infrared aerial photograph of Teuravuoma mire reserve. The red line shows the boundary of Natura 2000 area.

Aapamire in southern Lapland

Teuravuoma-Kivijärvenvuoma mire reserve

Eino Lappalainen, Eero Kaakinen & Teemu Tahvanainen

The Great Teuravuoma aapamire system in western Lapland lies some 150 kilometres north of the Arctic Circle, and is the biggest mire system in Finland. It covers an area in excess of 35 000 hectares. In this system, there are 54 separate mires. The largest mire massif is the Teuravuoma massif that covers 7080 ha and is the biggest single mire in Finland. In addition, there are 13 lakes and the 80 km long Naamijoki River and its tributaries within the Great Teuravuoma system. More than 150 springs discharge to the mires. The springs have greatly influenced the vegetation and the paludification during the last 10000 years. The total amount of peat accumulated is 260 million m^3 and as much as 234 million tonnes of water is held by the peat layers. Only the eastern part of the originally huge mire system is in its natural state and included in the Teuravuoma-Kivijärvenvuoma reserve.

The area of the European NATURA 2000 network in Teuravuoma-Kivijärvenvuoma is 5788 ha. The area was included in the National Mire Protection Programme in 1981 and it is included in the Ramsar list (Ramsar site no. 1535). Reindeer husbandry is an important livelihood in the surrounding areas and also permitted in the reserve. Hunting, fishing and picking of mushrooms and berries are permitted as well.

Vast aapa massifs are the dominant feature of the Great Teuravuoma system, while another distinct feature is the great number of scattered forest islets. The reserve consists mostly of mires, and forests only make up about 10% of the area. Open mire types cover 60% of the mire area. Drier, treed mire types are mostly pine mires, while spruce mires are also common. There are altogether 651 ha of rich mire types in the Natura 2000 reserve, most of which are located within the Teuravuoma massif. Of this area, 385 ha are open rich fens. Rich spruce mire types and rich birch fens together add 90 ha to the area of rich mire types. The rich birch fens are especially important as habitats for threatened species such as the mosses *Hamatocaulis lapponicus* and *H. vernicosus*, and the Yellow Marsh Saxifrage (*Saxifraga hirculus*). In addition, combination types of pine mire and rich fen vegetation comprise an area of 176 ha. In spite of the large area of rich fens, Teuravuoma cannot be considered to be a special reserve for rich fens, in particular, since the most diverse rich fens with an intermediate water level are missing. Compared to the rich fens of Kittilä area, for example, the diversity of rich fen types and vegetation is narrower in Teuravuoma.

Typical for the Teuravuoma-Kivijärvenvuoma area are the large flark fens that turn to a rusty colour in the midsummer due to the abundance of *Eriophorum russeolum*. The poor-rich gradient and the surface patterning vary in different parts of the mire system. Poor fen *Sphagnum*-flarks cover large areas, while the hydrologically more minerogenous areas are dominated by mosses of the Amblystegiaceae family. *Warnstorfia exannulata* is an especially typical species. In the rich flark fen areas, *Scorpidium scorpiodes* and *Scorpidium revolvens* are typical indicator species. The ridges in rich

Eriophorum russeolum is a characteristic species of flark fens in Lapland. Photo Raimo Heikkilä.

flark fens are usually quite low, while in poorer sites they are typically very high. Such especially distinct ridges are found for example in the central part of the Kivijärvenvuoma.

In the Teuravuoma-Kivijärvenvuoma area, relatively large mire areas have scattered birch trees. As with the flark fens, the different poor-rich levels of birch fens can be found in the Teuravuoma area. Surface water influence is very typical for some of these mires. Rich birch fens represent the richest level along the poor-rich continuum of mire sites in Teuravuoma, and have some very demanding species. The richest birch fens have species such as *Saxifraga hirculus, Carex heleonastes, Hamatocaulis vernicosus, Warnstorfia tundrae, Calliergon richardsonii* and *Tomentypnum nitens*. Among the animals found in the rich birch fens, *Vertigo geyeri*, a tiny whorl snail, is in the endangered species list.

The essence of Teuravuoma also includes small lakes and brooks. The influence of flooding can be seen in large areas, bringing the surface water influence to mires, especially along the little rivers. Intermediate spruce mires and swampy birch fens are concentrated along the rivers and brooks as narrow belts. Teuravuoma is also characterized by forest islands, which are locally called "*saajos*". These forest islands are noticeable in the landscape with their narrow shaped spruce trees and a mixture of birch trees. Most of these *saajos* represent forests in their natural state. In 73% of all forest area in Teuravuoma, the tree stands are more than 200 years old. In the *saajos* and their marginal areas, there are sometimes drier spruce mire types. In the marginal regions of the aapa mires, pine mires are typical and may sometimes occupy large areas. The largest pine mires are generally poor pine fens. Ombrotrophic bog vegetation is relatively marginal in Teuravuoma. The growth of *Sphagnum fuscum*

An oblique aerial photograph of aapamire in the central part of Teuravuoma – Kivijärvenvuoma mire reserve in the southern end of Lake Teurajärvi. Photo Hannu Vallas.

has been considerable only in some localities in the western part. The plant species of Teuravuoma are typical of the main aapa-mire zone, the northern element being dominant. The few southern species found in the rich birch fens include *Cicuta virosa* and *Calla palustris*.

The avifauna of the Teuravuoma-Kivijärvenvuoma area is very diverse. Altogether 96 bird species have been observed in the area; 24 of them belong to the Annex I of the Birds' Directive and 21 are nationally endangered. The most numerous bird species of the open mire habitats are the Yellow Wagtail (*Motacilla flava*), the Meadow Pipit (*Anthus pratensis*), the Wood Sandpiper (*Tringa glareola*) and the Reed Bunting (*Emberiza schoeniculus*). Other typical mire species include the Broad-billed Sandpiper (*Limicola falcinellus*), the Snipe (*Gallinago gallinago*), the Willow Grouse (*Lagopus lagopus*) and the Crane (*Grus grus*). The lakes of the area are favourable for waterfowl, and the Black-throated diver (*Gavia arctica*), the Smew (*Mergus albellus*) and the Velvet scoter (*Melanitta fusca*) enjoy their stay at these lakes. Naturally, the Bear (*Ursus arctos*) is the master of the mammals in the area. The forest islands offer appropriately covered places for the bears to hide.

The history of mires in Teuravuoma cannot be passed without mentioning the impact of human land use. In many places, the water levels have been regulated and the riverbanks have been mowed. These tradition biotopes further diversify the present Teuravuoma and the conservation of these biotopes calls for active management. The succession of these new biotopes following the altered hydrology can be clearly seen in some parts along the lakeshores and the riverbanks. The meandering of the Naamijoki River in the southern part of the Teuravuoma adds another rich component to the tradition biotopes.

An oblique aerial photograph of the eastern part of Teuravuoma – Kivijärvenvuoma mire reserve. The wooden boardwalk crosses aapamires and old-growth forest islands. Photo Hannu Vallas.

The Great Teuravuoma area offers good facilities for experiencing nature and for developing ecotourism activities and related products based on the environment of the mire region and the cultural heritage. By restoring a historical corduroy road and adjoining various natural and cultural trails, a novel site of attraction will be created where the Natura 2000 conservation programme can be implemented to offer local people opportunities for developing nature-based business and marketing. At the same time, the Natura programme supplements activities in Ylläs, Levi and Olos tourist centres, which are mainly focused on fell tourism. These destinations have an accommodation capacity of about 30000 beds.

Historical aspects of Teuravuoma

Eino Lappalainen

At an early phase of the Holocene, the water level of the Baltic Sea reached the Great Teuravuoma basin. This stage (10 800- 9000 cal yr BP) in the history of the Baltic Sea is called the Ancylus-Lake stage. The Great Teuravuoma basin was a northern bay of the Ancyclus Lake, which reached from the Teuravuoma area as far south as to the northern Germany. Due to the rather rapid land upheaval, the Ancylus phase continued here for only 500 - 600 years.

Clear evidence of human activity from the Kurtakko village, for instance, has been discovered along the shores of this ancient lake. Water level was approximately 175–180 metres above the current sea level, and during that geological period, the present mire islets were skerries of the great lake. Climatic conditions were favourable, as

the average temperature was a couple of degrees higher than present. For example, pine forests spread significantly further northwards than at present. Treeless fell tops were also much smaller and more indented than today.

The oldest prehistoric findings of that time appear to date back to the Mesolithic Stone Age. The evidence discovered includes depressions of habitation dikes, dwelling hollows, hunting pits and tepee-stove sites. The most common tools discovered were chisel-shaped items made from greenstone (blades, maces, ice-picks) and quartz scrapers. Based on these and other findings of stone objects, it appears very likely that these objects were quarried nearby. A possible Stone Age quarry of this kind may have been located 5 km from the Stone Age dwelling site. One point of special interest is the prehistory of today's mire islets, as many of these islands were also islands and islets of the ancient Ancylus Lake, and were therefore ideal for fishing and seal hunting. A fully comprehensive prehistoric study of the Great Teuravuoma`s mire environment has not been carried out as yet. However, based on preliminary studies, it may be presumed that the area was inhabited already in the Preceramic or Mesolithic Stone Age, or at least by the following Neolithic Stone Age. Chronologically, this would indicate human survival here in the current Great Teuravuoma mire environment, 150 km to the north from the Arctic Circle, for over 9000 years.

At the time when metal objects overtook stone objects in efficiency, deer hunting also increased. This period is termed the Metal Age (started approximately 2000–1000 B.C.). This period significantly shaped the culture of the Forest Lapp people. In the early stages, bows, arrows and spears were used as tools for hunting, skis for travelling, perhaps even with the help of a dog.

Typical evidence includes trap pits, which have been plotted in 32 sites in the surroundings of Great Teuravuoma mire complex. Various forms of reindeer fencing obtained their design from this period. The indigenous Forest Lapps who preceded agriculture also originated from this period. Evidence of their dwellings includes tepee foundations and hearthstone structures. During this cultural period, wooden idols and figures were used, four of which have been discovered from the area.

Of all the historical remains, the most impressive must be the duckboard route, or corduroy road, built between Kurtakko and Venejärvi villages between 1868–1881. This wooden corduroy road, called "Telatie" by the local villagers, was repaired during 1926–1927 and used until the 1960s, when rambling on mires gradually decreased and the duckboards began to rot and be covered with peat. Chronologically, the oldest relic is, however, the meadow hut in the grassy meadow region on the shore of the Naamijoki River. The building belongs to one of the oldest surviving log-built constructions in the municipality of Kolari and dates back to the beginning of the 19th century. Messages and dates have been inscribed on the walls of the hut for future generations to read, the oldest of which dates back to 1827. The grassy meadow of the Naamijoki River had over 50 hay barns in the beginning of the 1950s and the meadow was a very important area for the collection of forage for cattle. Some of these barns were removed, others repaired in 1998–99. This grassy meadow is a traditional peasantry biotope region and the largest remaining grassy meadow with a wilderness river environment in Finland. The cultural offering of the mire also includes the lake Iso-Kivijärvi, drained in the 1940s, as well as the drainage channels of the lakes Teurajärvi and Iso-Kivijärvi. In the beginning of the 1950s, the drained lake housed 21 barns, only a few of which still remain. The sides of the channels have become bushy and birch and willow species have started to grow.

Other historical cultural remains are structures belonging to reindeer husbandry, tar burning and coaling, logging, log-floating, agriculture and wartime. These include reindeer fences and round-up enclosures, tar-burning pits and coal-pit bottoms, peat and earth huts, forest cabins, dams, channels, log-floating chutes, timber depot and barking sites, dugouts for forest guardsmen, and home museums in local villages.

Pollen stratigraphy of Teuravuoma

Teemu Tahvanainen

The vegetation development in the Teuravuoma environment was studied by Moisanen (2004) using a pollen diagram constructed from a peat profile of the deepest part of the mire. The sampling site was located 500 m south of the Lake Teurajärvi. The peat depth was five metres. The bottom sample (493-497 cm) dated back to 10200 years cal BP. Thus, paludification started here during the Ancylus Lake stage of the Baltic Sea (10800-9000 cal BP), which corresponds to the Boreal Period in the postglacial climatic sequence. The aquatic Ancylus phase was relatively short here in the northernmost part of the north-reaching fjord of the Ancylus Lake and there was no Ancylus sediment in the base of the peat deposit. Three main phases were recognized in the pollen stratigraphy: 1) the birch stage (10200-8700 cal BP) corresponding to the Boreal Period, 2) the birch-pine-alder stage (8700-8300 cal BP) that continued through the Atlantic and the Sub-Boreal Periods, and 3) the pine-birch-spruce stage (8300 cal BP to present) of the moist Sub-Atlantic Period. By means of seven ^{14}C datings the peat accumulation rate in Teuravuoma has been estimated as 0.27-1.23 mm per year.

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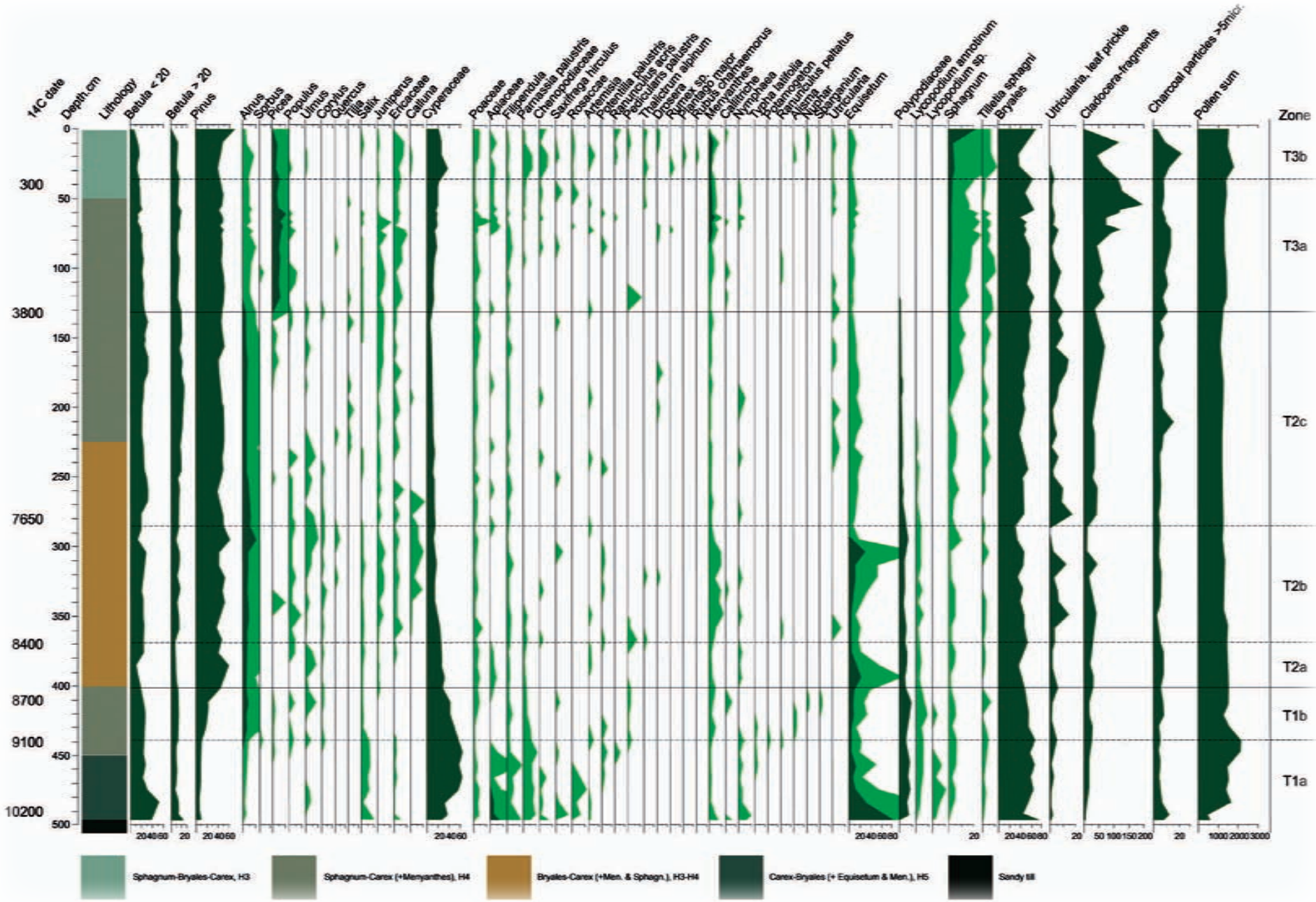


Pollen diagram from the deepest part of Teuravuoma mire. Redrawn after Moisanen (2004).

Ecohydrology of Lapland Hamatocaulis Moss, *Hamatocaulis lapponicus* (Norrl.) Hedenäs; a characteristic but very rare species of aapamire flarks

Tapani Sallantaus

The two species of the genus *Hamatocaulis, H. lapponicus* and *H. vernicosus*, are both at home in aapamires. Both are listed in Annex 2 of the EC Habitats and Species Directive. *H. vernicosus* is, however, not so uncommon in northern parts of Finland; there are about 300 known localities. *H. lapponicus* is truly rare. There are only about 20 present localities in Finland, and the species is classified as endangered. It is not known from Norway, in Sweden there are only 4 present localities, it is reported from Latvia and there is a very old finding from Germany. Its status is "only" vulnerable in Europe, since, as a taiga species, it is classified only as rare in Karelia and in the Murmansk Region (Ulvinen 2006).

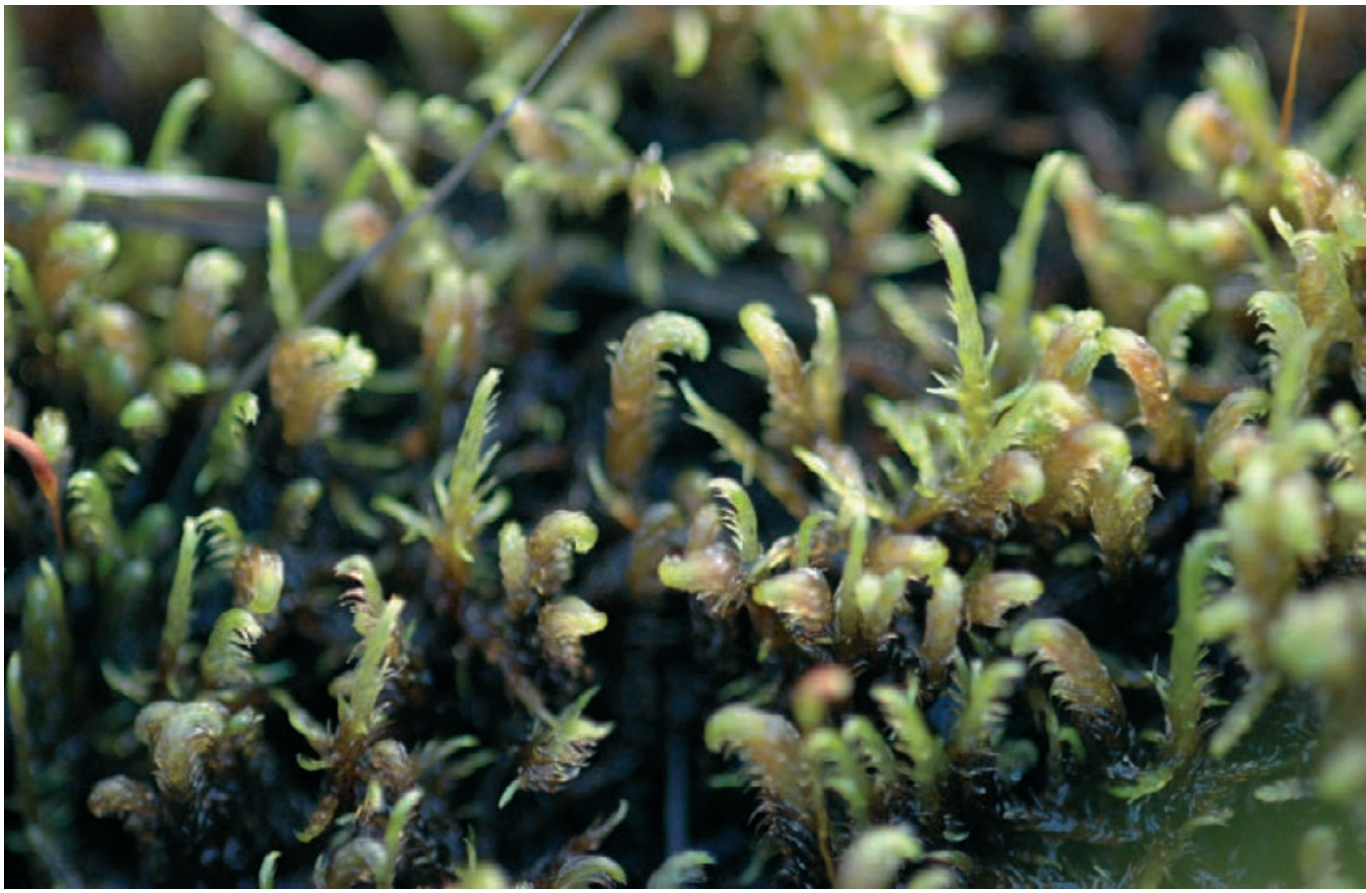
According to Hedenäs (1989), *Hamatocaulis* species are found in mineral-rich to intermediately mineral-rich, but usually not especially calcium-rich habitats, which are often slightly nutrient-enriched. Both species seem to favour or tolerate iron, and rich birch fens (*koivuletto* in Finnish) are their typical habitats in the north. *H. lapponicus* grows, however, in poorer habitats than *H. vernicosus* (Ruuhijärvi 1962). Many of the known sites are intermediate fens.

In Teuravuoma mire there are two known sites inhabiting *Hamatocaulis lapponicus* today, in the NE corner of the protected area. One location has been destroyed by ditching. The patches cover only a couple of square meters together. In the huge Olvassuo Natura 2000 area the moss grows in 4 separate locations, and these are probably the most important stands of the species in Finland, several tens of square meters together. In Hirvisuo mire there is also one fairly large patch; dominant in 4 m^2, present in another 4 m^2. There is also one old finding from Heinijänkä in Tervola, SW Lapland.

I took water samples at the two Teuravuoma locations of *H. lapponicus* in early August 2005. Both are clearly iron influenced, dissolved Fe was about 0,2 mg/l, but iron precipitates could be seen nearby. DOC was 7 mg/l in site Teuravuoma E a, where also *H. vernicosus* is growing. The vegetation was resembling that of rich birch fens, but the water was very dilute: alkalinity 0,08 mmol/l, Ca 1,4 mg/l, specific conductivity 1,3 mS/m – but pH anyhow 5,9, well in the range of intermediate fens, but in the lower end of transitional rich fens. The other site (Teuravuoma E b) had somewhat stronger water, but low DOC: alkalinity 0,19 mmol/l, pH 6,2, conductivity 2,4 mS/m, Ca 2 mg/l, DOC 3 mg/l and dissolved phosphate phosphorus as high as 11 µg/l.

In the mires of Olvassuo (Sallantaus & Turunen 2005) the water quality is rather similar to Teuravuoma. Alkalinities are typically in the range 0,1 – 0,3 mmol/l, Ca values low, around 2 mg/l, and Na is important in the charge balance. Median conductivities are about 3 mS/m, but pH values are rather high: medians at the 4 locations vary 5,8 – 6,2.

H. lapponicus grows also in lower pH; values even below 5 have been reported. It is clearly a mire species, although the sites have some groundwater influence. *H. vernicosus* can grow also in small spring mires, in pure groundwater, whereas *H. lapponicus* seems to demand slightly humus influenced water – but not dark waters typical of *Sphagnum* dominated mires. The localities of *H. lapponicus* in the south are not actually mires but small slightly humic lakes or ponds. The moss grows more or less submerged, as a riparian species attached to the floating littoral peat. In this way it can stay constantly wet, without getting too deep. Also these habitats may have



Hamatocaulis lapponicus. Photo Tapani Sallantaus.

somewhat dilute water, but yet usually positive alkalinities and some higher pH indicating plant species in the riparian zone, e.g. *Cicuta virosa*, *Peucedanum palustre* and *Potentilla palustris*.

As an intermediate species with respect to chemistry, the reasons for the rarity are not very obvious. Suitable habitats should be plentiful. *H. lapponicus* is clearly sensitive to hydrology, but many of the wet northern mires are still intact. It is a mysterious species, typical for Lapland.

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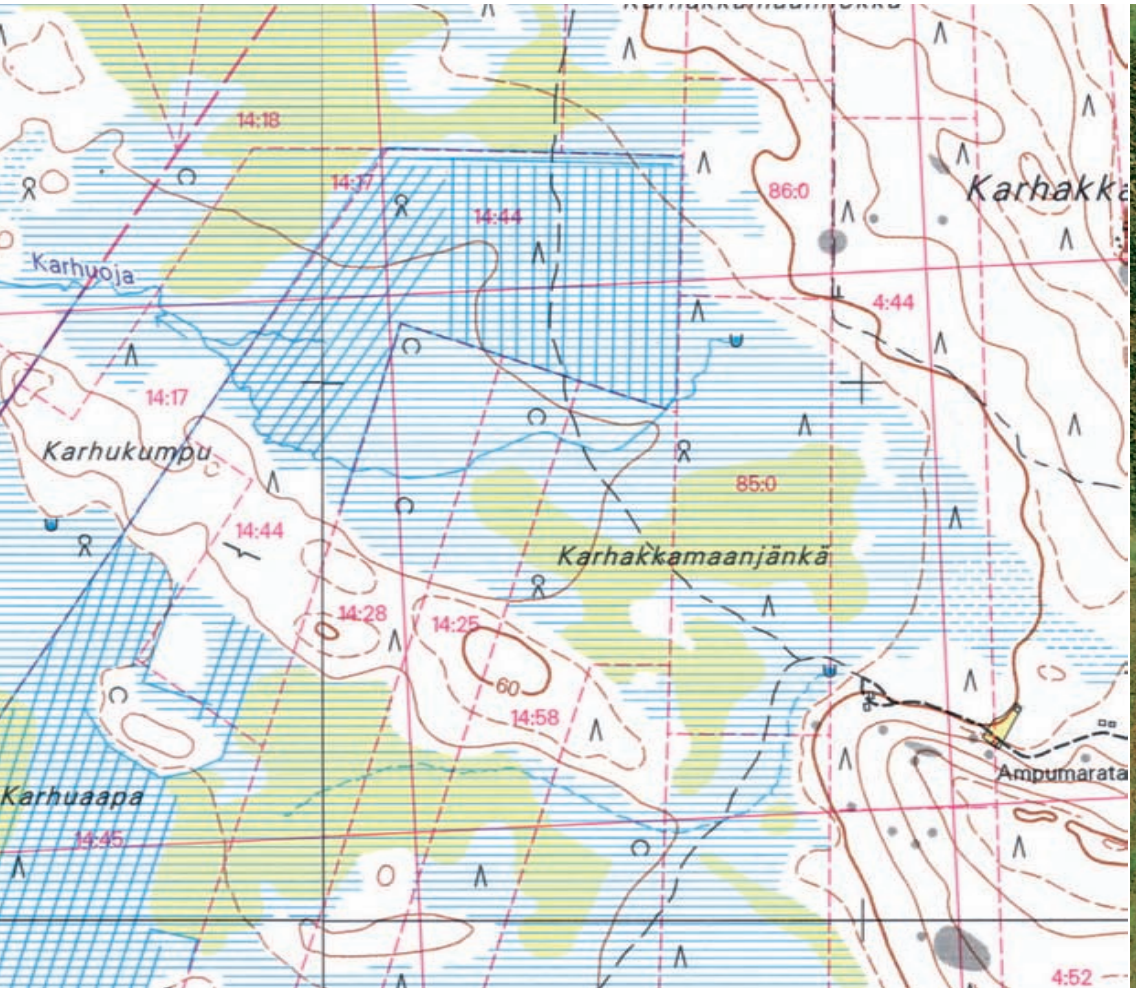

Topographic map of Heinijänkä – Karhuaapa mire reserve. Each grid square is 1 km².
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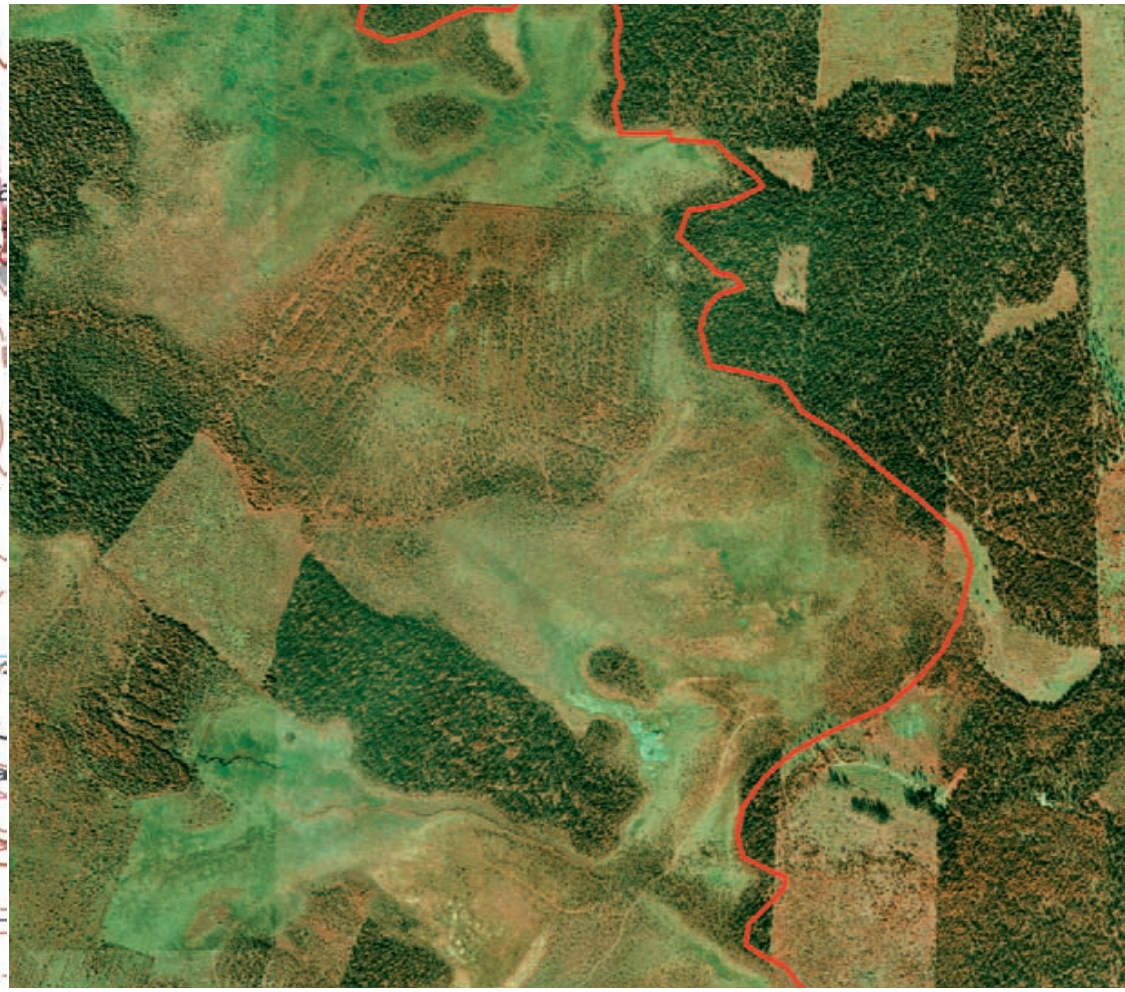

False-colour infrared aerial photograph of Heinijänkä – Karhuaapa mire reserve. The red line shows the boundary of Natura 2000 area.
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Rich fens in a northern dolomite bedrock area

Rich fens of the Lapland triangle in the Heinijänkä-Karhuaapa area

Teemu Tahvanainen & Raimo Heikkilä

The Heinijänkä - Karhuaapa mire reserve is comprised of a 900 ha wide aapamire system, which is divided into several lobes or massifs by forest islands. It is located within the alkaline bedrock region of south-western Lapland, the so called Lapland triangle. As a consequence of the geochemical environment, rich fens are common in the area. In the Heinijänkä - Karhuaapa mire system, about 60 % of the mire area is represented by rich mire types, including both open and treed types. The most common mire types are rich birch fens and rich flark fens.

It has been estimated that the area of rich fens in south-western Lapland has diminished to one tenth of the original due to their clearing for fields and drainage for forestry. The suitability of rich fens for agriculture was investigated in the early twentieth century and much of the field clearings took place in 1920-1930. Starting from 1950s, drainage was a major threat to rich fens until the late 1980s, when the drainage activity started to recede. The mires in the Heinijänkä - Karhuaapa system were luckily never cleared into fields, but almost a quarter of the mire area has been drained. Most of the drainage took place in late 70s and early 80s but an eastern part of the mire system, the Keskipalonjänkä mire, was drained as late as in the mid-1990s. Simultaneously to the drainage activity, this mire system was included in the National Mire Protection Programme in 1981 and, subsequently, in the European NATURA 2000 network. The conservation of the area was finally realised through the Aapami-re-LIFE project in 1998-2002, partly funded by the EU. As a part of the conservation effort, drained areas were restored by blocking the ditches.

The Heinijänkä – Karhuaapa mire system lies on dolomite bedrock, while some vulcanite and mica schist rocks occur as well. The alkaline geochemistry is reflected in the fen waters, which have extremely high cation concentrations and alkalinity, in Finnish standards. At one extremely rich fen site in Karhuaapa, near the western margin of the Karhukumpu forest island, alkalinity was 5.62 mmol/l, pH 7.2, calcium concentration 52 mg/l and magnesium 39 mg/l. The ratio of calcium and magnesium clearly reflects the composition of the dolomite minerals. In another site, located in a central moderately rich fen in the north-eastern part of the basin, water pH was 6.2 and calcium concentration was 11.7 mg/l. The near neutral pH of water is essential for rich fen vegetation. When calcium levels are high, the calciphilous element further increases the diversity of rich-fen vegetation.

More than half of the Heinijänkä-Karhuaapa mire is rich fens. Rich birch fen is by far the most common rich fen site type. Also *Scorpidium* flark fens and rich pine fens are common. There are also rich spring fens, rich spruce fens, *Warnstorfii* rich fens and *Campylium* rich fens (Keränen & Myllynen 2002). Largely the rich fens can be classified as extremely rich fens. In the extremely rich fens, calciphilous species such as

An oblique aerial photograph of Karhakkamaanjänkä rich fen in the northeastern part of the mire reserve in 2005. Behind the mire there is a forest clearcut from 2004, which extends to the mire margin. To the left of it there is a tree-covered rich fen, which was drained about 25 years ago and restored in the 1990s. Photo Hannu Vallas.

Catoscopium nigritum, Cratoneuron filicinum and Carex capitata are found, in addition to the typical moderately rich fen species like *Campylium stellatum, Scorpidium scorpioides* and *Tomentypnum nitens*, which do not require especially high calcium levels.

In gross scale, the poor-rich gradient in vegetation is best explained by the variation of water pH, while along the gradient there are certain patterns that are affected by additional factors. One conspicuously deviant feature is the occurrence of the rich birch fen vegetation type that is characterised by a distinct plant species assemblage. Noticeably, the rich birch fens do not deviate in water pH from other rich fens. Rich birch fens are typical in the Lapland triangle where they were described by Kotilainen (1928). Ruuhijärvi (1960) also gave detailed descriptions of vegetation in rich birch fens. The area of rich birch fens has diminished remarkably and this mire type is among the nationally threatened mire types. Also in the Heinijänkä-Karhuaapa area, only a small part of the rich birch fens is in natural condition.

In the Heinijänkä - Karhuaapa area, characteristic species of the rich birch fens include *Carex appropinquata, Carex diandra, Stellaria crassifolia, Saxifraga hirculus, Calliergon giganteum, Hamatocaulis vernicosus, Helodium blandowii, Warnstorfia tundrae, Sphagnum teres* and *Paludella squarrosa*. Some typical species of rich fens (e.g. *Scorpidium scopioides, Campylium stellatum, Selaginella selaginoides, Carex flava, Juniperus communis*) are sparse in rich birch fens, while common shared species include *Tomentypnum nitens, Sphagnum warnstorfii* and *Carex dioica*. Along with the character species, common mire species such as *Aulacomnium palustre, Carex lasiocarpa, Menyanthes trifoliata, Equisetum fluviatile, Andromeda polifolia, Potentilla palustris* and *Betula nana* are abundant in rich birch fens. There are shared elements in the species list with spring and flood mires. Furthermore, many of the characteristic species can be considered as

A calcareous spring in the northern margin of Karhakkamaanjänkä rich fen. In the foreground *Saxifraga hirculus* in bloom. Photo Raimo Heikkilä.

indicators of intermediate fens rather than rich fens (Sjörs 1952). Iron precipitation is typical in rich birch fens and high concentrations of iron and phosphorus have been considered to make the ecological difference between rich birch fens and other rich fens. In the rich birch fens of the Heinijänkä-Karhuaapa area, high cation concentrations (Ca 21 mg/l, Mg 16 mg/l), high pH (6.5) and conductivity (150 µS/cm) characterize the surface water chemistry. In three water samples from restored rich birch fen areas, iron concentrations were high (7.0, 7.6, 8.0 mg/l) and also phosphate was present in comparably high concentrations (19, 28 and 390 µgP/l). Thus, despite the abundance of the intermediate fen indicator species, the pH and cation concentrations are typical for rich fens. The high iron and phosphorus levels are consistent with some other observations from rich birch fens, although samples from the Heinijänkä-Karhuaapa area were only available from the restoration sites where the water chemistry may be anomalous.

Many nationally threatened plant species occur in the Heinijänkä-Karhuaapa area. Five of the threatened species belong to the EU habitat directive's appendix II (*Saxifraga hirculus, Cypripedium calceolus, Meesia longiseta, Hamatocaulis vernicosus* and *H. lapponicus*). Most of the threatened species are mire species and among them, many are calciphilous species. Within the Natura 2000 area, there are four stands of *Cypripedium calceolus*. Several *C. calceolus* stands are located in the vicinity, right outside the Natura area. Some of these have suffered from clear cutting of forest near the eastern border of the Natura area. Altogether, seven threatened orchids occur in the Heinijänkä-Karhuaapa area. In addition to *C. calceolus*, stands of *Epipactis palustris, Dactylorhiza traunsteineri, Dactylorhiza incarnata* ssp. *cruenta, Dactylorhiza incarnata* ssp. *incarnata, Listera ovata* and *Malaxis monophyllos* are known. Local specialities include

Tapio and Olli Lindholm standing on a dam of a blocked ditch in a restored rich fen. In the foreground there is a tussock of *Carex appropinquata*. Photo Raimo Heikkilä.

Stellaria fennica and *Eleocharis quinqueflora* (Keränen & Myllynen 2002). Occurrences of the many threatened species and of about ten endangered mire types makes the Heinijänkä-Karhuaapa area very valuable for mire conservation.

The restoration work in the Heinijänkä-Karhuaapa area is being conducted by the Metsähallitus. The restoration was started in 1996, when ditches were dammed with peat using an excavator. Earlier, in the 1990s a few plywood-board dams had already been constructed by the Lapland Regional Environment Centre. The dams were, however, placed in too sparse intervals and the rewetting was insufficient. The restoration was continued with more detailed planning during the Aapa Mire Life-project (1998-2002), partly funded by the EU. Dams were built in a more frequent design and some ditches were fully filled with peat during 2000-2001. By that time, the restoration area was 100 ha wide. The restoration has been further complemented in recent years by additional dams and by totally filling up some ditches. The tree stands have not been cut down. Birch (*Betula pubescens*) is the main tree species and cutting it down would only lead to rich sprouting. After ten years of restoration, there are still problems in rewetting the mire surfaces. Although the ditches are blocked, water does not easily rise high enough in the surfaces between the ditches. Most of the tree stands are alive and shade the field and ground layer vegetation. Also, in many areas the field layer has become very productive, preventing the development of the ground layer. Some areas of original rich birch fens are now dominated by a dense growth of *Calamagrostis* and *Carex* species, among them there is a threatened species *Carex appropinquata*.

The water chemical data mentioned above belong to unpublished data of A. Haraguchi, T. Tahvanainen and T. Sallantaus.

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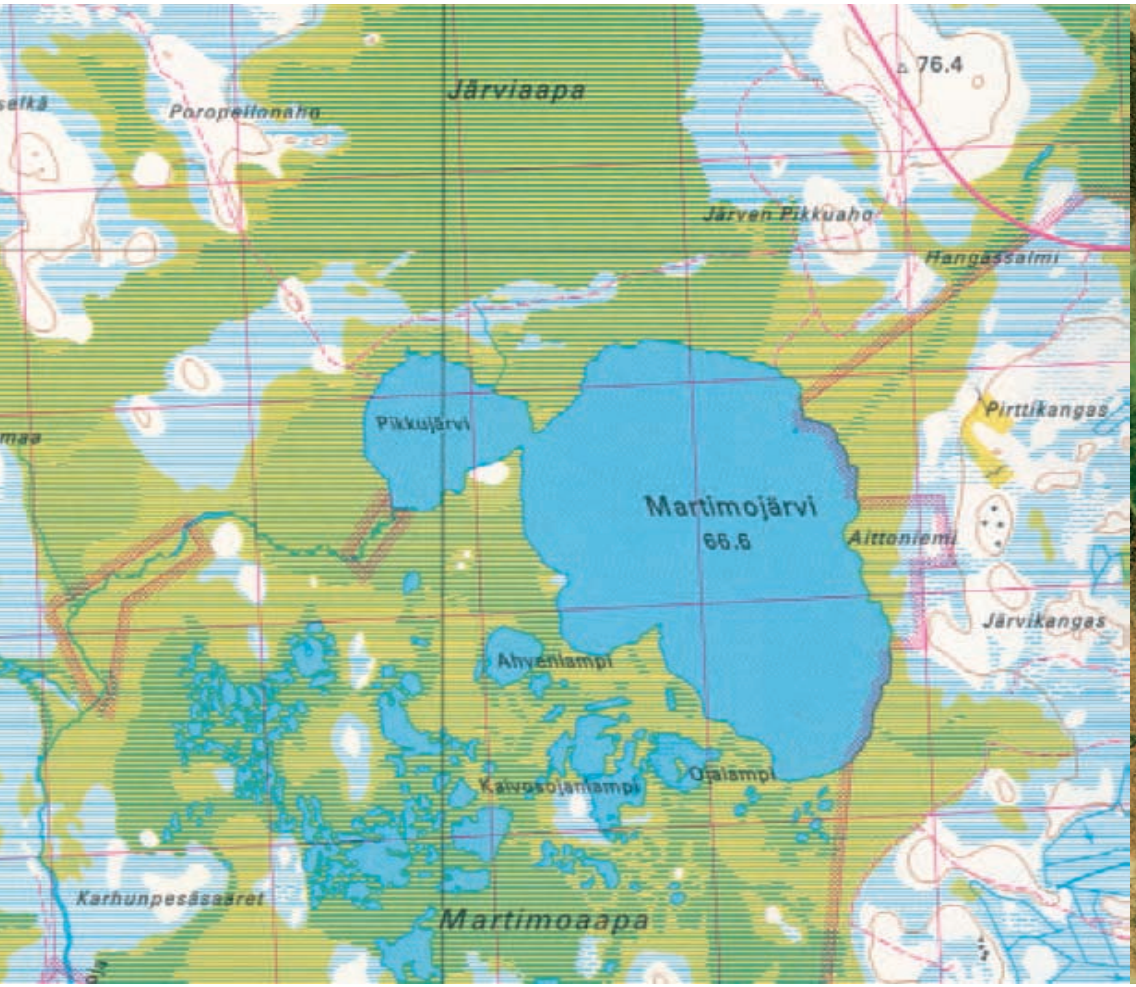

Topographic map of Martimoaapa mire reserve. Each grid square is 1 km^2.
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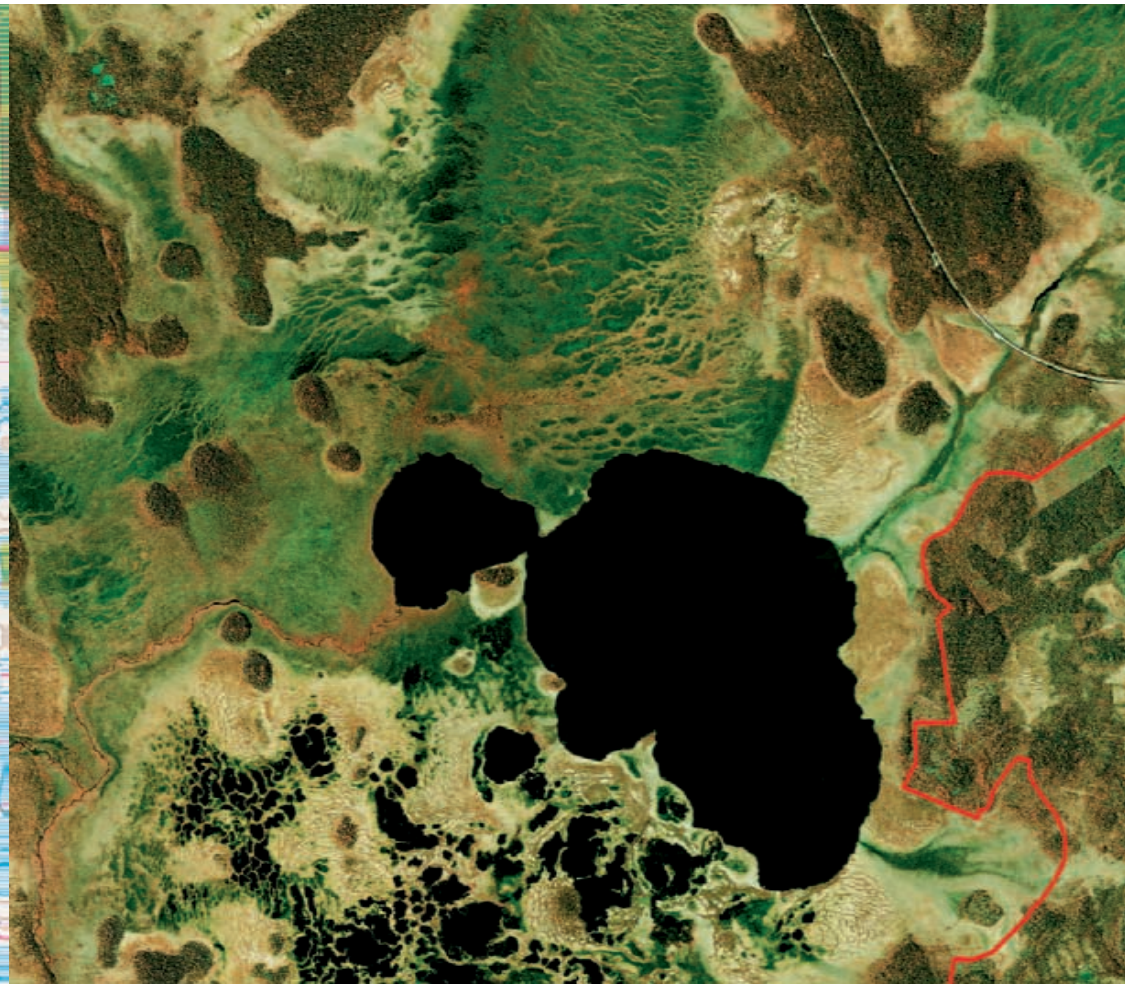

False-colour infrared aerial photograph of Martimoaapa mire reserve. The red line shows the boundary of Natura 2000 area.
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Wet aapamires and raised bogs: a paradise for birds

Martimoaapa

Teemu Tahvanainen

The mire system containing the Martimoaapa and other connected mire massifs is one of the most important mire reserves in northern Finland. The reserve was founded in 1981, and it covers an area of 124 km^2. There are several vast mire massifs in the area, which join in a single system in a gross-scale hydrological perspective. In the western part of the system, there appears some alkaline geochemical influence from the Kivalo quartz belt, while most of the mire area is fed by waters poor in mineral ions. Most of the mire area is characterized by poor fen vegetation and the predominant massif form is typical aapamires with minerotrophic flark and lawn surfaces in the centre. There are, however, raised bog massifs as well. In fact, the Martimoaapa massif, despite its name, is a raised bog, with its centre elevated from the margins.

The gross-scale hydrology makes the difference between the formations of the aapa-mire and raised-bog massifs. North from the Martimojärvi Lake, water from a wide drainage area gathers to the central parts of the Myllylänaapa and Järviaapa mires, where in the flat sloping mire surface, water flows evenly towards the south and the Martimojärvi Lake. South of the Martimojärvi Lake, the situation is very different. The Martimonoja River that originates from the Lake Martimojärvi gathers water from the upper mire areas and bypasses the Martimoaapa mire. The Martimoaapa mire is almost totally isolated from minerogenous water flow by the lake and the river system. This is a typical example of regulation by local hydrological factors and climate on the development of the different mire-massif forms. The Järviaapa massif north of Lake Martimojärvi represents a climatic zonal massif type of the southern aapa-mire zone, while the Martimoaapa massif represents an azonal raised bog massif type regulated by special local hydrological conditions.

In Martimoaapa bog, the direct precipitation to the mire represents a greater portion of the water input to the mire massif than in the Järviaapa aapa mire. Thus, there is a greater water and mineral budget in the aapa mire than in the bog. Water is also more stagnant in the bog. The stagnant hydrology makes it possible for the organic acidity to develop, as it is not flushed away, and the poor mineral input makes the water less buffered against acidification by organic acids. Another typical example of an azonal raised bog is found northeast of Lake Martimojärvi. A small eccentric bog has developed in the shelter of forest islands. Water from the upper drainage area loops around the islands and bypasses the small bog massif through fen soaks.

Järviaapa is a vast open aapamire massif, typical of the southern aapa mire zone. From Myllylänaapa mire to Lake Martimojärvi there is a ten metre gradient of elevation within a six kilometre course. There are no obstacles for water flow, as there are no forest islands or rivers in the Järviaapa massif. In the central fen area, very wet flark surfaces predominate. The whole of the central flark fen is patterned by strings. The strings are aligned perpendicular to the water flow, forming regularly arranged

An oblique aerial photograph of Järviaapa mire on the northern side of Lake Martimojärvi. The wooden boardwalks of nature trails cross the eccentric bog in the centre of the photo and aapa-mire on the foreground on the right. Photo Hannu Vallas.

patterns in places where water flow is unidirectional. The varying frequency of strings in such cases indicates the slope, a denser pattern being found where the slope is steeper. Especially in the lower central part, the strings from a reticulate network with often very large flarks, as the water flow becomes slower and more divergent. The marginal mire areas drain toward the centre and are therefore drier. The marginal zones are typically pine mires, often ombrotrophic *Sphagnum fuscum* pine bogs. At certain places, the hummock kermis of the marginal bogs have developed from strings of the aapa mire and the bog hollows or carpets from the flarks, respectively. In the aerial image, one can follow the surface patterns from a marginal bog to a central fen and see how the patterns are connected.

In the minerotrophic centre of the Järviaapa massif, poor fen vegetation dominates and typical species are *Carex rostrata, Carex magellanica, Menyanthes trifoliata, Schechzeria palustris* and *Utricularia intermedia. A*lso some rich fen influence is found, though. Around the hiking trail located in the southern part of the Järviaapa, north of the Martimonjärvi, several intermediate and some rich fen species occur (R. Heikkilä, unpubl.). *Dactylorhiza incarnata* is very abundant. Also *Hammarbya paludosa* has been found in considerable numbers. Characteristic species also include *Carex livida, Eriophorum gracile, Molinia caerulea, Selaginella selaginoides* and *Tofieldia pusilla*, and among the bryophytes *Sphagnum subfulvum, Sphagnum teres* and *Sphagnum warnstofii.* Only few true rich fen species are met, including *Campylium stellatum* and *Scorpidium scorpioides*. The vegetation of the Martimoaapa system is not fully investigated. There is a wide range of different habitat and vegetation types including mires and mineral land environments. The flora includes such regionally threatened species as *Alnus glutinosa*, *Carex heleonastes*, *Carex pallescens*, *Carex viridula* var. *bergrothii*, *Dactylorhiza incarnata* ssp. *cruenta*, *Rosa acicularis*, *Iris pseudacorus*, *Asplenium viride* and *Eriophorum brachyantherum*. In the northwest, the Martimoaapa mire sys-

tem is demarcated by the hills of the Kivalo Belt. There is a considerable discharge of ground water from the hills and rich fens are found within the ground water influenced areas of the Kivalonaapa and Lumiaapa mires.

Together, the Martimoaapa, Lumiaapa, Simoskanaapa, Myllylänaapa and Kivalonaapa mires comprise a very important and valuable reserve for typical avifauna of large mires. The vast wet aapas and pool labyrinths of the bogs harbour about 40 mire species of birds in the nesting period (Salminen 1980). Furthermore, the area is an important resting and feeding area to flocks of migrating birds. Waders are numerous; 13 species are known to have nested here, the most common ones being the Wood Sandpiper (*Tringa glareola*), the Ruff (*Philomachus pugnax*) and the Golden Plover (*Pluvialis apricaria*). Characteristic to the Martimoaapa mire system is the combination of southern and north-ern elements in the avifauna. The south-ern element is represented by the Horned Grebe (*Podiceps auritus*), the Garganey (*Anas querquedula*), the Lapwing (*Vanellus vanellus*), the Black-headed Gull (*Larus ridibundus*) and the Skylark (*Alauda arvensis*). The northern species include the Smew (*Mergus albellus*), the Velvet Scoter (*Melanitta nigra*), the Spotted Redshank (*Tringa erythropus*), the Jack Snipe (*Lymnocryptes minimus*), the Broad-billed Sandpiper (*Limicola falcinellus*) and the Red-necked Phalarope (*Phalaropus lobatus*). In addition to the Black-headed Gull, also the Herring Gull (*Larus argentatus*), the Common Gull (*Larus canus*) and the Great Black-backed Gull (*Larus marinus*) nest in the area. The commonest waterfowl species are the Teal (*Anas crecca*), the Bean Goose (*Anser fabalis*), the Mallard (*Anas platyrhynchos*) and the Tufted Duck (*Aythya fuligula*). Also the Whooper Swan (*Cygnus cygnus*), the Crane (*Grus grus*), the Black-throated Diver (*Gavia arctica*) and the Red-throated Diver (*Gavia stellata*) are common in Martimoaapa. Altogether twelve predatory bird species have been found nesting in the area. Typical species include the Northern Hobby (*Falco subbuteo*), the Merlin (*Falco columbarius*), the Northern Harrier (*Circus cyaneus*) and the Short-eared Owl (*Asio flammeus*). Among the numerous Passerines, the Meadow Pipit (*Anthus pratensis*) and the Yellow Wagtail (*Motacilla flava*) are the commonest species.

Wet intermediate flark fen in Järviaapa mire. *Carex livida* gives the greyish colour in the flarks. Photo Raimo Heikkilä.

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Forest restoration in Martimoaapa area

Teemu Tahvanainen

There are 4570 ha of forests in the Martimoaapa Natura 2000 area, 41 % of which is accounted for as old-growth forests. A remarkable part of the forests are young forests lacking the structural fea-tures of natural-growth forests. Adding dead wood by cutting down tree groups and by wounding trees is a method for increasing structural diversity. Using fire is a further means for increasing di-versity. The Martimoaapa area belongs, with 32 other reserves, to a EU LIFE project for the restoration of forests. The planning of the restoration was completed in 2002-2003 and the restoration work is completed in 2003-2012. Restoration of altogether 705 ha of forests is planned and the total costs estimated are 157 000€. Small clear cuts are applied on 591 ha and increasing dead wood by wounding on 91 ha. Respectively, the amount of dead wood will increase to 5-7 m^3 and 15-20 m^3 per ha in these areas. The average volume of tree stands in these restoration areas is 120 m^3/ha. Thus the increase of decaying wood equals 5-15 % of the living tree volume. After the restoration, the average amount of decaying wood will rise from 6 m^3/ha to 8-10 m^3/ha in the whole Natura 2000 area.

Burning young pine plantation adds decaying wood and starts natural forest succession. Photo Raimo Heikkilä.

One forest restoration method is burning, which is applied in order to mitigate natural forest fires. The burning is conducted in dry summer season after the main nesting period of birds. Forest fires are rare due to active fire prevention and many fire-dependent species are threatened. The continuum of fire environments in the landscape scale is important for many specialist species of insects, especially. In 2003, 23 ha of forests in six separate places were burned in the Martimoaapa area. For example, one small forest island (4.1 ha), surrounded my mires, northeast of the Martimojärvi lake was burned in 2003. Additional 68 ha of forest burning are planned to be conducted in intervals that create a continuum of fire disturbance in the Martimoaapa area.

The Whooper Swan, National Bird of Finland

Antti Haapanen

In the 1940s the Whooper Swan was in Finland close to extinction. It survived in the extensive aapamires of the Northernmost Finland. These aapamires, especially their wet central parts are very difficult to reach and were a good sanctuary for the birds.

The survival of the species is a result of efforts of scientists, well known authors and other artists. Einari Merikallio (1949), a well known Finnish ornithologist published a well documented study on the decline of the Whooper Swan population. He was able to show that the decline was totally due to over harvesting: taking of eggs and hunting for food.

Flying Whooper swans in Nukinrahka mire reserve, southwestern Finland. Photo Teemu Tahvanainen.

At the same time author Yrjö Kokko published a book on the bird (name in English: The Whooper Swan, the bird of Ulthima Thule) in 1950. The book became very popular. Some years later in 1954 he published another book: The Whooper Swan comes back. These books raised the interest of the general public to the preservation of this magnificent bird. I suppose the painting by Akseli Gallén-Kallela called Tuonelan virran joutsen (The Whooper Swan of the Hades river), Jean Sibelius´ compositions and the mystic stories of our National Epos Kalevala also contributed to the total change in the thinking of Finnish people.

The monitoring of the Whooper Swan population was started in early 1960´s. It has been shown that the population has increased with a steady rate by 11 % /year during the 40 years starting from about 10 breeding pairs in the late 1940´s (Haapanen 1991). Now the figure may be some thousands breeding pairs. The results of a trial to census the population in 2004 have not yet been published. The population is still increasing in the southern part of the country. In the north the number of habitats has already become a limiting factor. Whooper Swans are found all over the country far beyond the southern limit which Merikallio (1949) showed to be the southwestern limit of its range in the beginning of Finland's ornithological history in the mid 1800´s.

The existence of Whooper Swans has stimulated people to name places according to the bird itself or mostly its habitat (*Joutsenaapa* = Whooper Swan aapamire). It is quite probable that these names are hundreds of years old, maybe older. In most cases the small lakes or mires have been named according to Whooper Swan, very seldom bigger lakes but more often the bays of bigger lakes (Aaltonen 1987). In the attached map (Fig. 1) many names refer to the word *joutsen* (Whooper Swan) or *korte* (*Equisetum fluviatile*) a very important summer food of the bird. Even the name *Joutsenoja*, i.e. Whooper Swan brook, is an important sign of swans. The brook is a spring habitat of vital importance. These brooks are open already in April far before the snow disappears from aapa mires. The breeding birds arrive even in Lapland already in April when the rivers and brooks may be open. Later on they move to the breeding site (Haapanen & al. 1973, Haapanen & Hautala 1991).

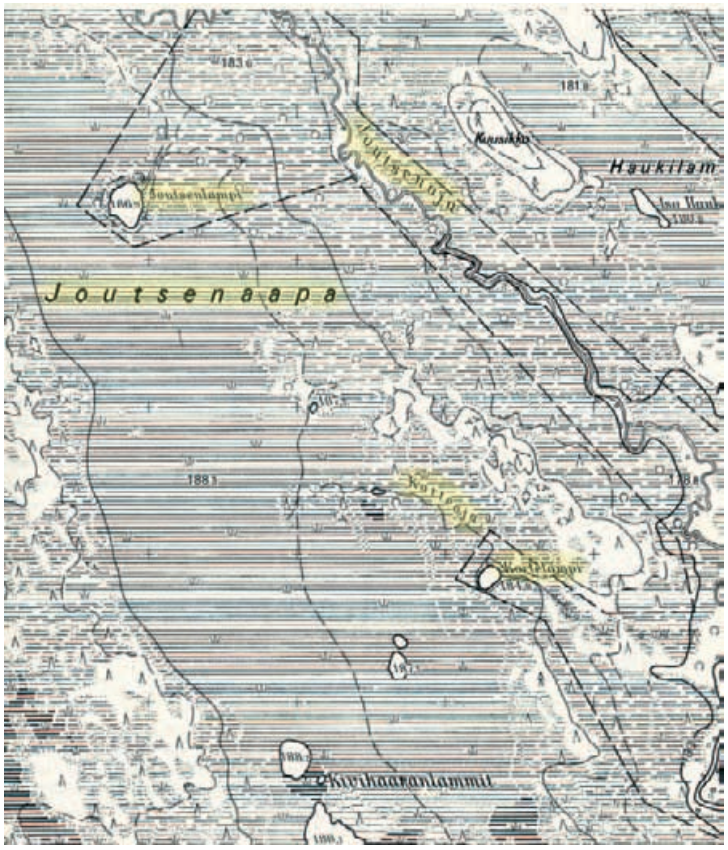

Fig. 1. The map of Joutsenaapa aapamire in Salla, Finnish Lapland. The names of different places refer to the fact that the aapamire has been known to be a Whooper Swan habitat from early spring to autumn migration. The names include the word joutsen (Whooper Swan) or the word korte *(Equisetum fluviatile)*, an important summer food of Swans.

Apparently the old names show the habitat types the Whooper Swans used in earlier historical times. When the monitoring of the population was started the habitat types used were more or less traditional. Merikallio (1949) listed several places where the Whooper Swans had bred some decades ago for the last time. These very same places were the first places where the breeding Whooper Swans appeared again in the 1960s.

The aapamires used by Whooper Swans are very extensive, often several hundreds of hectares. There are observation that a Whooper Swan family may attend several aapa mires and can walk through woodlands and shrubby areas. When they started to nest in middle boreal and southern boreal zones, their favourite habitat was small lakes or ponds, average area 50 ha. These small lakes are productive with extensive *Equisetum fluviatile* and *Potamogeton* spp. stands. In these ponds the Whooper Swan family may stay the whole summer season from late April until October. (Haapanen & al 1977).

Ombrotrophic bogs are generally not suitable Whooper Swan habitats. In certain cases they may breed in the wide minerotrophic edge of a bog or the nest can be on a hummock of bog but the feeding sites are outside the bog. Bog does not provide food for this species.

Quite new phenomenon from the 1990s was that Whooper Swans started to nest in big oligotrophic lakes. During the summer the family swims long distances from one suitable feeding area to another (Kauppinen 2006). We have made the observation already from the early 1970s. The Whooper Swan can locate the nest in a place which is not in a good feeding habitat, but a safe place during the incubation period, and even only some days old cygnets can move guided by the parents to a good feeding habitat. This capability makes them very well adaptable to different kinds of habitat. Accordingly, in recent times the species has shown to be very eurytopic in its habitat selection.

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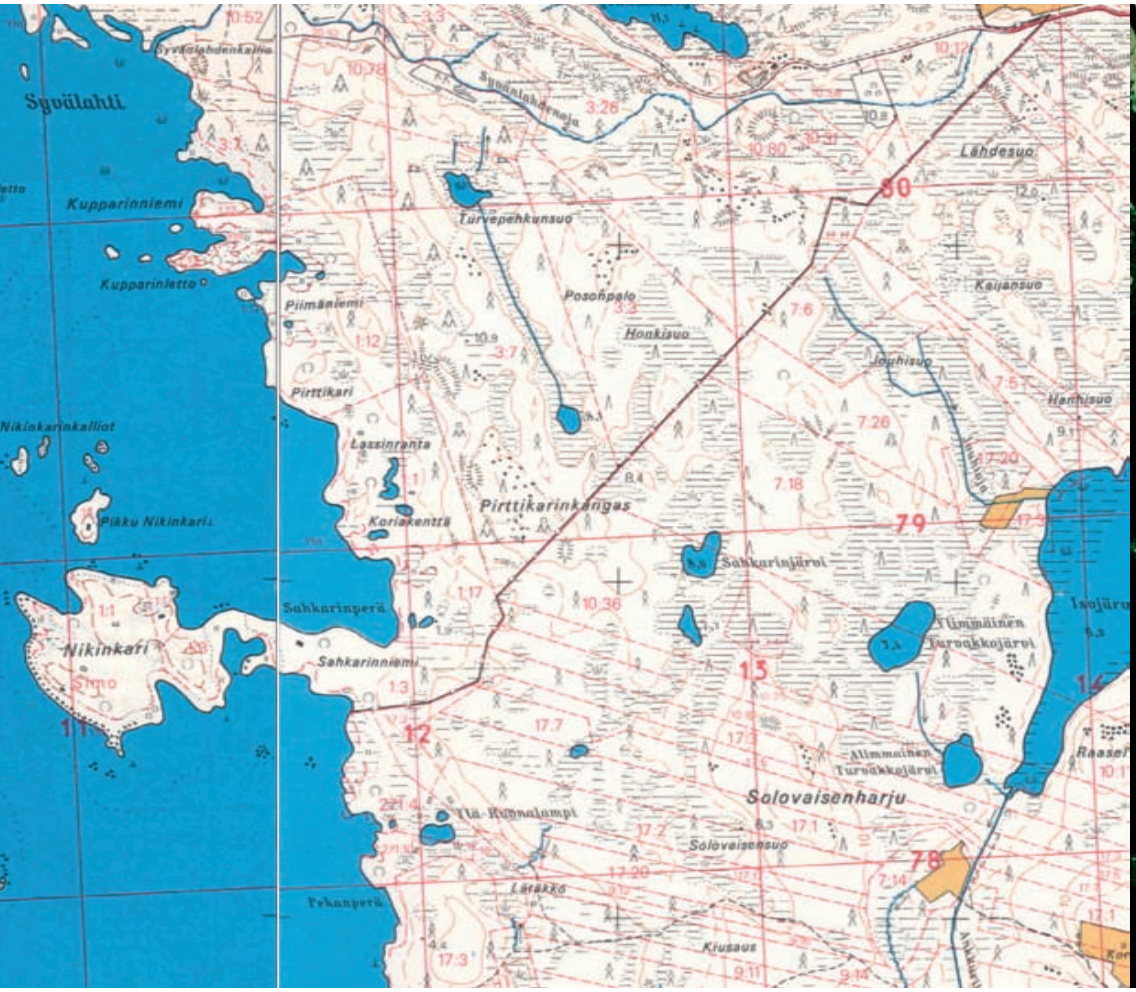
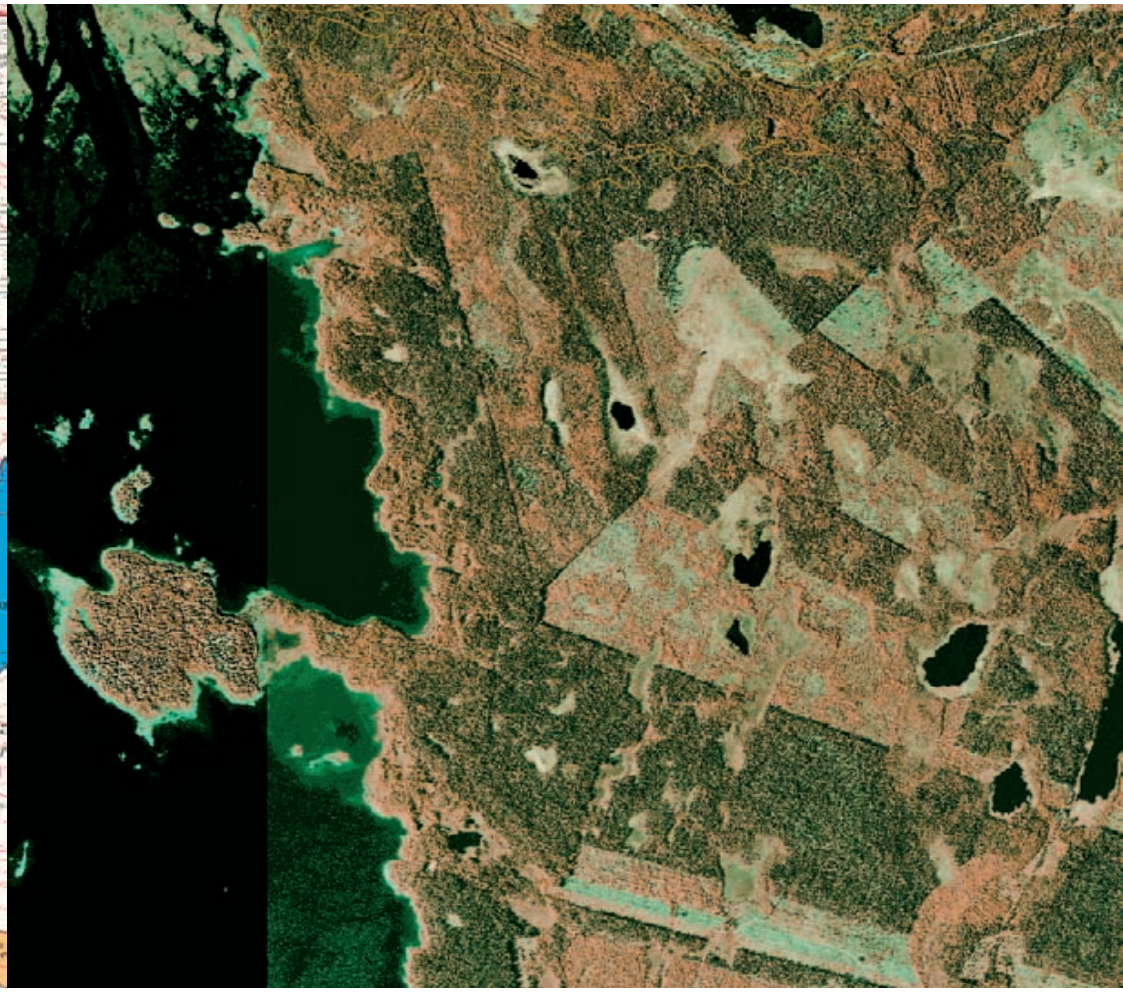


Topographic map of Ryöskäri area. Each grid square is 1 km^2.



False-colour infrared aerial photograph of Ryöskäri area.

Aapamire development in a land uplift coast

Ryöskäri – Ihanalampi area – land uplift succession of aapamires

Sakari Rehell

The area between the rivers Simojoki and Kuivajoki is a very valuable area for research, because it contains the best preserved series of comparable mire basins and adjacent small watercourses in the aapamire zone on the land uplift coast of Bothnian Bay. The bedrock is composed mainly of quite acidic granitoid gneiss and migmatite (GTK 1997), which is by far the most common type of bedrock in the aapamire zone of Northern Finland. It is overlain by a layer of bottom moraine, which forms drumlins in places. The topography is quite flat, rising steadily from the seashore to the higher situated areas. Mires cover 50-80% of the land surface everywhere. The land uplift is rapid in a global scale, about 8-9 mm/year and the regression of the sealine has gone on steadily after the end of the ice age. The topography and geology is so homogeneous that the age and developmental stage of the catchment areas can be thought to explain the main differences between them. So the successive mire basins form a good chronosequence. The age of the primary mire formation of the mire basins can be calculated from the elevation of the bottom of the mire (metres above sea level) using the published regression diagrams for the region (eg. Taipale & Saarnisto 1991).

The lowermost part of this succession series, Ryöskäri-Ihanalampi area, is a unique combination of unbuilt seashores and undrained small catchment areas up to about 20 m asl. These catchment areas consist of mire basins of different ages and also of forests partly in natural condition. The primary mire formation has taken place constantly since the uppermost parts of the area emerged from the sea about 2000 years ago. Also the expanding of mires to the nearby forests has in many places been able to continue without the disturbance of the soil tilling.

The whole area with undrained mires of scientific interest covers about 900 ha (+ 38 ha of small lakes and ponds). The areas with the greatest conservational value are situated near the sea (the Ryöskäri area, about 180 ha + 3 ha ponds) and on the uppermost part of the area (the Ihanalampi aapamire, about 130 ha + 3 ha pond). The area between these is more affected by forestry.

Ryöskäri - mire formation near the seashore

The Ryöskäri (Finnish form of the Swedish name “röd skär” meaning “red rock”) area covers the best preserved coastal area of this district, with mire basins from the seashore up to 8 m asl, 1,5 km from the seashore. The seashores have no roads or buildings. The shore meadows are large and variable and they have remained well in natural condition. There are plentiful stands of plant species demanding open, low vegetation, eg. *Primula nutans* and other threatened seashore species. On the littoral

An oblique aerial photograph of Ryöskäri area from the west. In the foreground there are young successional stages of mire development 0-1,5 m asl. Photo Hannu Vallas.

belt there are some glo-lakes (young lakes having still occasional contact with sea), which are typically eutrophic. There is also a variable series of so called fladas (basins with very restricted connection with the sea during lowest sea-levels) developing to glo-lakes and mire depressions in the future. The forests form a combination of natural forests of primary successional stages extending from the willow thickets and broad-leaved herb-rich belts near the coast to old, spruce-dominated natural forests about 3-10 m asl. Traditionally some cattle has been kept in the area near the coast and this has continued up to recent years in places. Mires cover about 1/3 of the lowest belts and about ½ of the upper belts.

In the littoral belt (the belt under the highest sea level, about 1,5 m asl) swamps prevail with species like *Myrica gale, Potentilla palustris, Carex aquatilis, Carex nigra, Cicuta virosa, Lysimachia thyrsiflora* and *Phragmites australis*. Only a few moss species grow commonly on the littoral zone (eg. *Drepanocladus aduncus, Campylium polygamum* and *Calliergon cordifolium*). The joints receiving terrestrial water have however greater amount of moss species typical for rich and intermediate fens (e.g. *Scorpidium scorpioides, Scorpidium cossonii* and *Calliergon giganteum*). These joints have also typical mire species like *Carex chordorrhiza, Carex rostrata, Equisetum fluviatile* and *Menyanthes trifoliata*, lacking usually in other parts of the littoral belt.

Above the highest sea level the trophy of the mires depends clearly on the area from which they receive water. Mire basins with strong water flow have mainly rich fens and also spruce fens with strong ground- and surface water influence. The vegetation in these parts of mire basins has a clear similarity to the vegetation on the seashore meadows, although the diversity of plant species is much greater. In the field layer Menyanthes and species associated with it are very typical. These joints may have a large number of demanding, threatened rich fen species, eg. *Hamatocaulis vernicosus*,

Meesia triquetra, M. longiseta, Sphagnum contortum, Dactylorhiza incarnata ssp. *cruenta, Dactylorhiza traunsteineri, Carex heleonastes, Carex rhynchophysa* and *Carex capillaris*.

The parts of mire basins near water divides seem to have a quick development into poor fens. These parts get a consistent *Sphagnum* carpet, which is at the belt 1 to 2 m asl dominated by *S. squarrosum* and later on by *S. riparium, S. recurvum coll*. and many other species. *Eriophorum vaginatum* is a species very clearly associated with these *Sphagnum*-dominated poorer parts. Hummock level *Sphagna*, e.g. *S. fuscum* and *S. magellanicum* cover small patches mainly near the edges of mires, and some patches are found just above the littoral belt.

The paludification of forests seems to be common especially in the upper parts of the Ryöskäri area, above 5 m asl. Large parts of forests have a quite uniform cover of *Sphagnum* mosses, mainly *S. girgensohnii*. These paludifying forests concentrate to parts near the edges of the primary mire basins indicating that these are expanding laterally. In the field layer *Carex globularis* and *Equisetum sylvaticum* are typical species associated with these habitats.

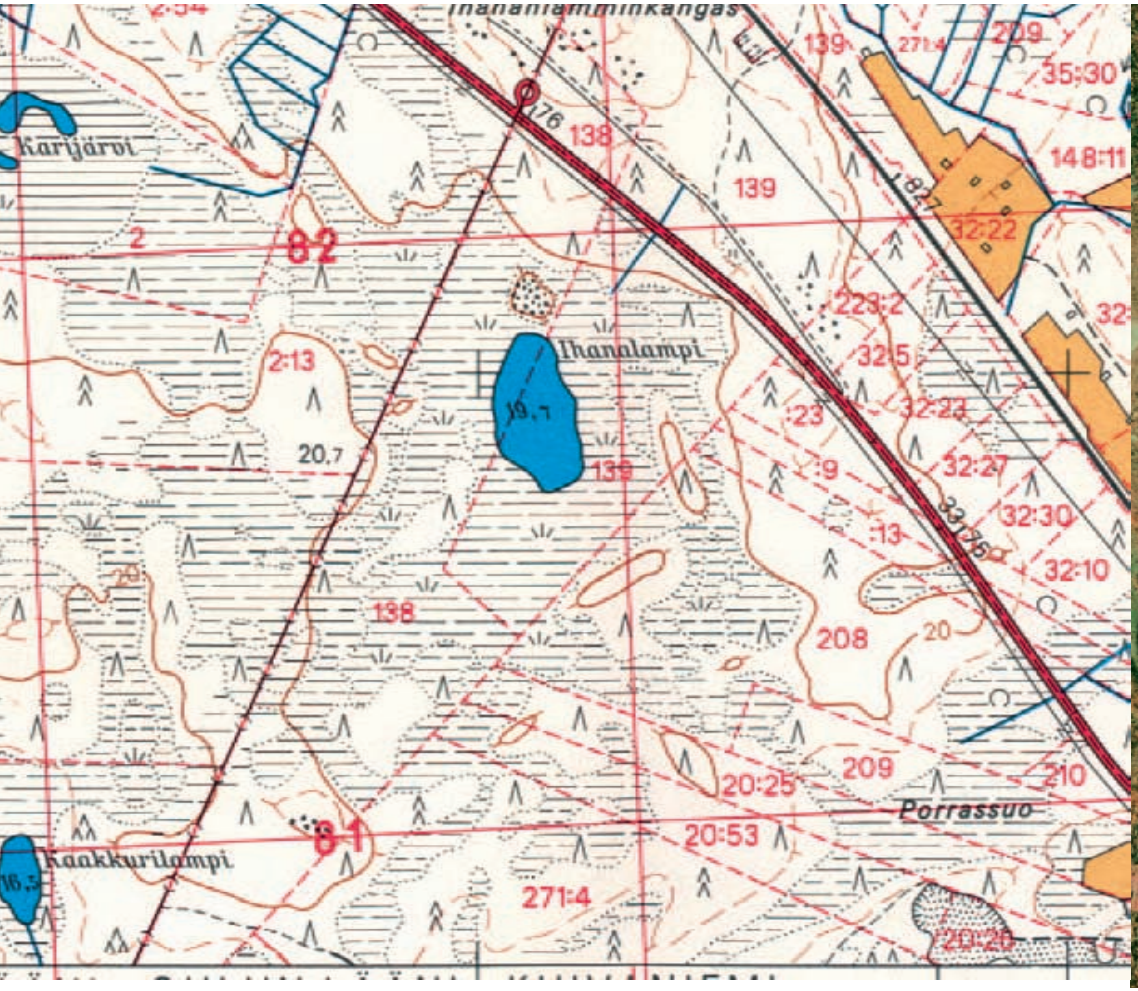
Ihanalampi – a developing aapamire

The Ihanalampi (Finnish word for "wonderful lake") area is situated about 16 to 21 m asl, 3 to 4 km from the seashore. It forms the oldest part of the Ryöskäri-Ihanalampi area risen above the sea nearly 2000 years ago. It covers a young aapamire with Ihanalampi pond in the centre, and heath forests around. This is a uniform catchment area, where the water flows from largely paludified heath forests near the water divides to the central parts of the aapamire. The pond has quite a large catchment area and it still resembles in many ways the young glo-lakes; it is eutrophic, with quite clear water and dense growth of *Chara* and *Potamogeton* species.

The mire is still quite young and e.g. spruce mires and spruce fens are quite common. It bears however many typical characters of an aapamire. The central part of the mire, which receives the water flow, is situated on the centre of the primary mire basin formed straight from the wet seashore meadows. It has the thickest peat layer of the mire (largely 100-180 cm. It is rich and intermediate by trophy, dominated by flark level vegetation.

The vegetation has many features in common with the water-flowing joints on the littoral belt and above it (eg. abundance of *Menyanthes* and some other species of flarks of rich fens) but the clearest indicators of ground- and surface water influence are scarce or lacking. Instead some "indifferent" or "mire expanse" species (Eurola & al. 1984) have become very common (e.g. *Carex lasiocarpa, Carex livida, Trichophorum caespitosum, T. alpinum, Rhynchospora alba, Sphagnum papillosum, S. subfulvum* and *S. subsecundum*). The string-flark topography characteristic for most fully developed aapamires seems to be in a stage of rapid development. On the central part of the aapamire separate patches of lawn (typically composed of *Sphagnum papillosum* and *Carex lasiocarpa*) are situated side by side with bare mud-bottom. The pattern is clearly developing to coherent strings and flarks.

The peripheral part of the aapamire is mainly composed of *Sphagnum*-dominated lawn and hummock level. Mostly they represent extremely poor minerotrophy, only some very small patches have the vegetation of true ombrotrophy. Little pine trees are common and other typical species are e.g. *Eriophorum vaginatum, Sphagnum magellanicum, S. angustifolium, S. papillosum* and *S. fuscum*. Paludifying is common on the edges of heath forests, with *Sphagnum capillifolium* and *S. russowii* along with *S. girgensohnii*. A large part of the forests have remained in natural state. Most of the peripheral part is quite thin peated (mostly clearly under 100 cm) and a large part of it has developed through the paludification of forests.



Topographic map of Ryöskäri area. Each grid square is 1 km^2.

False-colour infrared aerial photograph of Ryöskäri area.

Table 1. The proportion of mires and observations of peat thickness of the mapped vegetation patches in Ryöskäri-Ihanalampi area. 1. Elevation above sea level. 2. The proportion of mire-vegetation dominated area. 3. The proportion of water (ponds). 4. The proportion of heath forest (without peat). 5. Minimum and maximum peat thickness. 6. Mean peat thickness (the number of observations)

1.	2.	3.	4.	5.	6.
0-5 m asl	32 %	3,1 % (0,4 ha)	64,9 %	0,0-0,8 m	0,29 m (42)
5-10 m asl	40 %	8,4 % (3,9 ha)	51,6 %	0,1-1,5 m	0,67 m (95)
10-20 m asl	48,5 %	1,8 % (4,3 ha)	49,7 %	0,2-1,8 m	0,67 m (85)

Table 2. Trophic levels on different elevations on Ryöskäri-Ihanalampi area

Level m asl	Invented mire area	Eutrophy (rich)	Meso-eutrophy (intermediate)	Mesotrophy (moderately poor)	Oligotrophy (extremely poor)	Ombro-oligotrophy
0-5	60 ha	23 %	40 %	37 %	0	0
5-10	130 ha	10 %	10 %	57 %	19 %	4 %
10-20	160 ha	12 %	13 %	39 %	32 %	4 %
0-20	350 ha	13 %	16 %	47 %	21 %	3 %

The succession series of aapamires above Ryöskäri-Ihanalampi

The whole area surrounding the water divide between Kuivajoki and Simojoki have been a quite remote wilderness and there has remained a full series of aapamire systems on different levels. The largest and best preserved of them are nowadays protected. The heath forests have been largely cut for forestry, but in the remote mire-dominated reserves natural old forests are still found.

The chain of protected aapamire-areas is formed of the following areas:

Nikkilänaapa (346 ha, 35-45m asl, 9-12 km from the seashore)
Iso-Saarisuo-Hoikkasuo-Musta-aapa (767 ha, 60-75 m asl, 14-17 km from seashore)
Rimpijärvi-Uusijärvi (1391 ha, 85-95 m asl, 21-27 km from seashore)
Käärmeaapa and Jänesaapa (together 2209 ha, 105-115 m asl, 38-42 km from the seashore)
Litokaira (30376 ha, 100-145 m asl, 50-67 km from the seashore)

Together with the Ryöskäri-Ihanalampi area these protected areas can be said to form a chronosequence extending to about 8000 (uncalibrated C-14) years from present. The central parts of the aapamire systems have begun their development just when they rose above the sea, and the mire systems can be said to be the older and more fully developed, the higher they are situated. Nikkilänaapa, is a well developed aapamire with clear strings and flarks. It has quite a remarkable amount of rich or intermediate *Scorpidium* flark fens in the central part of the aapamire, and only a little amount of unpatterned ombrotrophic patches on the peripheral part. According to the data of Metsähallitus, the mires above it can be described as typical aapamires, with moderately poor flark fens in their central parts and extremely poor lawn and hummock level mires in the peripheral part. Rich and intermediate fens are largely restricted to spring-fed patches, covering some 1 - 10 % of the aapamire systems. Ombrotrophic eccentric bog massifs are accounted in most of the aapamire-systems, their amount being about 2-10 % of the mire systems.

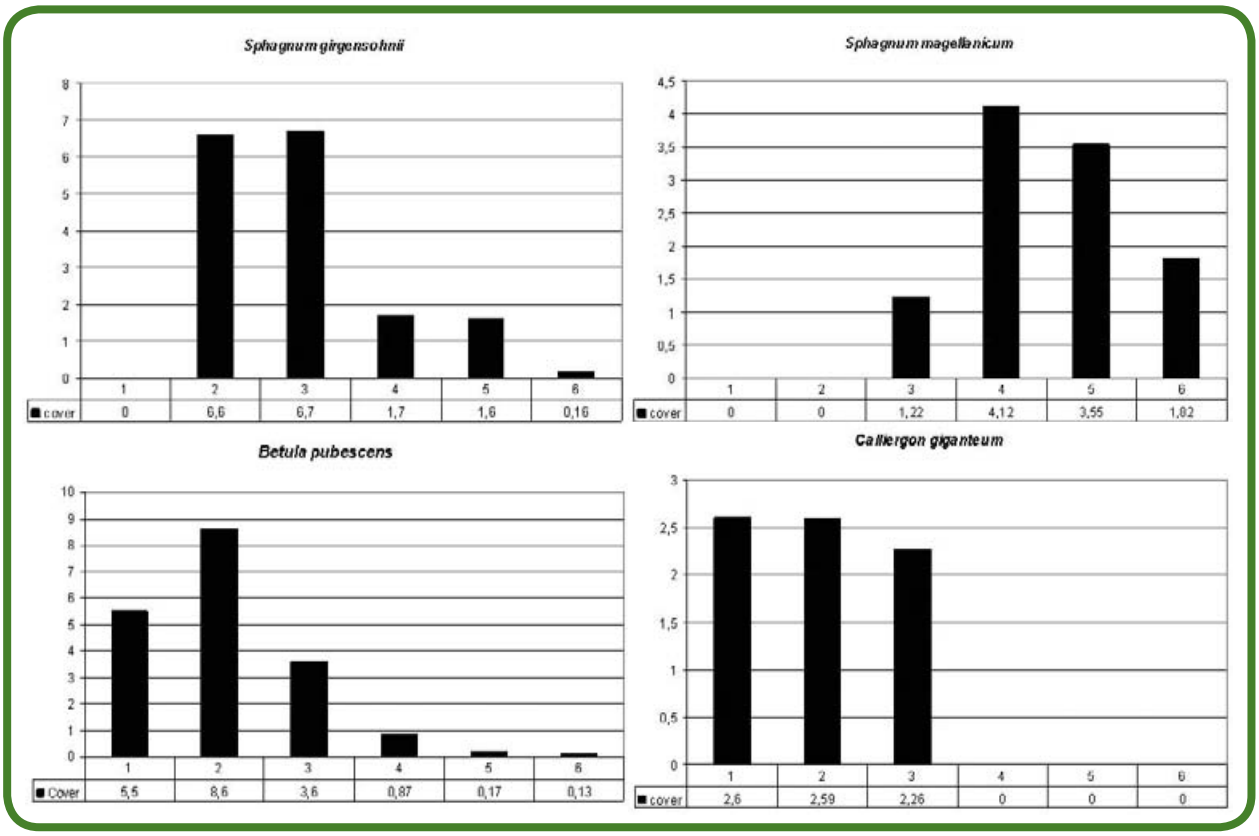


Figure: Mean coverages of eight different mire species on studied lines on different elevations along the aapamire succession series on Ryöskäri-Ihanalampi and Nikkilänaapa and Hoikkasuo above it. (1 = 0-1,5 m asl, 2 = 1,5 -5 m asl, 3 = 5-15 m asl, 4 = 15-30 m asl, 5 = 30-50 m asl, 6 = over 50 m asl.

How the development of mire basins differs in the zones of aapamires and bogs?

The central and southern parts of the Bothnian Bay land uplift coastland belong to the zone, where ombrotrophic bogs prevail. The most representative area of this southern land uplift coast in Finland is situated in the Kvarken area near the town of Vaasa, about 350 km southwest from the Ryöskäri-Ihanalampi area. Mires are not as dominant as in the more northern areas, and a great deal of them have been ditched. Only a few fully developed mire systems are found near the coastland, the most famous of them, Levaneva bog about 50 km from the seashore, and 80 metres asl.

In this area the most important area in studying the development of young mire basins is the Iskmo-Sidländet –area. The area to be protected there covers several sites near each other, 727 ha in total, stretching from the seashore to about 20 m asl. The topography is dominated by steep moraine hills and ridges. The natural old spruce forests cover a great deal of the area. Mires are situated in quite small basins, mainly 6-14 m asl. They cover nearly 30 % of the area. According to the inventories in the state owned parts, most of the mires are treed. More than half of them have clear mire margin influence and spruce and birch as dominant trees, swampy birch fens and herb-grass spruce fens being the most common site types. About 1/3 of the mires are dominated by hummock level vegetation with pine, the dominant site types among these are dwarf-shrub pine bogs and *Eriophorum vaginatum* pine bogs. Only about 5% of the mires are open fens, mainly tall-sedge and low sedge fens on the quaking shores of small ponds. Rich fens have not been found on that area, the most luxuri-

ant mire sites being the black alder swamps. Most of the mires are moderately poor (mesotrophy in Finnish tradition) or extremely poor (oligotrophic in Finnish tradition) in trophy. Small ombrotrophic patches with hummock level pine bogs appear in many places even in the central parts of mire basins mainly in the belt over 10 m asl.

The succession of mire basins on Iskmo-Sidländet seems to have two main differences when compared with the more northern Ryöskäri-Ihanalampi area. Firstly, the amount of open fens and rich fens in particular is lower. Secondly, the amount of hummock level pine bogs is greater, covering also central parts of mire basins. These features probably reflect climatic differences; the growth of *Sphagnum* seems to be greater in the south.

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Table 3. Plant species observed in the different belts of Ryöskäri-Ihanalampi area in the paludified vegetation patches and on the seashore meadows. The species growing in lakes or in the sea below mean seawater line not accounted. 1 = 0-1,5 m asl, 2 = 1,5-5 m asl, 3 = 5-15 m asl, 4 = over 15 m asl. Bold numbers show the most dominant species and brackets very rare species in the belt.

Trees and bushes

Alnus glutinosa (3)
Alnus incana 1,2,3,(4)
Betula nana 3,4
Betula pubescens 1,2,3,4
Hippophaë rhamnoides (1)
Juniperus communis (2),(3),(4)
Picea abies 2,3,4
Pinus sylvestris (2),3,**4**
Prunus padus (1),2
Rhamnus frangula 3,4
Salix aurita 3,4
Salix caprea 2,3,(4)
Salix cinerea 1,2,3
Salix lapponum (2),3,4
Salix myrtilloides 3,(4)
Salix pentandra (1),2,3,(4)
Salix phylicifolia **1**,2,3,(4)
Salix repens (3),(4)
Sorbus aucuparia 2,(3),(4)

Dwarf shrubs

Andromeda polifolia (2),3,4
Calluna vulgaris (3),(4)
Chamaedaphne calyculata 3,4
Empetrum nigrum (2),3,**4**
Huperzia selago (2),(3)
Ledum palustre (2),3,4
Linnaea borealis 3
Lycopodium annotinum 2
Myrica gale **1**,2,3,(4)
Vaccinium microcarpum 3,4
Vaccinium myrtillus 2,3,4
Vaccinium oxycoccos (1)2,3,4
Vaccinium uliginosum (2)3,4
Vaccinium vitis-idaea (2),3,4

Sedges and grasses

Agrostis canina 2,3,(4)
Agrostis capillaris 1,2
Agrostis gigantea 1
Alopecurus aequalis (2)
Calamagrostis arundinacea (2)
Calamagrostis canescens 2,3,4
Calamagrostis purpurea 2,3,4
Calamagrostis stricta 1,2,(3),(4)
Carex aquatilis 1,2,3,(4)
Carex caespitosa 2,(3),(4)
Carex canescens 1,2,3,4
Carex capillaris (2)(3)
Carex chordorrhiza (1),**2,3,4**
Carex diandra 1,**2**,(3),(4)
Carex dioica 2,3,4
Carex disperma 3
Carex echinata 2,3,4
Carex elongata (2),(3)
Carex flava (2),(3)
Carex globularis **3,4**
Carex heleonastes (2),(3)
Carex lapponica (2)
Carex lasiocarpa 2,**3,4**
Carex laxa (3)
Carex limosa 1,2,3,**4**
Carex livida 3,4
Carex mackenziei 1
Carex magellanica 2,3,4
Carex nigra **1**,2,3,(4)
Carex pallescens 2
Carex pauciflora 3,4

Carex loliacea 3
Carex rostrata 1,**2,3**,4
Carex rhynchophysa (2),(3)
Carex vaginata 2,3,(4)
Carex vesicaria (3),(4)
Deschampsia cespitosa 2,3
Deschampsia flexuosa 2,3
Eleocharis palustris **1**
Eleocharis quinqueflora (3)
Elymus caninus 2,(3)
Eriophorum angustifolium 1,2,3,4
Eriophorum gracile 2,3,4
Eriophorum latifolium (2),3
Eriophorum vaginatum (2),3,**4**
Festuca rubra 1,2,3
Hierochloë odorata 2,3,(4)
Juncus alpinoarticulatus 1,(3)
Juncus balticus 1,
Juncus balticus x filiformis (2),(3)
Juncus filiformis 1,2,3,(4)
Juncus gerardii 1
Juncus stygius 3,4
Luzula sudetica (2),(3)
Luzula pallescens (2)
Melica nutans 2,(3),(4)
Milium effusum 2
Molinia caerulea (1),2,3,4
Nardus stricta (3)
Phragmites australis **1**,(2),(3)
Poa alpigena (2),(3)
Poa trivialis (2)
Rhynchospora alba 4
Schoenoplectus lacustris 1
Trichophorum alpinum (2),3,4
Trichophorum cespitosum 3,4

Herbs

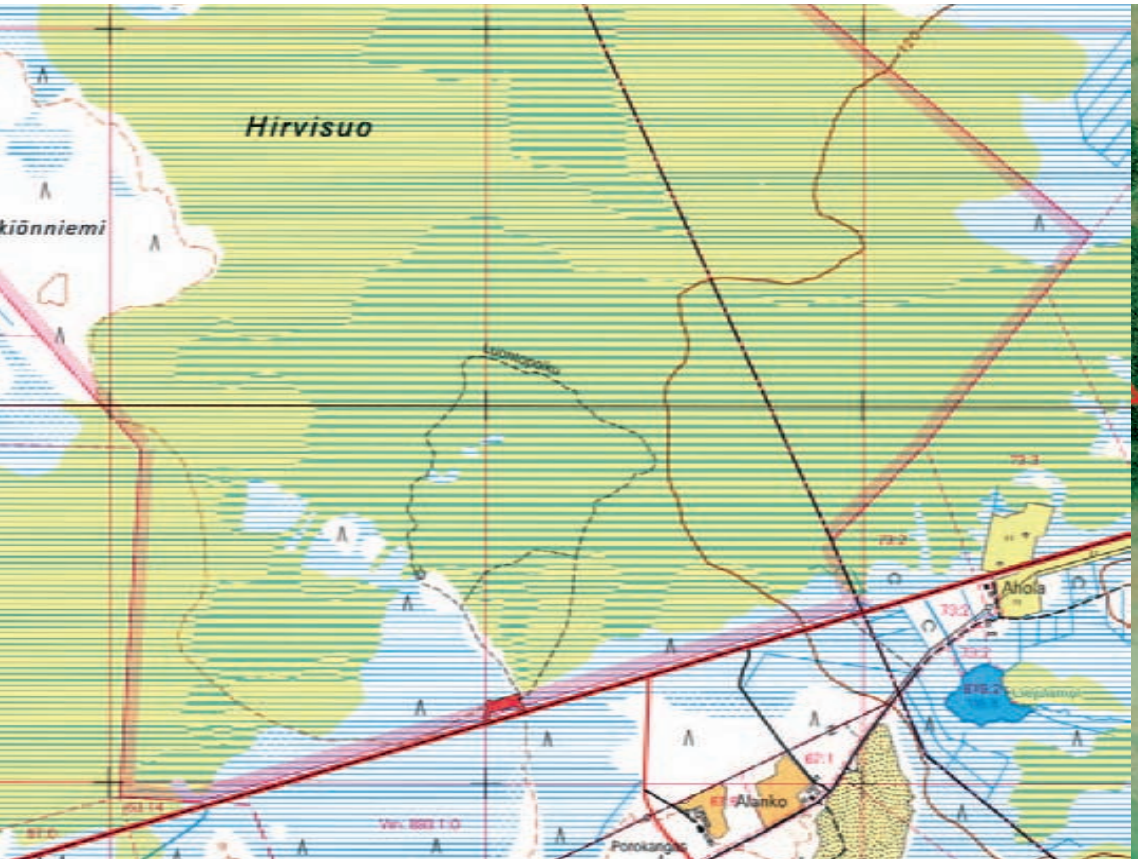
Alisma plantago-aquatica (1),(2),(3)
Angelica sylvestris 2,3,(4)
Anthriscus sylvestris (2)
Athyrium filix-femina 2,3,(4)
Bistorta vivipara (1),2,3
Butomus umbellatus (1)
Calla palustris 1,2,3
Caltha palustris 1,(2),(3),(4)
Cardamine pratensis (2),(3)
Cicuta virosa 1,2,3
Cerastium fontanum (2),(3)
Cirsium helenioides 2,3
Cirsium palustre (2),(3)
Coeloglossum viride (2),(3)
Convallaria majalis (3)
Corallorhiza trifida 3
Cornus suecica 2,3
Crepis paludosa 3
Dactylorhiza incarnata ssp. *incarnata* 3,4
Dactylorhiza incarnata ssp. *cruenta* 1,2,(3)
Dactylorhiza maculata 2,3,4
Dactylorhiza traunsteineri (2)
Drosera longifolia 3,4
Drosera rotundifolia 2,3,4
Dryopteris carthusiana 2,3,(4)
Epilobium palustre 1,2,(3),(4)
Equisetum arvense 1,**2**,3,(4)
Equisetum arvense x fluviatile 2,3,4
Equisetum fluviatile 1,2,3,4
Equisetum hyemale (2)
Equisetum sylvaticum **3,**4
Euphrasia sp. 1
Filipendula ulmaria 1,2,(3),(4)
Galium boreale 2,3
Galium palustre 1,2,(3),(4)
Galium trifidum 1,2,(3),(4)
Galium uliginosum 1,2,(3),(4)
Geranium sylvaticum 2,3
Geum rivale 2,(3),(4)
Hammarbya paludosa 2,3,4
Hippuris vulgaris 1
Lactuca sibirica (1)
Lathyrus palustris 1,2,(3)
Lemna minor (2)
Leontodon autumnalis 1
Listera cordata 2,3
Lysimachia thyrsiflora 1,2,3,(4)
Lysimachia vulgaris 1,2
Lythrum salicaria 1,2
Maianthemum bifolium (2),(3)
Melampyrum pratense 2,3,4
Melampyrum sylvaticum 2,3,4
Menyanthes trifoliata 1,**2,3,4**
Moneses uniflora 3
Paris quadrifolia 2,(3),(4)
Parnassia palustris 1,2,3
Pedicularis palustris 1,2,3,4
Pedicularis sceptrum-carolinum (2),(3)
Peucedanum palustre 1,2,3,4
Pinguicula vulgaris (3),(4)
Plantago maritima 1
Potentilla anserina ssp. *egedii* 1
Potentilla palustris **1,2**,3,(4)
Primula nutans 1
Pyrola minor 2,3,(4)
Pyrola rotundifolia 2,3,(4)
Ranunculus acris 2
Ranunculus auricomus 2
Ranunculus repens 2
Rubus arcticus 1,2,3
Rubus chamaemorus (2),3,4
Rubus saxatilis 2,3,(4)
Scheuchzeria palustris (2),3,4
Scutellaria galericulata 1,2,(3),(4)
Selaginella selaginoides 2,3
Silene dioica 2
Solidago virgaurea 2,3,(4)
Sonchus arvensis 1
Sparganium hyperboreum (2)
Stellaria crassifolia 2
Stellaria nemorum (1)
Stellaria palustris (1)
Thalictrum flavum 1,2
Thelypteris phegopteris (2),3,(4)
Tofieldia pusilla (4)
Trientalis europaea (2),(3),(4)
Triglochin maritima 1
Triglochin palustris 1,(2),(3)
Trollius europaeus 2
Utricularia intermedia 3,4
Utricularia vulgaris 1,2
Valeriana sambucifolia 1,2,(3)
Vicia cracca 1,2,(3)
Viola epipsila 2,3,(4)
Viola palustris 1,2,3,(4)

Bryophytes

Aulacomnium palustre 2,3,4
Brachythecium reflexum (2)
Brachythecium rivulare (3)
Bryum pseudotriquetrum (1),2,3,4
Calliergon cordifolium 1,**2**,3,(4)
Calliergon giganteum (1),**2**,**3**,(4)
Calliergon megalophyllum (1)
Calliergon richardsonii 2,3,(4)
Calliergonella cuspidata 1,2(3)
Campylium polygamun 1
Campylium stellatum (1),2,**3**,4
Cinclidium stygium 2,3,(4)
Cinclidium subrotundum 2,3,(4)
Cirriphyllum piliferum (2)
Climacium dendroides 2,(3)
Dicranum angustum (4)
Dicranum bergeri 4
Dicranum bonjeanii (2),(3)
Dicranum leioneuron 4
Dicranum majus 3
Dicranum scoparium 3
Drepanocladus aduncus **1**,(2),(3)
Fissidens adianthoides (3)
Hamatocaulis vernicosus 2,3
Helodium blandowii (1),2,3,(4)
Hylocomium splendens 2,3,(4)
Hypnum lindbergii 2,(3)
Meesia longiseta (3)
Meesia triquetra 2,3,(4)
Loeskypnum badium 3,4
Paludella squarrosa 2,3,(4)
Philonotis fontana (2)
Plagiomnium ellipticum 2,3
Plagiomnium medium 2,3
Pleurozium schreberi 2,3,4
Pohlia nutans 2,3,4
Polytrichum commune (1),2,3,4
Polytrichum swartzii (1),(2),(3)
Polytrichum strictum 2,3,4
Pseudobryum cinclidioides (1),2,3,4
Pseudo-calliergon trifarium 3,(4)
Ptilium crista-castrensis (2),(3)
Rhizomnium pseudopunctatum 2,3
Sanionia uncinata 2,3
Scorpidium cossonii (1),2,3
Scorpidium revolvens 2,3,**4**
Scorpidium scorpioides (1),**2,3,4**
Sphlachnum sp. 3
Straminergon stramineum (1),2,3,4
Thuidium recognitum (2)
Tomentypnum nitens 2,3,(4)
Warnstorfia exannulata 1,2,3,4
Warnstorfia fluitans 2,3,4
Warnstorfia procera 4
Warnstorfia sarmentosa (4)
Warnstorfia tundrae 1,2,(3)

Sphagnum mosses

Sphagnum angustifolium 2,3,**4**
Sphagnum annulatum/jensenii (2),3,4
Sphagnum aongstroemii 3
Sphagnum balticum (2),(3),4
Sphagnum capillifolium (2),(3),4
Sphagnum centrale (2),**3**,4
Sphagnum compactum (3)
Sphagnum contortum 2,3,(4)
Sphagnum fallax s.l. (1),2,**3**,4
Sphagnum fimbriatum 1,2, 3,(4)
Sphagnum flexuosum 2,3,4
Sphagnum fuscum (2),3,**4**
Sphagnum girgensohnii **2,3**,4
Sphagnum inundatum 2,(3)
Sphagnum lindbergii 2,3,4
Sphagnum magellanicum (2), 3,**4**
Sphagnum majus (2),(3),4
Sphagnum obtusum 2,3,4
Sphagnum papillosum 3,**4**
Sphagnum platyphyllum (1),(2),(3),(4)
Sphagnum riparium (1),2,**3**,4
Sphagnum rubellum (3),4
Sphagnum russowii 2,3,**4**
Sphagnum squarrosum 1,**2**,3,(4)
Sphagnum subfulvum (incl. ssp *purpurea*) 3,4
Sphagnum subsecundum (1),**2,3,4**
Sphagnum teres (1),2,**3**,4
Sphagnum warnstorfii **2**,3,(4)
Sphagnum wulfianum 3,(4)



Topographic map of the southern part of Hirvisuo mire reserve. Each grid square is 1 km^2.
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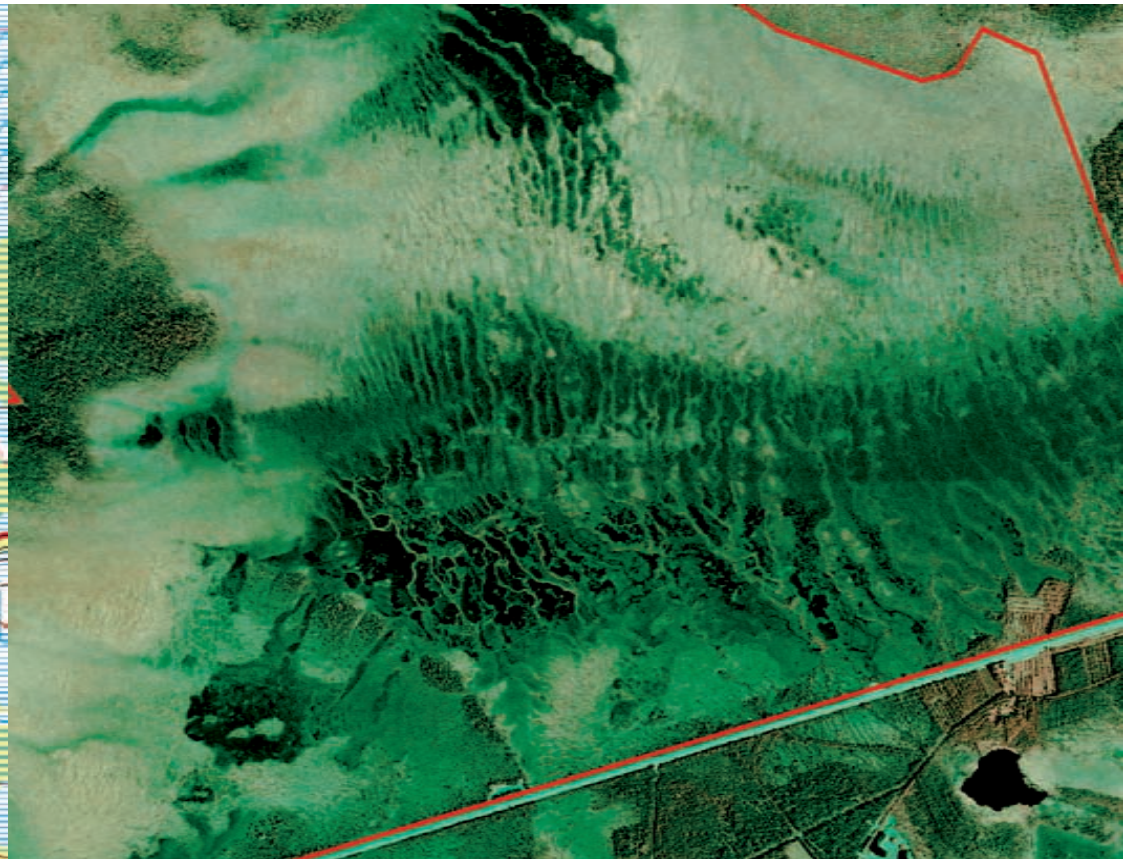

False-colour infrared aerial photograph of the southern part of Hirvisuo mire reserve. The red line shows the boundaries of Natura 2000 areas.
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Sedge aapamire massif with a well developed structure

Hirvisuo – a southern aapa mire system

Antti Huttunen & Jarmo Laitinen

General description

Hirvisuo is a lawn-flark aapa mire massif system with raised bog massifs on the coastal "flat-land" in western central Finland near the watershed between rivers Kiiminkijoki and Iijoki (65°14'N, 26°15'E, c. 120 m a.s.l.). It forms a kind of wet plateau of polyfurcation character leaking to all directions via ten rivulets, only the distinct streams to mention.

Moraine landforms on poor bedrock, partly drumlins, interrupt the mire vast. An interlobate glaciofluvial esker south of Hirvisuo was flattened and spread to sandy terraces and beach ridges by former Baltic Sea phases. The site emerged from the Baltic waters at Ancylus phase some 8500–8000 years ago.

The limited stratigraphic data available (Hänninen 1988) reveal *e.g.* by the basal peats of the transect in front of the sandy terrain (Fig. 1) that a small depression stayed in limnic state only for a short period to be replaced mainly by *Sphagnum-Carex* peats after terrestrialisation. Otherwise the data here suggest primary mire formation for large areas with *Equisetum-Carex* peats on the sand bottom. Peats in the transect were mostly of moderately humified *Scheuchzeria-Sphagnum-Carex* type. Paludification seemed to have been active in the marginal parts of the former mire basin, and have been an active process until recent decades when stopped by intense drainage. Ground radar mapping (Hänninen 1988) revealed the peat layer to be rather shallow, largely less than 1.5 metres. Over three metre depths were recorded only in three places.

Fig. 1. Peat depth (metres) of Hirvisuo detected by ground radar. Transect (A0 – A2400 m) at the southern mire part exaggerated in the figure bottom. Mineral soil areas marked by horizontal line shading, lakes and mire pools by grey (Modified from Hänninen 1988).

Conservation status and present use

Because Hirvisuo is part of a mire network, which covers some ¾ of land area in the region, its size is impossible to define. The central part, 3783 ha, was protected as Mire Reserve in 1981, and was later enlargened in the Natura 2000 Programme to 4481 hectares. Majority of the forest stands has been used for forestry at least to some extent decades ago. The stands of somewhat stunted Scots pines of raised bog massifs and mire margins may well represent totally pristine woods. The mire proper is in natural state, but some ditches in the marginal parts and the main road in the south have caused local drainage. Restoring activities begun in 2001 by filling ditches in the westernmost raised bog and by artificial increase of dead wood in the north. Burning of some wood islands is planned for near future.

The current use of Hirvisuo mire area is minimal. Hunting is concentrated on moose *(Alces alces)* and slightly on ducks, and the small-scale fishing on pike *(Esox lucius)* and perch *(Perca fluviatilis)*. The water basins are dystrophic humus lakes and ponds (the biota of these waters is largely unknown). In practice the main and most impressive part of Hirvisuo, north of the mineral islands Kokkosaaret ("Islands of Golden Eagle"), which hide the main mire scenery to be seen from the south) is empty of human beings – except the picking time of cloudberry *(Rubus chamaemorus)*.

Metsähallitus (a state enterprise whose task is *e.g.* to manage most of Finland's protected areas) has planned to keep activated rambling in a small area near the southern road. A one km long nature trail and a bird-watching tower have been built inside the protected area.

Fauna

Bear *(Ursus arctos)* is a more or less regular visitor of Hirvisuo, once even over-wintering inside one bordering forest stand. Wolfs *(Canis lupus)* visit the area seldom, wolverines *(Gulo gulo)* still more rarely. In spite of the name Hirvisuo ("Moose Mire") moose is not especially abundant in the area, although passes trough the mire in quantities via certain routs during its wandering time. Reindeer *(Rangifer tarandus* ssp. *tarandus)*, instead, is an usual sight on the mire, not only eating in the few herb-rich sites (especially *Menyanthes trifoliata)* but escaping the flocks of insects to more windy places. The amount of mosquitoes in Hirvisuo is near one third of the total human population of the world.

Birds are the best known feature of Hirvisuo among the public – in addition to the mire scenery and cloudberries. The avifauna of the mire is rich (Table 1) by species diversity and by over 3000 nesting pairs. Common species are meadow pipit *(Anthus pratensis)* especially on poor site types and yellow wagtail *(Motacilla flava thunbergi)* on a bit more fertile sites. Often visible are also whooper swan *(Cygnus cygnus)* and common crane *(Grus grus)*, both with several nesting pairs; bean-goose *(Anser fabalis)* is present in a bigger flock.

Breeding areas of a species couple, southern curlew *(Numenius arquata)* and northern whimbrel *(Numenius phaeopus)* overlap here. Northern species are *e.g.* spotted redshank *(Tringa erythropus)*, red-necked phalarope *(Phalaropus lobatus)*, jack snipe *(Lymnocryptes minimus)* and broad-billed sandpiper *(Limicola falcinellus)*. At least 23 species existing in Hirvisuo are mentioned in the Annex I of Bird Directive of European Union.

Biotope boundaries, in many scales, seem to be favourable for birds. Wet flarks and flark pools are also important *e.g.* for several waders and for colonies of herring gull *(Larus argentatus)*. The forest islands are essential for birds of prey (*e.g.* merlin, *Falco columbarius)*.

Table 1. A preliminary list (Huttunen 1983, Metsähallitus web-pages 2002) of birds observed in Hirvisuo mire reserve in their breeding time. The lakes are insufficiently inventoried. Two species (*)(VU, EN) are outlisted on protection basis. [*] = Species listed in Annex I of the EU's Birds Directive. IUCN threat category 2000: EN = endangered, VU = vulnerable, NT = near threatened, LC = least concern. IR = International Responsibility Species.

Accipiter gentilis (L.)
Aegolius funereus (L.) [*][LC, IR]
Alauda arvensis[1] L.
Anas acuta L.
A. crecca L. [IR]
A. penelope L.
A. platyrhynchos (L.)
Anser anser[1] (L.)
A. fabalis (Lath.) [NT, IR]
Anthus pratensis (L.)
A. trivialis (L.)
Apus apus (L.)
Asio flammeus (Pontoppidan) [*][LC]
Aythya fuligula (L.)
Bucephala clangula (L.)
Buteo buteo (L.)
Carduelis flammea (L.)
C. spinus (L.)
Circus cyaneus (L.)[*][NT]
Corvus corax L.
C. corone cornix L.
Cuculus canorus L. [NT]
Cygnus cygnus (L.) [*][LC, IR]
Dryocopus martius (L.) [*][LC]
Emberiza rustica Pallas
E. schoeniclus L.
Erithacus rubecula (L.)
Falco columbarius L. [*][VU]
F. subbuteo L.
F. tinnunculus[2] L. [NT]
F. vespertinus[1] L. [*]
Ficedula hypoleuca Pallas
Fringilla coelebs L.
F. montifringilla L.
Gallinago gallinago (L.)
Garrulus glandarius[2] (L.)
Gavia arctica (L.) [*][LC]
Grus grus (L.) [*][LC]
Lagopus lagopus (L.)
Lanius collurio[1] L. [*][NT]
L. excubitor L. (NT)
Larus a. argentatus Pontoppidan
L. marinus[1] L.
L. ridibundus L. [VU]
Limicola falcinellus (Pontoppidan) [NT, IR]
Loxia curvirostra L.
Lymnocryptes minimus (Brünnich) [IR]
Melanitta nigra[1] (L.)[NT]
Mergus albellus[1] L. [*][LC]
Motacilla alba L.
Motacilla flava thunbergi Billberg
Muscicapa striata (Pallas)
Numenius arquata (L.)
N. phaeopus (L.) [IR]
Pernis apivorus[2] (L.) [*][NT]
Phalarobus lobatus (L.) [*][LC]
Philomachus pugnax (L.) [*][NT]
Phoenicurus phoenicurus (L.) [IR]
Phylloscopus sibilatrix Bechstein
P. trochilus (L.)
Picoides tridactylus (L.) [*][NT, IR]
Pluvialis apricaria (L.) [*][LC]
Saxicola rubetra (L.) [NT]
Sterna hirundo[12] L. [*][LC, IR]
S. paradisaea[12] Pontoppidan [*][LC]
Strix uralensis[2] Pallas [*][LC]
Surnia ulula[1] (L.) [*]
Sylvia curruca (L.)
Tetrao tetrix L. [*][NT, IR]
T. urogallus L. [*][NT, IR]
Tringa erythropus (Pallas) [IR]
T. glareola L. [*][LC, IR]
T. nebularia (Gunnerus) [IR]
Turdus iliaceus L.
T. philomelos Brehm
T. pilaris L.
T. viscivorus L.
Vanellus vanellus (L.)

[1]Occasional.
[2]Not necessarily nesting inside the protected area.

Flora

Vascular flora (113 taxa) of Hirvisuo is typical for southern aapa mires, not especially rich. However, some regionally threatened species are found like *Carex rotundata* (species typical for northern aapa mires in Forest and Fell Lapland), northern *Eriophorum russeolum* ssp. *russeolum* (frequent already in southern Lapland), southern *Rhynchospora fusca,* and near threatened *Dactylorhiza incarnata* ssp. *incarnata*, and *Lycopodiella inundata*. A rare northern hybrid *Carex rostrata* x *rotundata* is also present.

Mosses (64 taxa) also indicate mainly poor to intermediate rich habitats. The rarest species is the nationally endangered eastern *Hamatocaulis lapponicus* growing in a small area in the southern mire part. *Meesia longiseta* belongs also to the endangered taxa of the mire. Among others, southern *Sphagnum subnitens* and northern

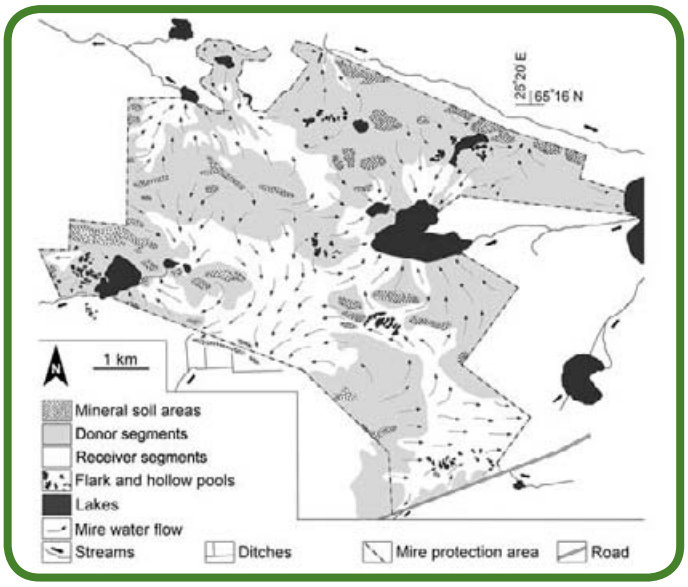

Fig. 2. Hydrotopographic water flow pattern of the Mire Reserve of Hirvisuo (Modified from Laitinen & al. 2005).

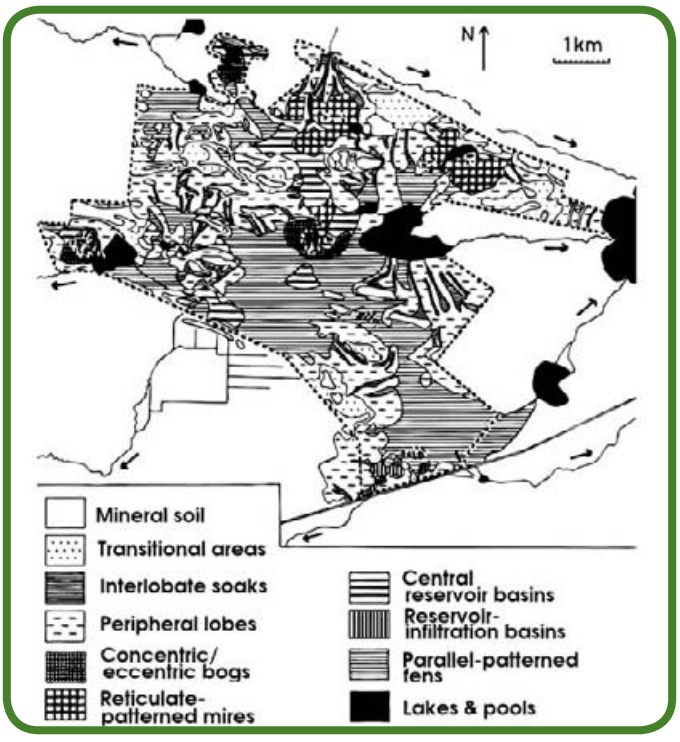

Fig. 3. Mesotopographic pattern of the Mire Reserve of Hirvisuo (Laitinen & al. 2005).

Cinclidium subrotundum belong also to regionally threatened taxa. Moss flora in North-Europe is very diverse, and responsibility for species is laid on each state in the region. At least nine moss species (*Aplodon wormskioldii*, *Cinclidium subrotundum*, *Hamatocaulis lapponicus*, *Meesia longiseta*, *Sphagnum annulatum* incl. *jensenii*, *S. aongstroemii*, *S. pulchrum*, *S. subfulvum* and *S. wulfianum*) in Hirvisuo are such international responsibility species.

Vegetation and ecohydrology

Situating on an upland plateau, having restricted water income, locating on poor bedrock, the overall vegetation is more or less oligotrophic. Several places which are beside of water flow – often near water basins - have thus developed already to ombrotrophy, ten of which to morphological raised bog massifs (Figs. 2 and 3). Some of those, however, are in a transitional phase as reticulate-patterned mires ("pseudo bogs"), *i.e.* morphology resembles that of raised bogs but the last minerotrophic floristic elements are still present.

The lawn-flark aapa mire massif of Hirvisuo belongs to the largest massifs of that type within the whole southern aapa mire zone. Mesotopographic mire units have displayed as useful tool in interpreting mire hydrotopography (Laitinen & al. 2005). Outermost of the mire, inside the very peripheral parts of aapa mire system, the thin peated marginal forest mires prevail. On southern sandy substratum they are often of heath like *Calluna* type (Fig. 4).

Next to above mentioned transitional units broad – as typical for southern (lawn-flark) aapa mires – peripheral belts or lobes prevail. These essential water yielding parts of donor segments are mostly lawn to hummock level units, which can be open or treed. Rather typical vegetation site types for such lawn are poor short-sedge *Sphagnum papillosum* fens. Within the treeless central and outer parts of the lobes, the vegetation ranges from evident minerotrophy (tall sedge fens) to ombrotrophy (*Empetrum–Sphagnum fuscum* bogs).

Concentric and eccentric raised bogs belong also to donor segments. They are well patterned by *Sphagnum fuscum* hummock ridges and by mud-bottom or wet *Sphagnum* covered hollows. Vascular flora in these hollows is usually sparse composing typically of *Carex limosa*, *Eriophorum vaginatum* and *Scheuchzeria palustris*. The best example of raised bogs is the massif in the middle of the mire reserve, west of the large lake. It is formed of rather thick (in Hirvisuo scale, Fig. 1) peat layer on the contrary to *e.g.* the evidently young bog massif on the southern sand terrace near the main road, where peat thickness is less than one metre.

Among water receiving mire segment,s the central reservoir basins are the wettest. They consist of stringless minerotrophic flark fens or flark pools. They are connected to the main hydrotopographic unit of aapa mires, to parallel-patterned fens. These flark-string patterns act as water receiver and retardant conveyer of horizontal water flow. Their vegetation is always minerotrophic, in Hirvisuo nearly totally from oligotrophic to mesotrophic in character. The dominant flarks are either mud bottomed or covered by hydrophilous Sphagna or seldom by Bryales like *Warnstorfia exannulata* and *W. procera*.

Altogether 35 mire site types were identified inside the original mire reserve, which is quite much for a generally rather poor area – especially because spring mire vegetation and swamps (surface water influenced mires) are totally lacking, and thin-peated spruce mires are only sparsely present. The number of site types is much result of the Finnish mire classification system, which takes in consideration the mire margin vegetation with similar accuracy than the site types of the massifs. Mire site types, as such, have their own space in macro- and mesotopographic mire units, and an indicative position with respect to stability of water regime and to behaviour of groundwater and surface flow (Laitinen & al. 2005).

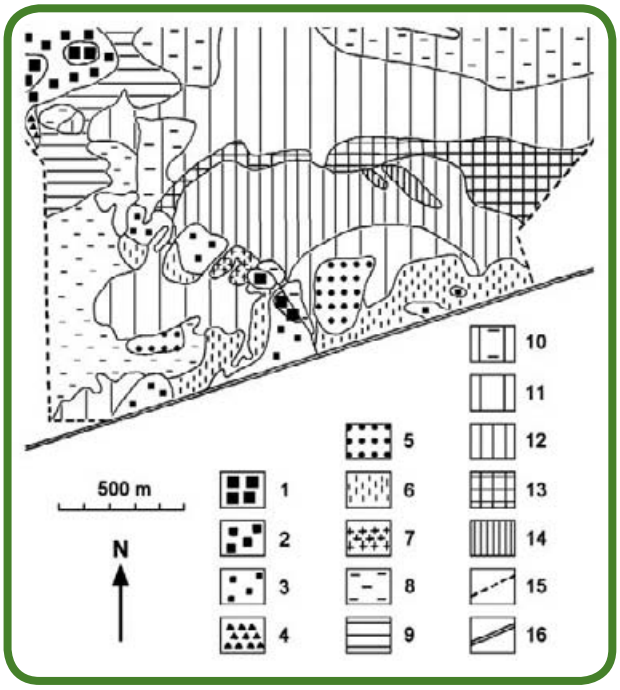

Fig. 4. Mire site type pattern of the southern part of Hirvisuo. 1 = *Empetrum-Vaccinium* forest site type, paludified *Empetrum-Vaccinium* forest site type; 2 = thin-peated pine forest; 3 = thin-peated, semi-open *Calluna* pine mire; 4 = *Carex globularis* pine mire; 5 = *Sphagnum fuscum* bog with hollows; 6 = short-sedge pine fen dominated by *Sphagnum compactum*, poor *Sphagnum compactum* fen, small mud-bottom patches; 7 = short-sedge pine fen dominated by *Sphagnum compactum*, mesotrophic *Sphagnum compactum* fen, small mud-bottomed areas; 8 = poor *Sphagnum papillosum* fen with small flarks, poor *Sphagnum papillosum* fen; 9 = tall-sedge fen, *Sphagnum papillosum* tall-sedge fen; 10 = *Sphagnum* flark fen; 11 = poor mud-bottom flark fen; 12 = mesotrophic mud-bottom flark fen; 13 = poor mud-bottom flark fen, mesotrophic mud-bottom flark fen, true tall-sedge fen, mesotrophic tall-sedge fen, mesotrophic *Drepanocladus* flark fen; 14 = *Scorpidium* flark fen as an interface against a pond, 15 = boundary of the mire reserve, 16 = road (From Laitinen & al. 2005).

Ecohydrologic interpretation of the SW-part of Hirvisuo

Because the flattened glaciofluvial esker form the edge and the basal substratum of southern Hirvisuo, its vegetation on thin peat is subjected to seasonal drought (Laitinen & al. 2005). It is seen in vegetation not only as *Calluna* type of marginal forest mires, but also as site types dominated by *Sphagnum compactum* and *Trichophorum cespitosum*, especially (Figs. 4 and 5). Poor to mesotrophic mud-bottom flark fens dominate the thin peated (to some 0.6 m) sandy terrace to be replaced by various

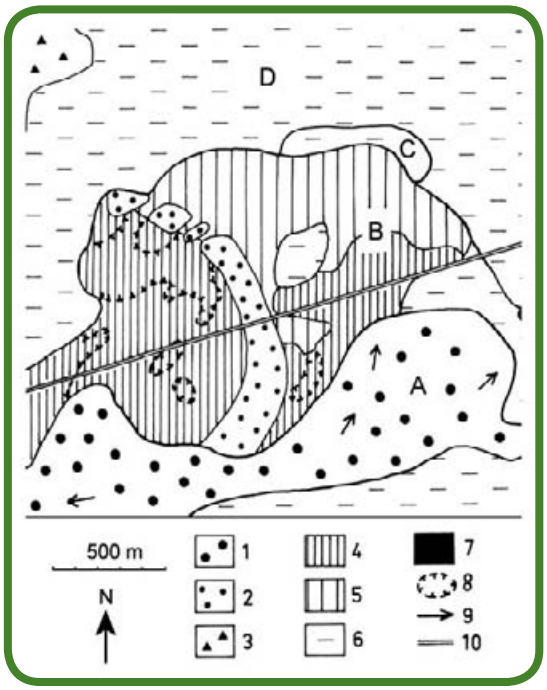

Fig. 5. A simplified map of the stability of water regime and the groundwater recharge-discharge pattern interpreted for the southern part of Hirvisuo. Patterns of mineral soil formations and the stability of water regime in mire areas: 1 = glaciofluvial interlobate complex (gravel, sand), 2 = raised beach ridge (sand), 3 = till areas, 4 = mire areas with unstable water regime, 5 = mire area of unsta-ble and stable water regime, 6 = mire areas with stable water regime. Other codes: 7 = lake, 8 = reservoir–infiltration basin, 9 = direction of groundwater flow, 10 = road. The groundwater recharge–discharge pattern: A = groundwater recharge area, B = transitional area, C = groundwater discharge area, D = surface layer flow area. Area C includes patches of (i) true tall-sedge fens dominated by *Carex rostrata*, (ii) mesotrophic tall-sedge fens (including *Helodium blandowii*), (iii) mesotrophic *Drepanocladus* flark fens (including *Hamatocaulis lapponicus*) and (iv) mesotrophic fens with surface water influence (including *Cinclidium subrotundum, Sphagnum squarrosum, Sphagnum teres, Sphagnum fimbriatum*) (From Laitinen & al. 2005).

site types – even by a site of rich *Scorpidium* flark fen – on the sudden step to deeper basin towards north.

Ecohydrological interpretations consist entirely of the groundwater, topography and permeability of mire floor, and the vegetation. The esker formation of sorted material in the southern mire part acts as the main groundwater recharge area (Fig. 5). Diffuse discharge of groundwater seems evident in the frontal steep of the thin peated sand flat. This is seen in the patches of plant cover by elements *(Hamatocaulis lapponicus)* with affinity to groundwater influence. Also species of other kind of mire margin effect like *Helodium blandowii* and *Sphagnum squarrosum* exist in this discharge zone.

In areas with unstable water regime some areas have been deducted as occasional infiltration basins, mainly west of the beach ridge (Fig. 6). They appear as very thin peated poor mud bottomed flark fens with steep edge hummocks without orientation. During floods they become water filled to be rather soon drying again. Partly they flow over to east via the throughlets in the beach ridge. Sometimes mire water level in those straits are at lower level ("negative springs") than in both sides of the surroundings suggesting that the beach ridge also acts as a groundwater recharge area.

Hirvisuo has become a target of several activity forms in conservation and in research. After vegetation mapping and ecological survey of Laitinen (1987) and later by Palojärvi (1995) with other inventories of Metsähallitus, a series of studies begun based on material of Hirvisuo. In addition to hydrotopographic and associated water-flow pattern (Laitinen & al. 2005), large periodic changes in moisture, especially, gave frame to researches of a classification and ordination study and of relationships in vegetation and water-table fluctuations (Laitinen 1990).

Hirvisuo, as an example, shows again that in land use planning and deciding boundaries for a reserve especially in aapa mires, it is essential to consider any site as a large ecohydrological or hydrogeological entity functioning in a landscape scale.

Fig. 6. Oblique aerial view of SW part of Hirvisuo. Photo Hannu Vallas. Photo towards NW. Explanation for codes: 1. Thin-peated *Calluna* pine mire, 2. *Empetrum-Vaccinium* forest site type, 3. Poor *Sphagnum papillosum* fen, 4. Poor mud-bottom flark fen, 5. Eccentric bog (*Sphagnum fuscum* bog with hollows), 6. Flark pools. (Mesotrophic mud-bottom flark fen), 7. Bird tower, 8. Mesotrophic *Sphagnum compactum* fen, 9. String fen (Parallel patterned fen)(Poor mud-bottom flark fen), 10. Soak, 11. Peripheral lobe (Poor tall-sedge fens), 12. Reservoir-infiltration basin (Poor mud-bottom flark fen), 13. Short-sedge *Sphagnum compactum* pine fen, 14. Lake Särkilampi.

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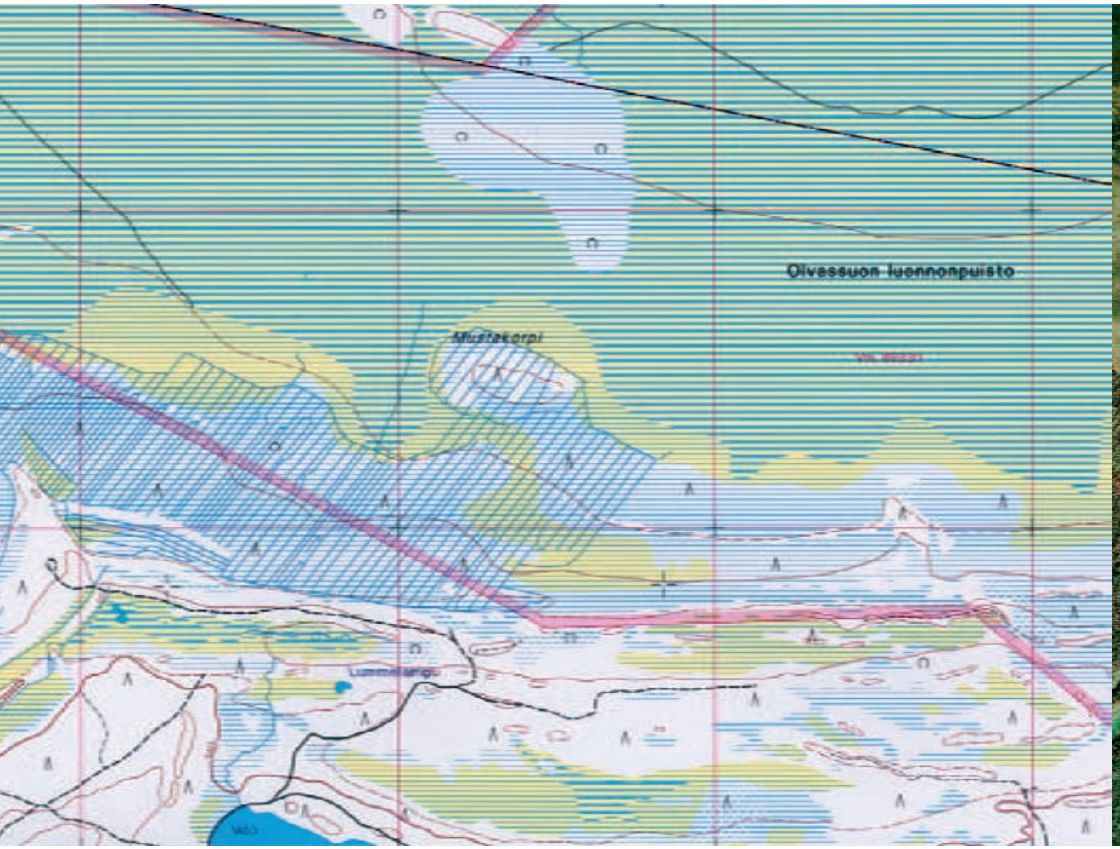
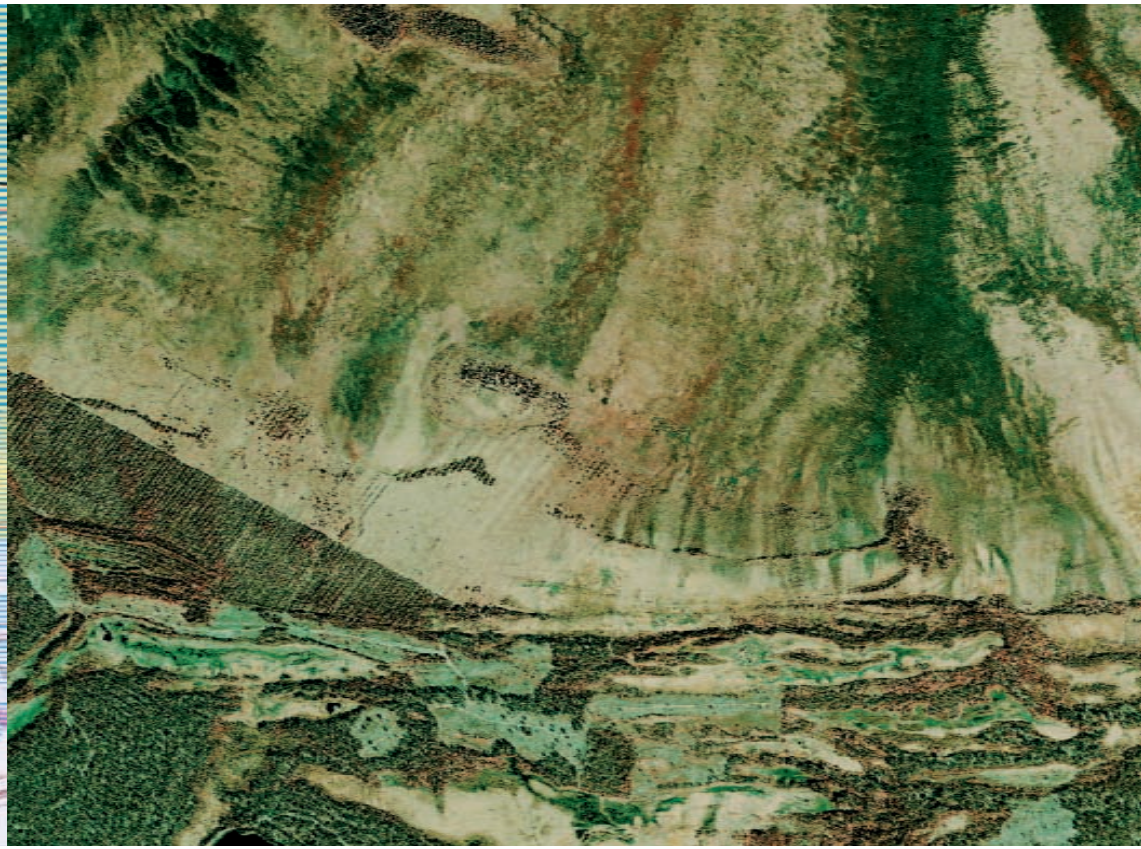


Topographic map of the southern part of Olvassuo mire. Each grid square is 1 km^2.



False-colour infrared aerial photograph of the southern part of Olvassuo mire. The red line shows the boundaries of Natura 2000 areas.

Mire Wilderness

Olvassuo

Sakari Rehell & Teemu Tahvanainen

The conservation history of Olvassuo

The importance of the Olvassuo environment has been recognised for a long time and its conservation has been put forward in several occasions. Häyrinen & Ruuhijärvi (1969) listed Olvassuo and Leväsuo mires, the two biggest mire areas in the region, in their list of valuable natural environments on state land in North-Finland. In 1970s, Metsähallitus made the decision of reserving the Olvassuo and Leväsuo area as a reserve of natural heritage outside normal management ("aarnialue"). In the report of the national park committee (Tallgren & al. 1976) a strictly protected, large nature reserve (larger than the current Natura 2000 area) was suggested in the area. In the justifications it was said that the area in question was the only area in the county of Pohjois-Pohjanmaa where it was possible to preserve a representative natural landscape with lakes, forests and mires. The Olvassuo Strict Nature Reserve was then established in the early 1980s, although in a smaller size than had been originally planned. At the same time, however, most of the area left outside the strict nature reserve, was included in the National Mire Protection Programme (Maa- ja metsätalousministeriö 1981). Two wide mire reserves were founded in connection with the nature reserve.

This combination of reserves was included as a whole in the European Natura 2000 network. The total area of the Natura area sums up to 27074 ha, 99.9% of which is state owned land. This area is accounted in several international programmes such as the Important Bird Areas (IBA), the international mire conservation programme Project Telma and in the Ramsar list (Ramsar site no. 1524). In addition, Olvassuo area has been considered as a possible candidate to the UNESCO World Heritage. The area consists of parts with different conservation status:

- The Olvassuo Strict Nature Reserve (5958 ha) is located in the heart of the Natura area and it is the most strictly protected part of the Natura area. Most activities are strictly forbidden. Hunting and fishing are not allowed at all. Reindeer husbandry is allowed though and local people are allowed to wander in the area when picking berries and mushrooms. There is also a trail from Lake Kirkaslampi to Olvassuo mire, where visitors are allowed to walk but one must not divert off the trail. Along this footpath there is an observation tower.
- The Oravisuo-Näätäsuo-Sammakkosuo mire reserve (6456 ha) and the Leväsuo-Kärppäsuo mire reserve (2251 ha) are protected by law. Hiking and gathering is allowed and for local people also hunting and fishing are permitted, but the nature is kept intact from management such as forestry practices.

- Some additional areas owned by the state are also protected on the basis of the nature conservation law (ca 10 000 ha). A part of these areas has been bought from other land owners for conservation. The most significant of these areas are the western part of Olvassuo mire and Tupakkisuo mire east of the Olvassuo Nature Reserve. The same restrictions apply to these areas as to the mire reserves.
- In the Kälväsvaara-Iso-Palovaara esker reserve (1252 ha), gravel taking and all other quarrying of land is ruled out, while forestry practices are continued by Metsähallitus. Forestry management is limited, however, in order not to diminish the area and representativeness of the Natura 2000 natural site types. Among these site types there are 59 ha of open mires, 4 ha of treed mires, 1.2 ha of natural growth forests and 0.5 ha of springs and spring mires, which are left outside the forestry practices.
- Within the Natura 2000 lineation there is also one nature reserve (33 ha) founded on private land.

Biotopes

Mires cover about ¾ of the Olvassuo Natura area. Vast open aapamire massifs are interconnected into wider systems so that it is difficult to delineate separate mire basins. As a typical feature for the mire massifs of the southern aapa-mire zone, the marginal zones are dry pine mires, while the central areas are wet flark fens. The hydrological diversity of the mires is increased by the rich discharge of ground water from the eskers. Springs are exceptionally abundant in the mire margins. Smaller springs with lesser water flow and poor vegetation are formed by perched ground water or smaller local ground water mounds, while some larger springs have very rich water flow and intermediate to moderately rich vegetation. Often the ground water discharge occurs as diffuse up-welling to the mire surface, in which case rich birch fens, in particular, occur. In one specific case, outside the Natura area, a black alder swamp has developed around a richly flowing spring stream.

There are mires also within the ground-water recharge areas along the esker formations. In these areas, the mires typically have a seasonally fluctuating water table. Hydrologically unstable aro-wetlands are found (Laitinen & al. 2005, Kontula & Raunio 2005) as are also Rhynchosporion assemblages similar to those described from Central Europe (Heikkilä & al. 2001).

Although the aapa-mire forms predominate, there are also bog massifs, which comprise about 5 % of the mire area of Olvassuo. The bog massifs have eccentric forms and they are located on local water divides or near rivers, in places where the water input is limited.

The thickest peat layers in Olvassuo mire are 4 metre thick, the greatest depth measured is 4.9 metres. In most of the area the peat thickness is less and in considerable areas it is less than one metre. Weakly or moderately decomposed *Carex* peat and *Bryales-Carex* peat predominate and there are no considerable aquatic sediment layers. There are no detailed studies of the developmental history but the references available indicate that the early development in the Olvassuo has not differed from what is common in the region. The central parts of the current mire basins became dominated by mire vegetation soon after the emergence from the Baltic. The mire systems have then become connected by expansion of the mires and paludification of forests. According to the elevation (ca 120 m asl) the area has been above the sea level for about 7500 years.

In addition to mires, natural growth forests are an important part of the Olvassuo reserve. People have utilised the forests for centuries and it is hard to find a truly

pristine forest site. In every case, more than half of the forests may be classified as natural growth forests as their tree stands are more than 100 years old. The influence of earlier cutting is seen in the rarity of large decayed wood (>30cm diameter).

Lakes and rivers are an important part of the reserve of Olvassuo. The water courses belong to the drainage area of the river Kiiminkijoki, which is one of the most important protected river systems in Finland. Kiiminkijoki is among the last large rivers, which have not been harnessed for electricity production. It belongs to the international Project Aqua programme as well as to the Natura 2000 programme. The river Nuorittajoki, a tributary of the Kiiminkijoki, passes through the Olvassuo area. There are also numerous smaller rivers and lakes. There are oligotrophic lakes with bright water as well as dystrophic mire-water lakes.

Species

The mire vegetation in the Olvassuo area is very diverse thanks to the well preserved entities of the mire systems (Heikkilä & al. 2001, Ala-Risku 2005). Most of the rare and threatened species are found in the ground water influenced rich fens. The characteristic species of the rich birch fens (*Carex diandra, Carex heleonastes, Stellaria crassifolia, Helodium blandowii, Calliergon giganteum, Calliergon richardsonii*) occur in wide areas, while the most demanding species such as *Saxifraga hirculus, Hamatocaulis vernicosus, Meesia triquetra* and *Sphagnum contortum* are located in few hot spots only. The typical species of northern rich fens (*Scorpidium* spp., *Campylium stellatum*) are scanty. The Olvassuo area is considered as the single most important site in Finland for the endangered moss *Hamatocaulis lapponicus*, which is found here in few patches in mud-bottom flarks. These sites are characterized by a very stable hydrology, ground water discharge and comparably low calcium concentrations of surface water (Sallantaus & Turunen 2005).

The avifauna of the aapa mires in the Olvassuo area is very rich and representative of the southern aapa-mire zone. In fact, all the typical aapa mire species are found. The wetness of the central parts of the mires and the abundance of pools and lakes is of great importance to the avifauna. Of individual species, *Anser fabalis* must be mentioned, as the environment is optimal for it. *Gavia arctica, Gavia stellata, Mergus albellus* and *Melanitta nigra* dwell in the pools and small lakes (Tuohimaa 2005). In the old growth forests, *Tetrao urogallus, Picoides tridactylus, Perisoreus infaustus* and even the very rare *Tarsiger cyanurus* (Tuohimaa 2005) are met as well as the flying squirrel *Pteromys volans*.

Restoration and threats to conservation

About 2 % of the mire area had been drained before the conservation decisions in the Olvassuo area. Most of the drainage had taken place in mire margins, where the mire types were pine fens. These drainage areas are now under restoration. In 1998, a 70 ha area in the southern marginal zone of the Olvassuo massif was restored. The restoration was continued in 2004-2005 on 350 ha of drained mires. The oldest restoration area is being recolonised by mire vegetation. This area is easily reached by visitors, as the trail to the scenery tower crosses it. One can easily see that the landscape is not natural as yet. The filled ditches are wet and treeless stripes on the otherwise drier mire. At some places there is a high density of pine seedlings. In the filled ditches, the peat surface is still clearly depressed and the water table does not rise high enough in the areas between the ditches.

An oblique aerial view of Olvassuo towards NW. The southern marginal part of the mire was drained around 1970 and restored in 1998. A wooden boardwalk leads to an observation tower. Photo Hannu Vallas.

A major threat to the reserve is a plan for ground water pumping in the esker areas of Kälväsvaara and Pitääminmaa. Especially the water pumping plan in the Kälväsvaara area would have serious effect on the hydrology of the protected mires (Heikkilä & al. 2001). According to the plan, a major part of the ground water supply (7000 m^3/day) would be utilised. The water pumping would cause the drying of springs and streams near Kälväsvaara and it would also lower the water table and affect the water quality of the Iso Kirkaslampi lake. In longer term, the hydrology of the rich birch fens and other minerogenous mire types in the central parts of the Olvassuo and Leväsuo mires would be affected as well and this would promote vegetation changes towards poorer vegetation types. Furthermore, the seasonally dry mires and aro wetlands might dry out. At present, the Olvassuo area is in an unusually natural state as a large scale catchment and, as such, it is an important reference area of natural hydrological conditions. In addition, the hydrological changes would have an effect on the river Kiiminjoki, another Nature 2000 resort, as well. The water-pumping would be detrimental to the Natura 2000 areas and, thus, the assessment of the plan will be a significant precedent for cases in the future if Natura 2000 areas were to be threatened by similar plans.

Some other threats to the conservation occur as well. Reindeer husbandry is important to the natural diversity of the area in general, but in forest areas the winter grazing by reindeers causes severe degradation of lichens. In recent years the lichen stands have slowly started to recover, though. Another severe problem in the region is the poaching of large predators. Guarding is very limited, and especially the destroying of eagle nests has been common. Also the bear and lynx are being hunted both legally and illegally. Wolf and wolverine are not found in the area. The persecution of the predators takes place mainly because of the damage they cause to reindeer and domestic animals.

Hydrology

The Kälväsvaara hill is an enlargement of an esker consisting of several ridges and delta-like parts. Typical of its surface morphology are ice-melt holes of different sizes in the middle part of the formation and well developed shore banks on its edges. It has been interpreted to have been formed in a joint of two ice shelves during the retreat of the glacial. The coring and sounding results from the area show that the soil layer is more than 20 metres and in some places more than 60 metres thick (Ahonen & al. 1999, Rundelin 1999). The bedrock is well below the ground-water level and it does not form thresholds. The structure of the esker is quite complex. While some pure deposits are found, in most places silt, sand, gravel and moraine layers alternate in a complex pattern. Northwest from the Kälväsvaara, the Pitääminmaa and Kokkomaa areas are much simpler narrow sand eskers.

Kälväsvaara hill is a large recharge area from where the ground water discharges to the mires and springs around it. In the small Kokkomaa esker, water infiltrates from the upper mire area and discharges to a lake. The Pitääminmaa esker discharges ground water into a large spring outside the Natura 2000 area. The ground water recharge-discharge pattern of the Kälväsvaara area is shown in a map (Fig. 1) constructed on the basis of piezometre data a ground water model (Ikäheimo & Hintikainen 1999) and field observations (Heikkilä & al. 2001). There are different levels in ground water discharge. Ground water may sometimes come to surface also in recharge areas, in which case the springs are typically unstable and spring vegetation is not found. In more stable springs, mosses like *Loeskypnum badium* and *Warnstorfia sarmentosa* can occur. In the actual discharge area, the springs are usually intermediate rich in the Kälväsvaara area. Often they are located in the mire margins. Typical moss species include *Warnstorfia exannulata, Pseudobryum cinclioides, Philonotis seriata* and *Scapania paludicola*. Ground water discharge takes place also in the more central parts of the Olvassuo and Leväsuo mires. There the ground water welling is diffuse and it comes from deeper layers. Typical rich birch fen vegetation, rich in spring fen species, is found in such discharge areas. There is also a clear limnogenous element in vegetation, as represented by species like

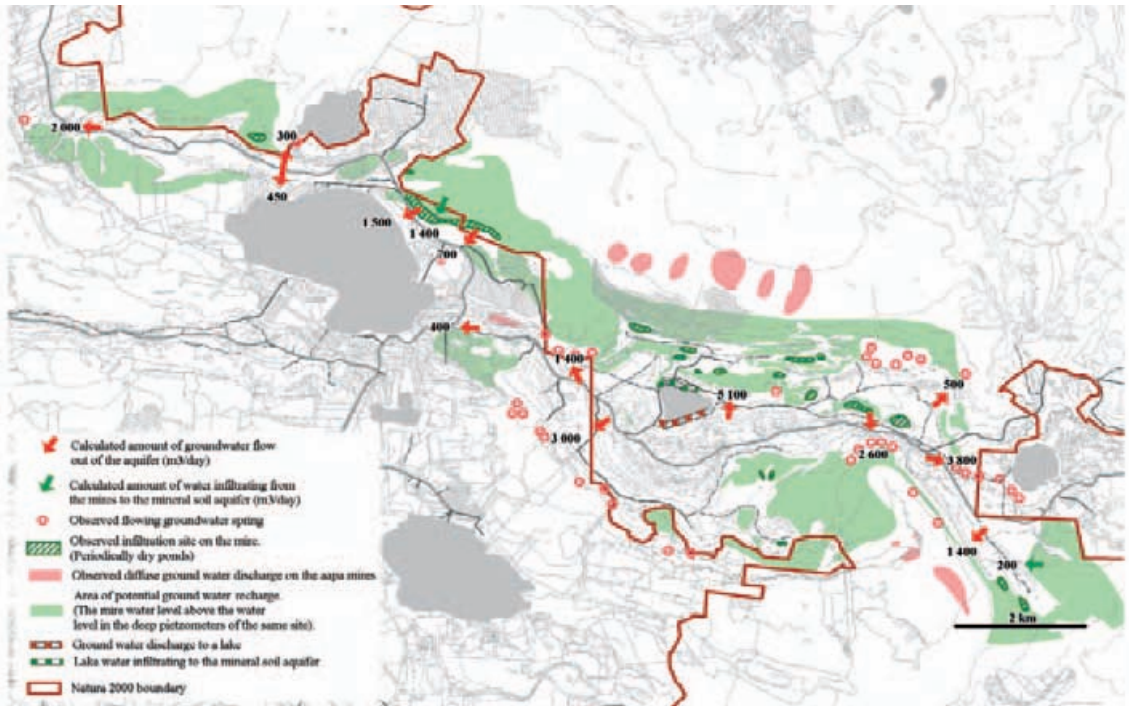


Fig. 1. Groundwater conditions in Kälväsvaara esker system, and Olvassuo and Leväsuo mires.

Calla palustris, *Potentilla palustris*, *Cicuta virosa* and *Eriophorum gracile*. Within these up welling areas also mound-like springs are found. The mounds appear like small forested islets where spring species are found in wet surfaces in between hummock surfaces.

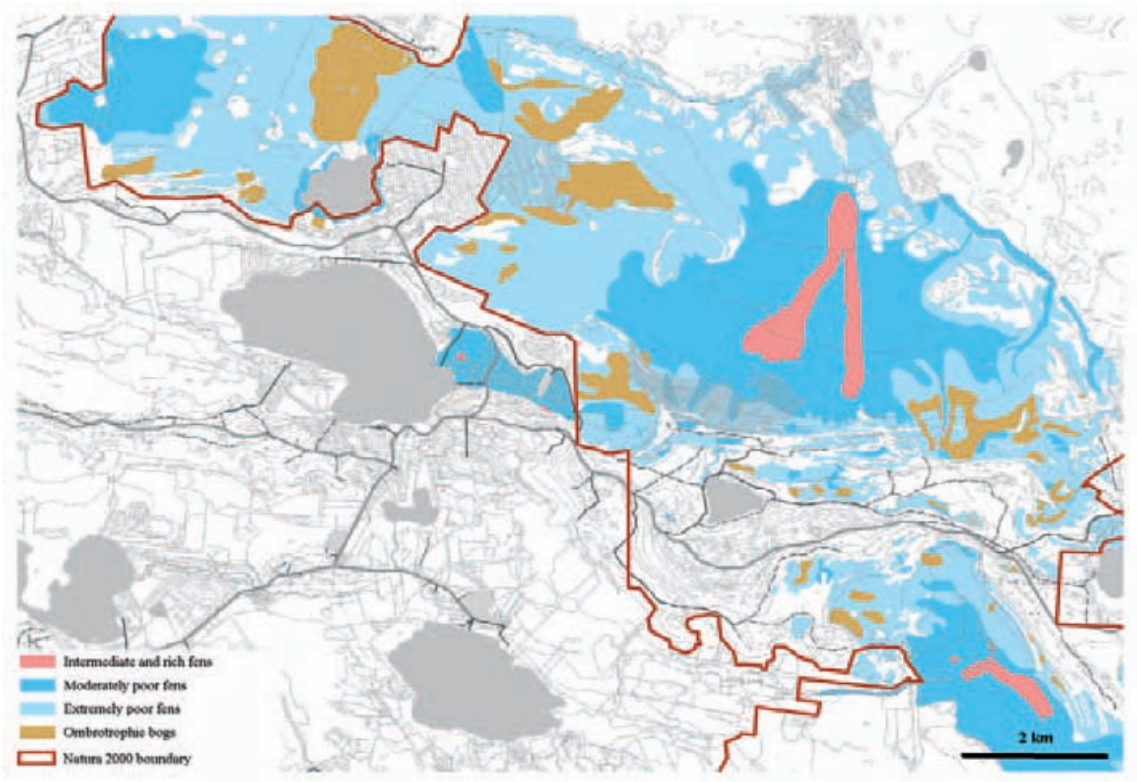


Fig. 2. The main division of mire site classes in Olvassuo and Leväsuo mires.

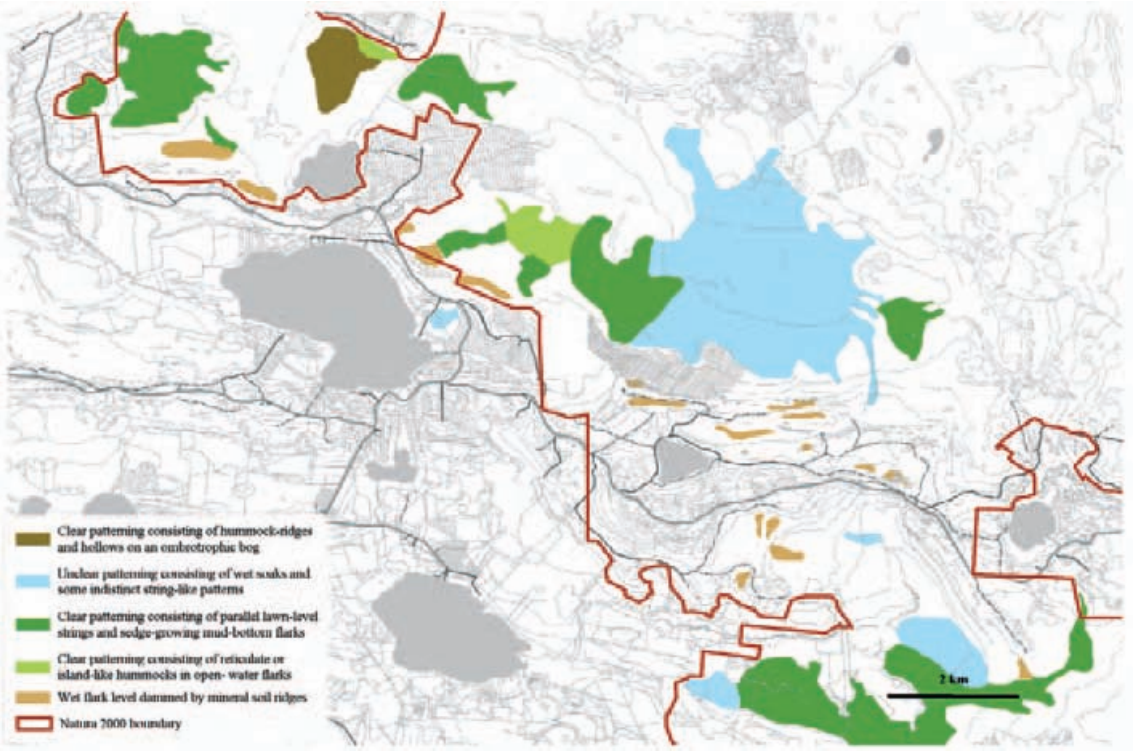


Fig. 3. Aapamire patterns in Olvassuo and Leväsuo mires.

The comparison of the ground water recharge-discharge pattern with peat thickness shows that the up welling of ground water takes place at the deepest depressions, in places with the thickest peat layer. This is a feature typical of aapa mires. Very often there is ground water discharge in places where there is a step change in peat thickness or, in other words, a steep slope in the soil under the peat layer. The ground water pattern also affects the poor-rich gradient in vegetation (Fig 2) and the morphology and surface patterns of the mire (Fig 3). In Olvassuo and Leväsuo mires, with rich ground water input, the rich and wet central fens are much wider than they are in other aapa mires with lesser ground water discharge. In Olvassuo area, the ground water influence most typically results in intermediate fen vegetation along the poor-rich gradient.

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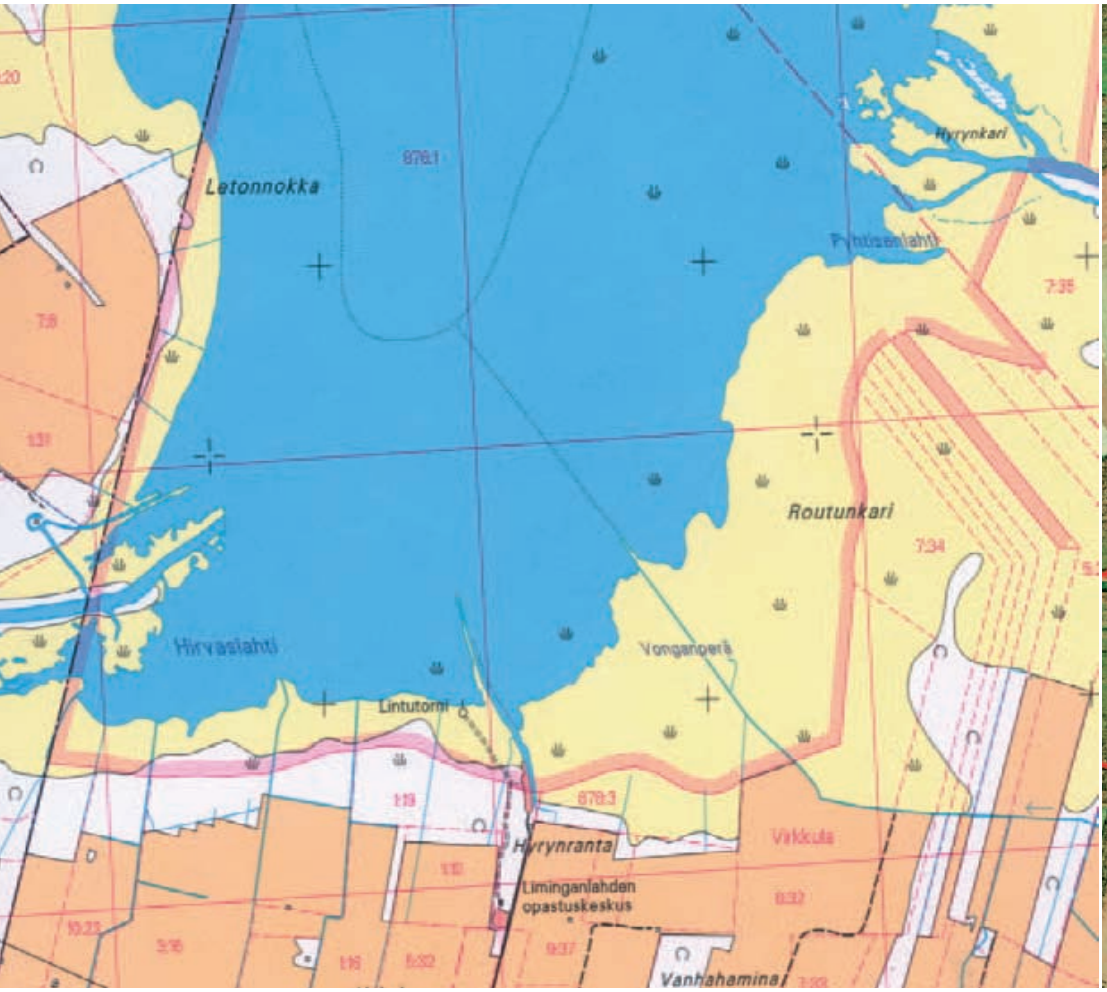

Topographic map of the southern end of Liminganlahti bay. Each grid square is 1 km2.

False-colour infrared aerial photograph of the southern part of Liminganlahti bay. The red line shows the boundaries of Natura 2000 areas.

A bird sanctuary in a flat uplifting landscape with a shallow bay and wide meadows

Liminganlahti

Jorma Pessa & Teemu Tahvanainen

Liminganlahti is the largest bay in the northern part of the Gulf of Bothnia. It is 109 km^2 wide and its coast-line is 110 km long. The bay is shallow and even, and the depth of the water is less than one metre in most parts of it. At the bottom of the bay, the land rises with the pace of about 82 cm per one hundred years. In less than a hundred years, the coast-line moves 1.5 kilometres and after 500 years it will be in the level of the islands in the mouth of the bay. Changes in the landscape will be noticeable already within a couple of decades. The water level is variable in Liminganlahti following the changes of wind directions. The water is usually at its highest level in October-November when the prevalent wind direction is from the southwest. In spring and early summer, the shore line may move towards the sea for up to two kilometres with the north wind. Several small rivers and ditches discharge in the bay and the salinity is low. The freshwater comes from agricultural land and peatlands, and brings about 60 000 tons of dissolved and particulate material per year to the bay. Nitrogen input in river discharge is 500 tons and that of phosphorus 60 tons per year. The shallowness, variable water level, river sediments and high nutrient levels together with the land-uplift history already make the Liminganlahti Bay a most unique and diverse environment. Further diversification of the environment is brought about by the traditional land use, the occurrence of saline soils and the six-month annual ice cover (Markkola & al. 1993, Pessa 2004).

Vegetation

Due to the land uplift the vegetation zones are in constant motion and the series of vegetation zones represent a successive as well as an environmental gradient. The development from the shoreline's spike-rush meadow to a shore forest takes only 60-160 years in Liminganlahti. The land uplift makes the vegetation zonation unstable.

The aquatic vegetation in Liminganlahti resembles that of a shallow lake. In the mouth of the bay, where the water is more saline, species like *Potamogeton vaginatus, Potamogeton pectinatus, Aster tripolium* and *Limosella aquatica* are found. The aquatic vegetation is sparse in the mouth but very rich elsewhere, totally covering most of the bay area. Typical species are *Potamogeton perfoliatus, Ranunculus confervoides, Zannichellia palustris* var. *repens, Eleocharis acicularis, Myriophyllum verticillatum, Myriophyllum sibiricum, Sagittaria natans, Butomus umbellatus, Lemna trisulca, Potamogeton friesii* and *Utricularia spp*. Closer to the shore, *Eleocharis palustris* is abundant. In the shore habitats, *Phragmites australis* reeds cover an area of 1190 ha, sedge meadows 523 ha, low-growth meadows dominated by *Juncus gerardii* and *Festuca rubra* cover 303 ha and sandy habitats are represented by 26 ha.

An oblique aerial view over the southern end of Liminganlahti bay towards the southeast. In the centre there are two observation towers, and Virkkula nature centre on the right. Photo Hannu Vallas.

One speciality of Liminganlahti Bay is the occurrence of saline soils, salt patches and halophyte vegetation (Siira 1970, 1971). The salinity of water in the bay is less than one tenth of the salinity of oceans. The soil salinity is caused by sea sediments from the Litorina phase and possibly from preglacial marine strata. The soil must be fine enough finesand for capillary adhesion of water and the net water balance needs to be negative. In such circumstances, the evaporative concentration leads to accumulation of salts in the soil surface. The climate in Liminganlahti is subarid during the summer months (V-IX) with precipitation of 257 mm and mean temperature of 11.9 °C, although the annual figures indicate subhumid conditions. The salt patches may be divided into those with halophyte vegetation and those without. The halophyte species in Liminganlahti include *Juncus gerardii, Blysmus rufus, Salicornia europaea, Puccinellia distans* ssp. *borealis, Eleocharis uniglumis, Carex glareosa, Carex paleacea, Carex halophila, Carex mackenziei, Spergula salina, Primula nutans* var. *jokelae, Glaux maritima, Odontites litoralis, Plantago maritima* and *Triglochin maritima*. The pathces with high electrolyte concentrations range from near-neutral chloride-salt pathces to chloride-sulphate pathces and acid sulphate pathces. The sulphate patches lack halophytes and are often dominated by *Calamagrostis stricta*. Other typical species include *Eriophorum angustifolium, Rumex acetosella* and *Agrostis canina*.

There are two plant species endemic to the Bothnian Bay, namely *Deschampsia bottnica* and *Euphrasia bottnica*. *D. bottnica* grows near the water line in rocky shores and *E. bottnica* is a species of upper shore meadows. *Alisma wahlenbergii* is a rare aquatic plant endemic to the Baltic Sea, which had wider distribution earlier, but it is today restricted to the Finnish coast of the northern-most Bothnian Bay.

A bird paradise

The flat, shallow topography, variable vegetation and muddy sediments make the area a true bird paradise. Liminganlahti has a great importance during the migration; up to 20 000 individuals of waterfowl have been counted at the same time in Liminganlahti. The development of Liminganlahti's waterfowl population has been monitored since the 1950's. The amount of waterfowl pairs has been increasing.

The importance of the area is underlined by the regular nesting of ten bird species listed among the endangered species in Finland. Liminganlahti is the most important breeding place for the critically endangered Southern Dunlin (*Calidris alpina* ssp. *schintzii*) and Yellow-breasted Bunting (*Emberiza aureola*) as well as for the endangered Black-tailed Godwit (*Limosa limosa*).

The Greylag Goose (*Anser anser*) is one of the most distinctive birds on Liminganlahti. The population of the Greylag Goose in the area was about 20 pairs in the 1960s. Since then, the nesting population has increased and settled to around 120 pairs. In addition to the nesting Greylag Geese, a rich number of juvenile nonbreeding individuals are seen in the area (Table 1.).

Table 1. The mean pair numbers of breeding wetland bird species in the nine sub-areas in 2000-2001 at Liminganlahti.

Podiceps cristatus	101
Podiceps griseigena	5
Podiceps auritus	5
Anser anser	204
Anas platyrhynchos	148
Anas strepera	9
Anas acuta	115
Anas penelope	113
Anas crecca	122
Anas querquedula	49
Anas clypeata	122
Tadorna tadorna	8
Aythya marila	4
Aythya fuligula	430
Aythya ferina	5
Bucephala clangula	9
Melanitta fusca	12
Melanitta nigra	7
Mergus merganser	58
Mergus serrator	142
Waterfowl, total	**1608**
Circus aeruginosus	24
Circus cyaneus	6
Circus pygargus	1
Falco tinnunculus	1
Raptors, total	**32**
Grus grus	7
Fulica atra	39
Botaurus stellaris	10

Cranes, storks etc., total	**56**
Larus minutus	201
Larus ridibundus	1289
Larus canus	222
Larus argentatus	14
Larus marinus	5
Sterna hirundo	148
Sterna paradisaea	305
Sterna albifrons	5
Sterna caspia	1
Larids, total	2190
Haematopus ostralegus	14
Charadrius dubius	4
Charadrius hiaticula	25
Vanellus vanellus	107
Calidris temminckii	1
Calidris alpina ssp. schinzii	14
Philomachus pugnax	175
Lymnocryptes minimus	3
Gallinago gallinago	80
Limosa limosa	29
Numenius arquata	123
Tringa totanus	149
Tringa nebularia	27
Tringa glareola	32
Actitis hypoleucos	37
Arenaria interpres	9
Phalaropus lobatus	11
Waders, Total	**840**

The Tufted Duck (*Aythya fuligula*) is the most abundant waterfowl species of the area. Pintail (*Anas acuta*) has been the most abundant dabbler until a decline in recent years. Following the eutrophication of the bay, the Shoveler (*Anas clypeata*) has become more abundant. The Wigeon (*Anas penelope*), the Mallard (*Anas platyrhynchos*) and the Teal (*Anas crecca*) populations have been steadily numerous in Liminganlahti, while the Gadwall (*Anas strepera*) is a south-eastern small-numbered species, which appeared in the area in the 1980s. Liminganlahti is on the northern verge of the range of the Great Crested Grebe (*Podiceps cristatus*). Yet, as many as 100 pairs nest on the bay.

The gull avifauna on Liminganlahti is exceptionally varied. Large communities of gulls and terns give sheltered breeding grounds also to the waterfowl and the waders. The most common gull is the Black-headed Gull (*Larus ridibundus*). Since the last century this southern species has quickly extended its range northwards. The amount of the Common Gulls (*Larus canus*) nesting in Liminganlahti has varied between 100 and 250 pairs. The most of the Common Gulls nest in a loose community on the shore meadows in Long Beak, Lumijoki. The Little Gull (*Larus minutus*) population has been increased since early 1980s and nowadays it the second most numerous gull species in the area. 200-400 pairs of the Common Terns (*Sterna hirundo*) and the Arctic Terns (*Sterna paradisaea*) nest yearly in the area. A new arrival to the avifauna is the Little Tern (*Sterna albifrons*). Little Terns nest usually on sandy shores with scanty vegetation or on gravely soil mostly on the same places as the Caspian Tern (*Sterna caspia*). Occassionally the Black Tern (*Chlidonias niger*) has nested near the river estuaries.

Regularly, 18 species of waders nest on Liminganlahti. The most common waders are the Ruff (*Philomachus pugnax*) and the Common Redshank (*Tringa totanus*). The populations of the Common Snipe (*Gallinago gallinago*), the Curlew (*Numenius arquata*) and the Northern Lapwing (*Vanellus vanellus*) are also numerous. The Rednecked Phalarope (*Phalaropus lobatus*) nests in Lapland, but the species is abundant also in Liminganlahti. Puddly meadow shores and small rocky shores form the typical environment of the Rednecked Phalarope. The Southern Dunlin, which is at its most numerous in Finland in the region of Oulu, lives on the bay on the northern limits of its range, as also does the new arrival, Black-tailed Godwit. The Ringed Plover (*Chaladris hiaticula*), the Little Ringed Plover (*Chaladris dubius*), the Common Oyster Catcher (*Haematopus ostralegus*), the Turnstone (*Arenaria interpress*) and the Common Sandpiper (*Acitis hypoleucos*) are the waders of hard-bottomed meadow shores and islands. One of the most typical sights of Liminganlahti in the summer is the Marsh Harrier (*Circus aeruginosus*) hovering above the endless reeds. It belongs together with the Black-headed Gull, the Northern Lapwing, Bittern (*Botaurus stellaris*) and many ducks to the southern group of birds, which has considerably spread north during the last decades. The Northern Harriers (*Circus cyaneus*) are more dependent on small mammals than the Marsh Harriers and they are nearly missing in the years when there are a small number of voles to catch. Kestrels (*Falco tinnunculus*) have diminished because of changes in agricultural land use.

Of the owls, the Short-eared Owl (*Asio flammeus*) is common in Liminganlahti in good vole years. Also the Long-eared Owl (*Asio otus*) nests on the islets of forests on the fields surrounding the bay. The Eagle Owls are feeding in the area regularly during the breeding season and the Hawk Owls mainly in late autumn and winter. Other owls are sporadic in Liminganlahti.

The bay offers exhaustlessly insect nutriment and nesting places to passerines. The most abundant birds of the reeds are Sedge Warbler (*Acrocephalus scoenobaenus*) up to 5000 – 8000 pairs and the Reed Bunting (*Emberiza schoeniclus*). The density of the avifauna has in some places been calculated to be 750 pairs per a square kilometre; the Sedge Warbler, the Reed Bunting and the Willow Warbler (*Phylloscopus trochilus*) are the most numerous species. Other nesting species which are typical but distinctly

fewer in number are the Scarlet Rosefinch (*Carpodacus erythrinus*), the Yellowhammer (Emberiza citrinella), the Whinchat (*Saxicola rubetra*), the Garden Warbler (*Sylvia borin*), the Whitethroat (*Sylvia curruca*) and the Yellow-breasted Bunting.

The gaudy Yellow-breasted Bunting (*Emberiza aureola*) is a rare eastern species. It is a new arrival in the Finnish avifauna. Liminganlahti's population was 30 pairs in 1965 and about 12-15 pairs in 1985. After that the decreasing trend was turned deeper and just one single male was seen in 2004. It requires open willow thickets of flood meadows where common reed hardly grows.

The numbers of staging birds are high. The recent counts have shown that the staging populations of Whooper Swan (*Cygnus cygnus*), Bean Goose (*Anser fabalis*), Teal (*Anas crecca*), Pintail (*Anas acuta*), Shoveler (*Anas clypeata*), Goldeneye (*Bucephala clangula*), Smew (*Mergus albellus*), Goosander (*Mergus merganser*), Broad-billed Sandpiper (*Limicola falcinellus*), Spotted Redshank (*Tringa erythropus*) and Little Gull (*Larus minutus*) are considered as internationally important exceeding the thresholds drawn by the Birdlife International. Moreover the Barnacle Goose (*Branta leucopsis*) exceeds the threshold value occasionally. Because of these species and the value of breeding bird populations Liminganlahti is a part of a larger IBA area, Oulu Region Wetlands (IBA code 028) (Table 2).

Table 2. The peak numbers of staging wetland species and the species considered as threatened in Finland. The observation period is 1996-2002. Species marked in bold exceed 1 % population threshold. Species marked in brackets are considered as irregular visitors.
DSpecies included to the Annex I of the Directive of Wild Birds (Councils Directive 79/409/EEC). Species marked with (x) are proposed to Annex I species
THSpecies considered as threatened in Finland. CR = critically endangered, E = endangered, VU = vulnerable, NT = near threatened (Rassi & al 2001)
1 % Population thresholds of a flyway or biogeographical region (BirdLife International 1995 and Scott & Rose 1996 for waterfowl from *Cygnus cygnus* to *Mergus merganser*))

Species	Spring	Autumn	D	TH	1%
Gavia stellata	10	3	x	NT	750
Gavia arctica	27	4	x		1 200
Podiceps cristatus	350	450			5 000
Podiceps griseigena	100	3			250
Podiceps auritus	10	2	x		410
Phalacrocorax carbo	2	1	x		1 200
Botaurus stellaris	5	5	x	NT	
Cygnus cygnus	**1 150**	**850**	x		400
Cygnus columbianus	9	3	x		170
Anser f. fabalis	**8 100**	80		NT	800
Anser brachyrhynchos	80	-			340
Anser albifrons	30	-			6 000
Anser erythropus	12	-	x	E	40
Anser anser	1 100	1 700			2 000
Branta leucopsis	1 000	**2 500**	x		1 760
Branta bernicla	1	5			3 000
Tadorna tadorna	8	12		NT	3 000
Anas penelope	4 300	4 500			12 500
Anas sterepera	15	20			300
Anas crecca	**5 500**	**4 200**			4 000
Anas platyrhynchos	1 500	3 500			20 000

Species	Spring	Autumn	D	TH	1%
Anas acuta	**1 200**	**3 500**			600
Anas querquedula	90	190			20 000
Anas clypeata	**450**	**700**			400
Aythya ferina	25	2			3 500
Aythya fuligula	7 500	4 500			10 000
Aythya marila	76	12		VU	3 100
Clangula hyemalis	15	55			20 000
Melanitta nigra	30	110		NT	16 000
Melanitta fusca	40	45			10 000
Bucephala clangula	**4 500**	2 400			3 000
Mergus albellus	**350**	50	x		250
Mergus serrator	480	140			1 250
Mergus merganser	**4 500**	450			2 000
Pernis apivorus	2	5	x	NT	
Haliaeetus albicilla	3	2	x	VU	
Circus aeruginosus	40	130	x	NT	
Circus cyaneus	12	18	x	NT	
Circus pygarcus	4	5	x		
(Circus macrourus)	2	0			
Aquila chrysaetos	2	1	x	VU	
Pandion haliaetus	4	1	x	NT	
Falco tinnunculus	6	13		NT	
Falco columbarius	3	2	x	VU	
Falco subbuteo	3	7			
Falco peregrinus	4	4	x	E	
(Falco rusticolus)	1	0	x	E	
(Milvus migrans)	1	1	x	E	
Tetrao tetrix	10	30	(x)	NT	
Crex crex	5	0	x	NT	
Fulica atra	60	110			15 000
Grus grus	550	150	x		600
Haematopus ostralegus	60	25			9 000
Charadrius dubius	5	15			3 200
Charadrius hiaticula	80	350			2 400
Pluvialis apricaria	35	160	x		10 000
Pluvialis squatarola	15	50			1 700
Calidris canutus	10	50			3 500
Calidris minuta	5	900			2 100
Calidris temminckii	30	35		VU	3 000
Calidris a. alpina	1 000	1 500			14 000
Caldris a. schinzii	30	50	(x)	CR	200
Calidris ferruginea	6	25			4 500
Calidris alba	1	10			1 200
Limicola falcinellus	**450**	5		NT	400
Philomachus pugnax	19 000	1 500	x	NT	33 000
Lymnocryptes minimus	17	12			660
Gallinago gallinago	440	120			47 000

Species	Spring	Autumn	D	TH	1%
Limosa limosa	40	85		E	3 500
Limosa lapponica	36	20	x	NT	1 000
Numenius phaeopus	80	15			5 300
Numenius arquata	450	120			3 500
Tringa erythropus	**3 500**	550			720
Tringa totanus	450	150			1 500
Ttringa nebularia	1 200	250			1 800
Ttringa ochropus	18	5			10 000
Tringa glareola	6 700	4 500	x		11 000
(Xenus cinereus)	1	0	x	CR	
Actitis hypoleucos	20	7			15 000
Arenaria interpres	15	8			700
Phalaropus lobatus	250	45	x		
Larus f. fuscus	10	40		VU	2000
Larus ridibundus	3000	5000		VU	60000
Larus minutus	**1 200**	**1 500**	(x)		680
Sterna caspia	10	6	x	VU	50
Sterna hirundo	150	140	x		6 000
Sterna paradisaea	480	740	x		13 000
Sterna albifrons	10	15	x	E	340
(Chlidonias niger)	1	0	x	VU	1700
Cuculus canorus	5	10		NT	
(Nyctea scandiaca)		1 winter	x	E	
Jynx torquila	1	0		VU	
Dendrocopos minor	4	5		VU	
Picoides tridactylus	1	3	x	NT	
Luscinia svecica	40	1	x		
Saxicola rubetra	150	500		NT	
Oenanthe oenanthe	20	40		NT	
(Turdus torquatus)	2	0		NT	
Panurus biarmicus	30	300		NT	
(Parus cinctus)	0	1		NT	
Lanius collurio	10	30	x	NT	
Lanius excubitor	3	5		NT	
Sturnus vulgaris	20	300		NT	
Emberiza aureola	8	10		CR	

Protection of Liminganlahti

The natural values of Liminganlahti are internationally acknowledged. It has been one of the resorts of the international Project Mar programme already since 1965. The meaning of the programme is to protect the best nesting and resting areas of waterfowl and waders in Europe and North Africa during migration. In 1973, Liminganlahti was included in the catalogue of the most important waterfowl sites in Scandinavia, and its position as one of the major sites in the Finnish national programme of wildfowl reserves was confirmed in 1982. The bay is also included in Ramsar convention, the international contract of protecting wetlands.

Shoreline meadow in Liminganlahti bay. *Lathyrus palustris* is abundant in the foreground. *Salix phylicifolia* forms thickets. Photo Raimo Heikkilä.

The whole Liminganlahti area, 11 823 hectares, was accepted to the European Natura 2000 –reserve network in 2004 as an SPA (based on the Councils Directive of the Wild Birds) and SCI (based on the Councils Directive of Habitats) area. Almost 80 % of the Natura 2000 area has already been protected by establishing nature reserve in the means of the Finnish Nature Conservation Act.

The international recognition of Liminganlahti's value is based on local work. Doctor Jouko Siira began a systematic research of the avifauna and the vegetation in the 1950's. Dozens of ornithologists from various countries got to know the resorts of the bay under his guidance during an ornithological congress in 1958. His team has also studied the quality of the water, soil, plankton and the effects of the uplift. In 1992, Jouko Siira and Jorma Pessa published an account on the need of protection and management, on which the management projects later were based on. The bay was threatened by drainage, clearing of farmlands, unauthorised building of summer cottages, the dredging of the places for boats, eutrophication and acidification.

In 1995, a project called "The protection of the internationally valuable wetland of Liminganlahti in the ways of conservation, management and environmental awareness" was launched, financed by the EU's nature conservation fund (LIFE), the North-Ostrobothnia Regional Environment Centre, the municipality of Liminka and The World Wildlife Fund (WWF). The main methods include the founding of reserves

and clearing, cutting and pasturing grasslands that have become overgrown with reeds and bushes. The regional environment centre has organised mowing by use of voluntary work already since 1993, aided by land owners, private contractors, scouts and Vapo Oy. The management plan for the whole wetland area was done during the LIFE –project in a cooperation with the state and municipality authorities, local land owners, hunters, fishermen and nature conservationists NGO's.

Legal waterfowl hunting is a very popular hobby at Liminganlahti. The area is one of the best known hunting sites in Finland. Up to 2000 hunters are shooting ducks and geese regularly in the area from 20 August to the late autumn. The game bag is several thousands of birds mainly Teals, Mallards, Shovelers, Wigeons, Pintails, Tufted Ducks, Greylag Geese and the Goldeneyes (*Bucephala clangula*). Because of the high conservation values of the area, the regional environment centre has established reserves for the waterfowl and other migratory birds where the hunting is not allowed.

Management of coastal meadows

The wide scale management of coastal meadows restarted in 1996 funded by the EU's LIFE-Nature project. The habitat loss of coastal meadows since late 1960's was caused a threat to most breeding birds dependent of the low growth coastal meadows. Large scale measures for removing of the reed from former low growth meadows were carried out. After that the cattle grazing as a recurring management measure was able to launched (Pessa & Anttila 1998, 2000). Nowadays, up to 1000 hectares of coastal meadows are pastures or mowing areas supported by the EU's Agri-environmental scheme. Thanks to these measures the populations of many endangered bird and plant species has started increasing.

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Topographic map of the southern part of Hummastinvaara mires. Each grid square is 1 km^2.
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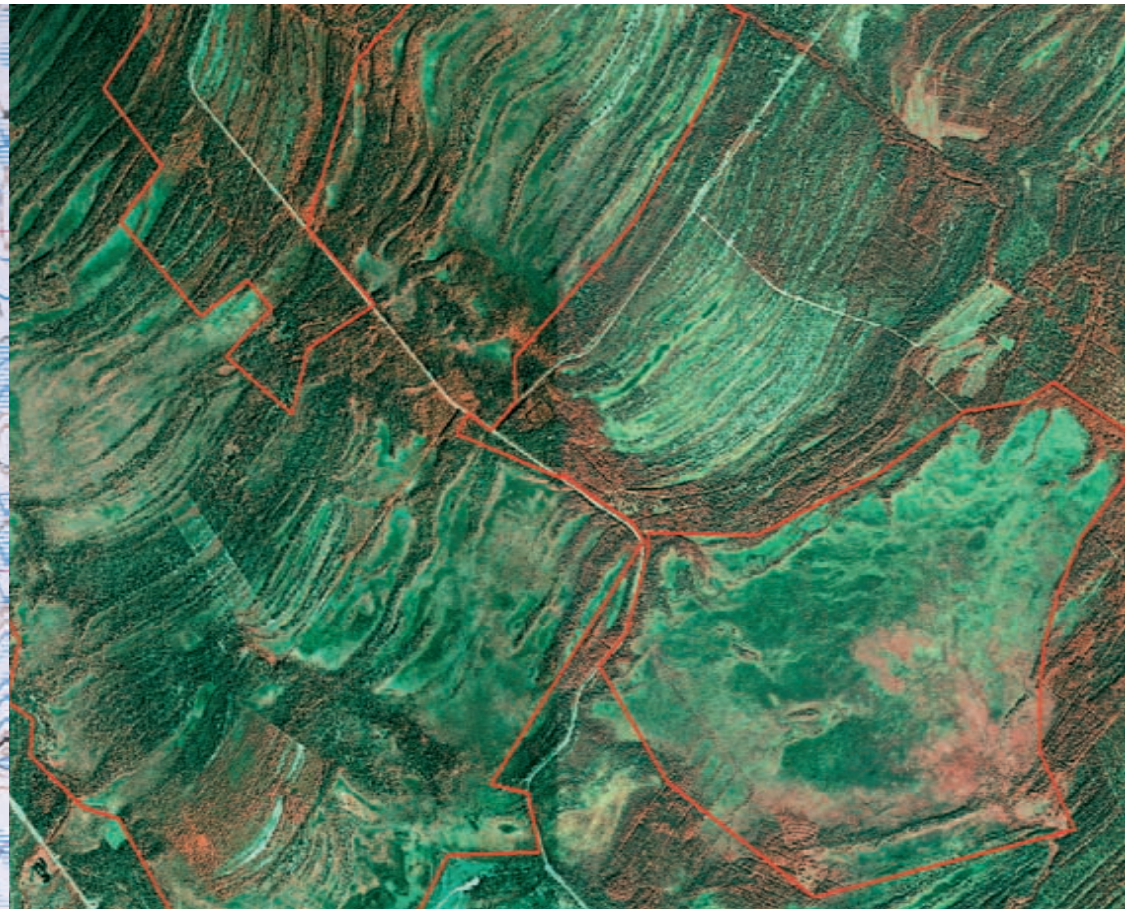

False-colour infrared aerial photograph of the southern part of Hummastinvaara mires.
The red line shows the boundary of Natura 2000 area.
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5000 years of mire development within a few kilometres

Successional series of mires in the land uplift coast of the Hummasti area

Kari Kukko-oja, Sakari Rehell & Teemu Tahvanainen

Tauvo and Hummasti areas in the Siikajoki parish represent an example of the successional series of mires in the coastal land-uplift area. The successional series of mires are included in the scattered Natura 2000 area of the Siikajoki bird areas. Mires cover altogether an area of 2069 ha. Almost 70 % of the Natura area is comprised by EU Nature Directive's habitat types, which include rich fens, aapamires, dune meadows and coastal ridges. The coastal bird areas of Ulkonokanhietikko, Merikylänlahti and the Siikajoki river delta, together with the lakes Säikänlahti and Ulkoniitynlahti, also belong to the Finnish Important Bird Areas (FINIBA). The mires in the Natura area contain a 2500-2800 year successional series of natural mires from the sea shore to 25-30 metre elevation above the sea level. The landscape of the inland areas is patterned by repeated ridges of old shorelines, where mires occur in between the forested ridges. In surrounding areas, most mires are drained.

A general map of the Siikajoki bird areas. Tauvonniemi dune beaches and Merikylänlahti bay in the north, Lake Säikänlahti and Lake Hietaniitynlahti in the centre and Hummastinvaara mires in the south. The red line shows the boundaries of Natura 2000 areas.

Rich flark fen in Isoneva mire. *Carex limosa* dominates in the field layer and *Scorpidium scorpioides* in the ground layer. Photo Raimo Heikkilä.

A successional series of mires in the land-uplift chronosequence

The vegetation changes following the land uplift are rapid in the shoreline zone up to two metres elevation above the sea level. Efficiently dispersing species such as *Salix phylicifolia* are typical. The moss layer is sparse and there are only few species due to the sea water influence. The young mires are flooded fens, either open or with shrubs or trees. *Phragmites australis* is abundant in the shoreline. In upper zones, many sedge species are typical, including *Carex halophila*, *C. paleacea*, *C. aquatilis* and *C. nigra*. Other characteristic species are *Epilobium palustre, Peucedanum palustre, Lathyrus palustris, Potentilla palustris, Lysimachia thyrsiflora* and *Myrica gale*, and among the few mosses *Calliergon cordifolium* and *Drepanocladus polygamus*. Inland from the shoreline, there are the Säikänlahti and Hietaniitynlahti lakes that have been isolated from sea bays into shallow lake basins. Lake Säikänlahti is still a so called glo lake, as it is in an unstable contact with the sea. Lake Hietaniitynlahti is surrounded by young sedge fens; around the Säikänlahti lake the mire vegetation zone is narrower. The peat deposits are thin (up to 30-40 cm) and their age is approximately 100 years (Kukko-oja & al. 2003).

In the coastal zone at 5 to 15 metre elevation above the sea level, the peat accumulation has started some 600 to 1000 years ago. The deeper depressions in the landscape

An oblique aerial view over the southern part of Hummastinvaara mires towards the northeast. Isoneva mire in the centre, and a carbon gas balance measuring station on the right in front of the road. Photo Hannu Vallas.

have been paludified by primary mire formation. The peat layers are typically less than 60 cm thick. Often the mire expanse vegetation is typical of limnogenous, flooded mires. The moss layer is already well developed with species such as *Sphagnum riparium, S. flexuosum, S. fimbriatum, S. fallax, S. teres, Calliergon giganteum, Helodium blandowii* and *Straminergon stramineum*. In the tree layer, *Betula pubescens, Alnus incana* and *A.glutinosa* are found. In the marginal parts of the open fens, *Carex lasiocarpa* is characteristic, indicating the development to a more mature sedge fen phase. In addition to the primary paludification, the palufication of forests is seen in this zone. Spruce mires are especially typical but also pine mires are found. In them the characteristic species range from *Carex globularis* and *Equisetum sylvaticum* to *Vaccinium uliginosum* and *Ledum palustre*, for example. In the elevation zone of 12 to 14 metres above the sea level, corresponding to about 1400-1600 years, the mires already have some typical characters of aapa massifs. Also pine mires become more common and the limnogenous influence is fading away; the peat layers are 60-100 cm thick. Mires in this elevation zone of the Hummasti area are mostly narrow strips between the beach ridges (Kukko-oja & al. 2003).

In the elevation of 23-25 metres, there are some larger basins where the mires have developed over 2500-2800 years. The peat layers are more than one metre thick in central parts and the aapa-mire features are moderately developed. Many typical mire plants that are not found in the youngest mires of the shoreline zones are abundant. Such species include *Carex lasiocarpa, C. livida, Trichophorum cespitosum, T. alpinum* and *Rhynchospora alba*, and among the mosses *Sphagnum papillosum* and *S. subfulvum*. In Järvineva mire, there are two metres of peat in the deepest parts of the basin, where the elevation of the basal peat is 24.5 m above the sea level. There are mud and gyttja layers below the basal peat with remains of aquatic plants, indicating that the mire development has started by terrestrialisation. In the marginal zones, paludification of forest is apparent as well (Kukko-oja & al. 2003).

In the Isoneva mire, the central part is dominated by rich fen vegetation. Rich fens are also found elsewhere in the Hummasti area, in the narrow mire stripes between the beach ridges. The ridge formations are highly permeable and in places where there is enough slope, ground water influence can be rich. Apparently, ground water infiltrates in the sandy ridges and discharges where rich fens are situated. The geochemistry in the area is not particularly alkaline and the high pH of rich fen waters is dependent on rich ground water influence. Although there are no especially high cation concentrations, the organic acidity is effectively removed in the process of ground water infiltration. The frequent sand ridges play an important role as filters of ground water. Typical rich fen indicators in the Hummasti area are moderately rich fen species such as *Scorpidium scorpioides, S. revolvens* and *Campylium stellatum*, and the regionally endangered species *Cinclidium stygium, C. subrotundum, Sphagnum contortum* and *Meesia triquetra*. Also *M. longiseta*, a nationally endangered extremely rich fen species occurs at one rich fen in this area. Among less demanding moss species, the moderately poor fen indicator *Sphagnum aongstroemii* is a regionally endangered species. Several threatened vascular plant species also occur in the rich fens of the Hummasti area. These include *Dactylorhiza incarnata* ssp. *cruenta, D. traunsteineri, Rhynchospora fusca, Hammarbya paludosa* and *Juncus stygius* (Kukko-oja & al. 2003).

Ecological research of mire succession

The chronological sequence of the mires in the land-uplift coast gives a unique change for ecological studies concerning the succession of mires. Vegetation, hydrology, microbiology and material balance of mires change in the course of succession. The Finnish Forest Research Institute and the Department of Forest Ecology of the University of Helsinki have conducted studies of carbon-gas balance and methanogen communities along a transect of five study sites ranging in age from 100 to 2500 years in the Hummasti area. In general, the community-scale productivity becomes lower and less variable during the course of succession of mires.

The youngest mires (50-500 years) appeared to be sinks of methane in dry seasons, while the older mires were sources of methane to the atmosphere. In wet seasons, all sites were methane sources. The carbon dioxide and methane dynamics of young mires is very sensitive to meteorological conditions. When the growth period is exceptionally dry, the youngest mires easily lose carbon, while the oldest mire may still remain carbon sinks. The differences between young and old sites are partly due to differences in vegetation.

Merilä & al. (2005) studied the methanogen communities along the five-sites transect. They determined *Archaea* assemblages from peat samples by amplification of a methyl coenzyme M-reductase gene marker and subsequent terminal-restriction fragment length polymorphism fingerprinting. Ordination of the methanogen-DNA data revealed a gradient related to the age of the five mire sites. Thus, mire succession was concluded to involve the succession of methanogen communities.

The carbon gas balance measuring station in the southernmost tip of Hummastinvaara mires. Photo Tapio Lindholm.

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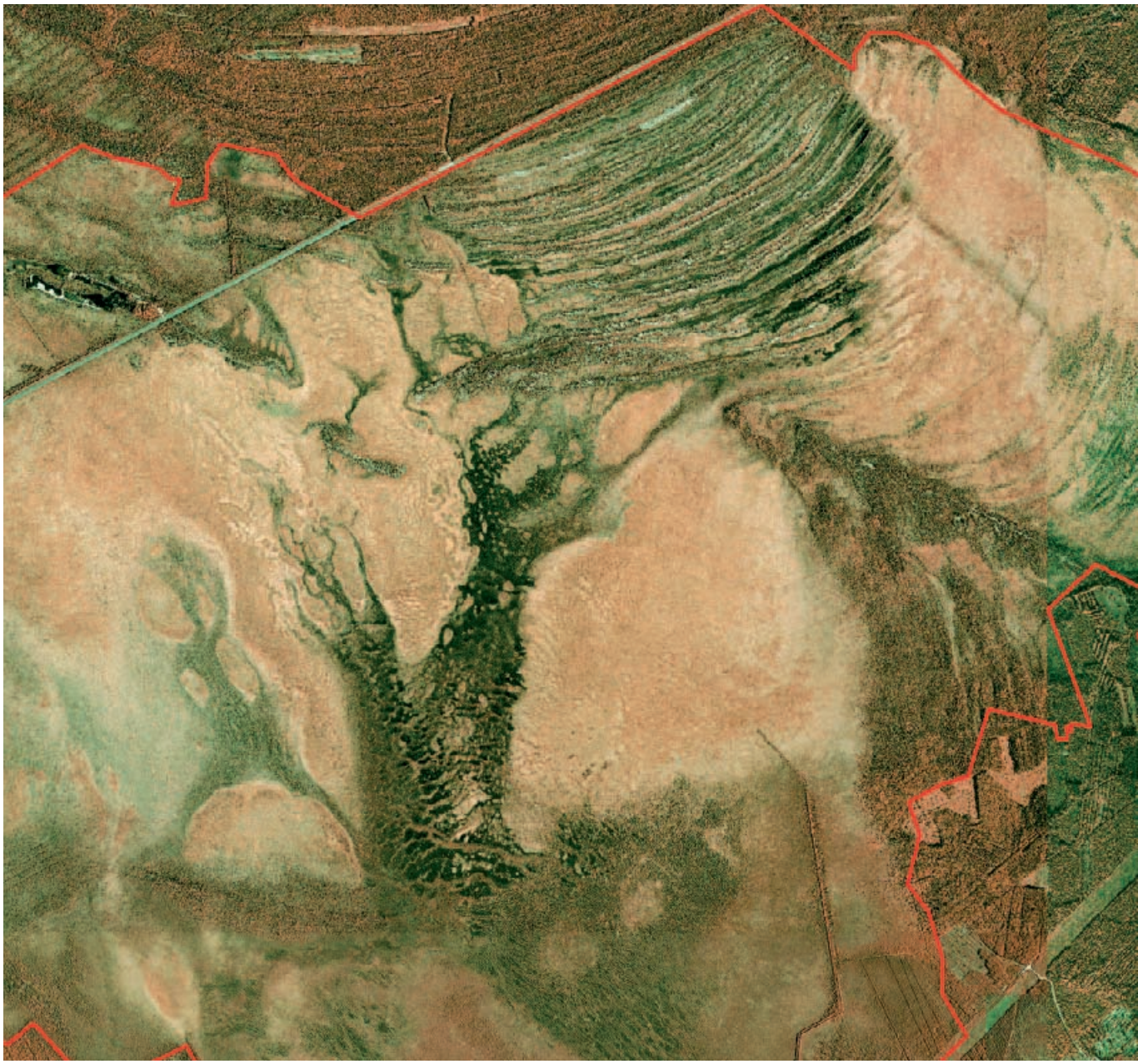
Revonneva-Ruonneva, a combination of aapamires and ombrotrophic bogs

Sakari Rehell

Revonneva and Ruonneva cover together about 3800 ha of protected mires. They are situated about 50-65 m asl and so they have risen from the sea about 4600-5100 years ago. At that time the waves and the wind shaped the sandy esker chain in the centre of the area to a series of sandy beach ridges and dunes marking today the ancient coastlines. So the topography of the mire basins resembles in places that of the Hummasti area near the present seashore. The protected area of Revonneva-Ruonneva is, however situated largely on a very flat water divide district and that partly explains the great amount of ombrotrophic bogs here. The peat layers of these mires are poorly known; according to some occasional drillings the peat layer on very large parts of the mires is quite thin and *Sphagnum*-dominated. The areas with peat layers deeper than 1,5 m are so small that the area has never rousen the interest of peat mining companies.

The Revonneva-Ruonneva mire system could be best described as a combination complex of aapamires and ombrotrophic bogs (Tolonen 1967). Aapamire- and bog massifs cover areas of about the same magnitude. The aapa massifs have a clear and versatile string-flark –topography. Some of the bog massifs have distinct eccentric hummock ridges, some are nearly unpatterned hummock level. The large amount and situation of the bogs makes the area different from the typical aapamire systems. The bogs are not restricted to some special situations, but they cover also largely the central parts of the basins. This undoubtedly is largely due to the climate, and the southwestern border of aapamire zone has in some maps been drawn across the area (Eurola 1962, Ruuhijärvi 1960).

Sphagnum fuscum hummocks form the most typical vegetation of the bogs. The lawn and carpet level is largely dominated by *S. balticum*, only some wettest hollows are covered by *S. majus*. The wet minerotrophic soaks are clearly visible on the aerial photographs. Often the marginal soaks fade to the bog, a typical characteristic for mire systems in the zone of southern eccentric bogs. The flarks of the minerotrophic aapamires are largely mud bottom flarks, and the strings sedge-dominated lawn. In the centre of the Revonneva basin, where the flow direction of water branches, the strings are replaced by small *S. fuscum* islands. Some parts of the aapamires are formed of minerotrophic, thin-peated basins dammed by sand bars. The trophic level of the aapamires is usually extremely poor to moderately poor. Intermediate or rich fens are encountered only in some sites with strongest surface and ground water influence. There has been a large area of rich fens in the northeastern corner of Ruonneva, but this has largely been ditched for forestry; only a small part of it is in natural condition and situated inside the protected area.



False-colour infrared aerial photograph of the northern part of Revonneva mire reserve. The red line shows the boundary of Natura 2000 area.

Downy Birch Finland, mires after silvicultural drainage

Forestry drainage – extensive destruction of mires

Raimo Heikkilä & Tapio Lindholm

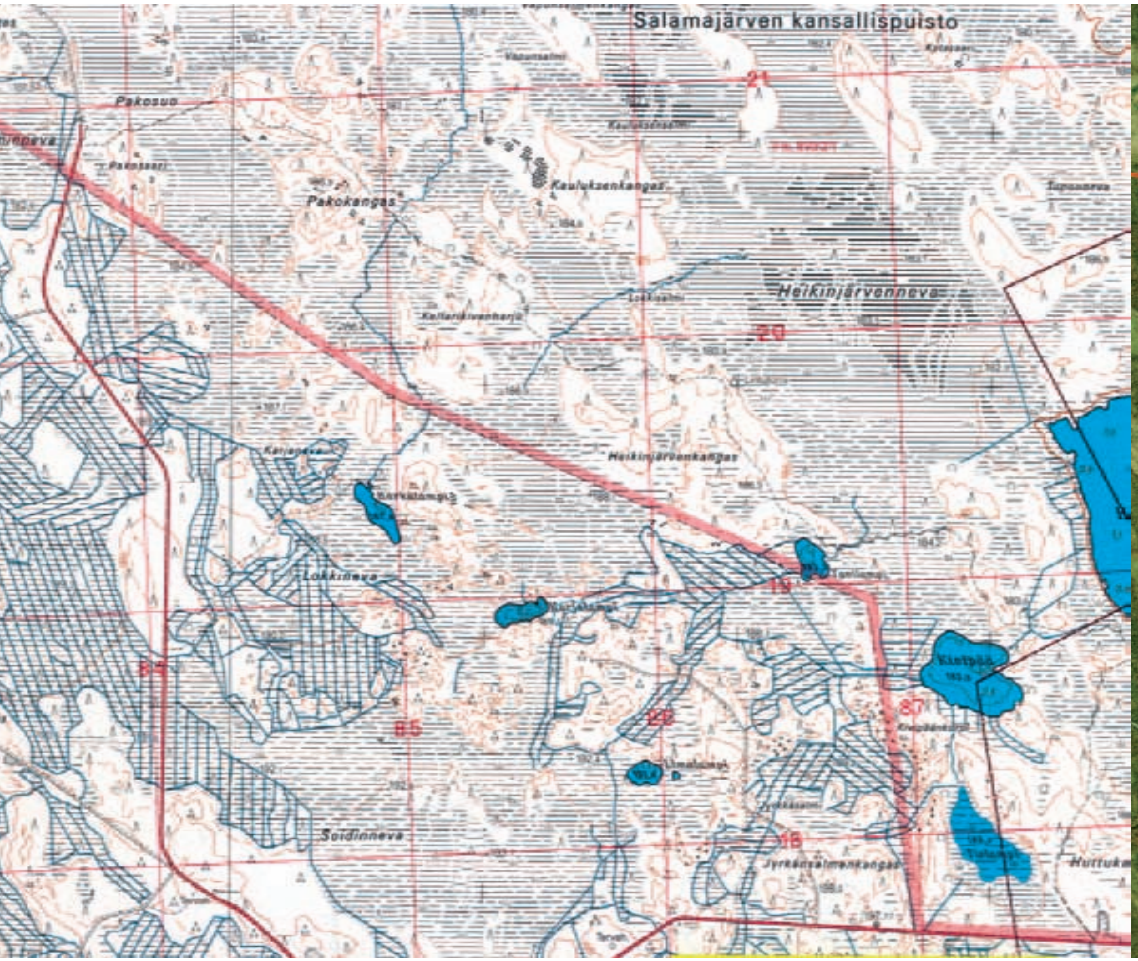
In the western Finnish plains in Ostrobothnia, in an area of about 40 000 km^2, the degree of paludification in large areas exceeds 60%. There are regions where up to 80% of the territory has been covered by mires in natural state. The mires have been sedge aapamires. The most typical mire sites have been poor open fens and pine fens. Locally there has been also rather extensive areas of rich birch fens. Since the 1960s, practically all the mires have been drained for forestry or peat mining. Also agriculture has taken wide mire areas. As a consequence of this destruction, there are now wide areas, where more than 60% of the landscape is drained mires.

Forestry drainage in the aapamires has largely resulted in the growth of *Betula pubescens* instead of *Pinus sylvestris*. This has decreased the economic profit of the drainage. This kind of development has given origin for the name "*Hieskoivusuomi* or *Suokko-Suomi*"(*Betula pubescens* Finland).

In the understorey vegetation *Betula nana* has increased enormously. There are large areas where *Betula nana* thickets are up to 1,5 metres high. In more rich sites *Molinia caerulea* has taken over the field layer vegetation. In the ground layer in drained originally wet sites *Polytrichum commune* covers most of the mire surface. Most of the mire plants have disappeared, as well as birds of open and wet habitats. The bushes and dwarf shrubs offer a perfect shelter for mosquitoes, which are really numerous in the drained areas. The crops of cloudberry (*Rubus chamaemorus*) and cranberry (*Vaccinium oxycoccos*) have collapsed in most of the region.

Due to the ditches, bush and dwarf shrub thickets, and mosquitoes, drained areas are really difficult and disgusting for hiking, hunting or picking berries. It is also very difficult to define one's location in these areas, especially because in the new Finnish topographic maps all ditches are not marked, but a drained area symbol is used.

Figure: A piece of topographic map from 1991 in Kärsämäki, northern Ostrobothnia, along the main road number 4. Practically all mires have been destroyed by forestry drainage and in the NE corner of the map also by peat mining. © National Board of Survey, permission no. 7/MYY/06.



Topographic map of the Heikinjärvenneva mire area in Salamajärvi national park. Each grid square is 1 km^2.
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False-colour infrared aerial photograph of the Heikinjärvenneva mire area in Salamajärvi national park. The red lines show the boundary of Natura 2000 area and an area in the mire, where it is not allowed to pass during the breeding season of birds.
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Locus Classicus site of the Finnish aapamire concept

Salamajärvi national park

Teemu Tahvanainen

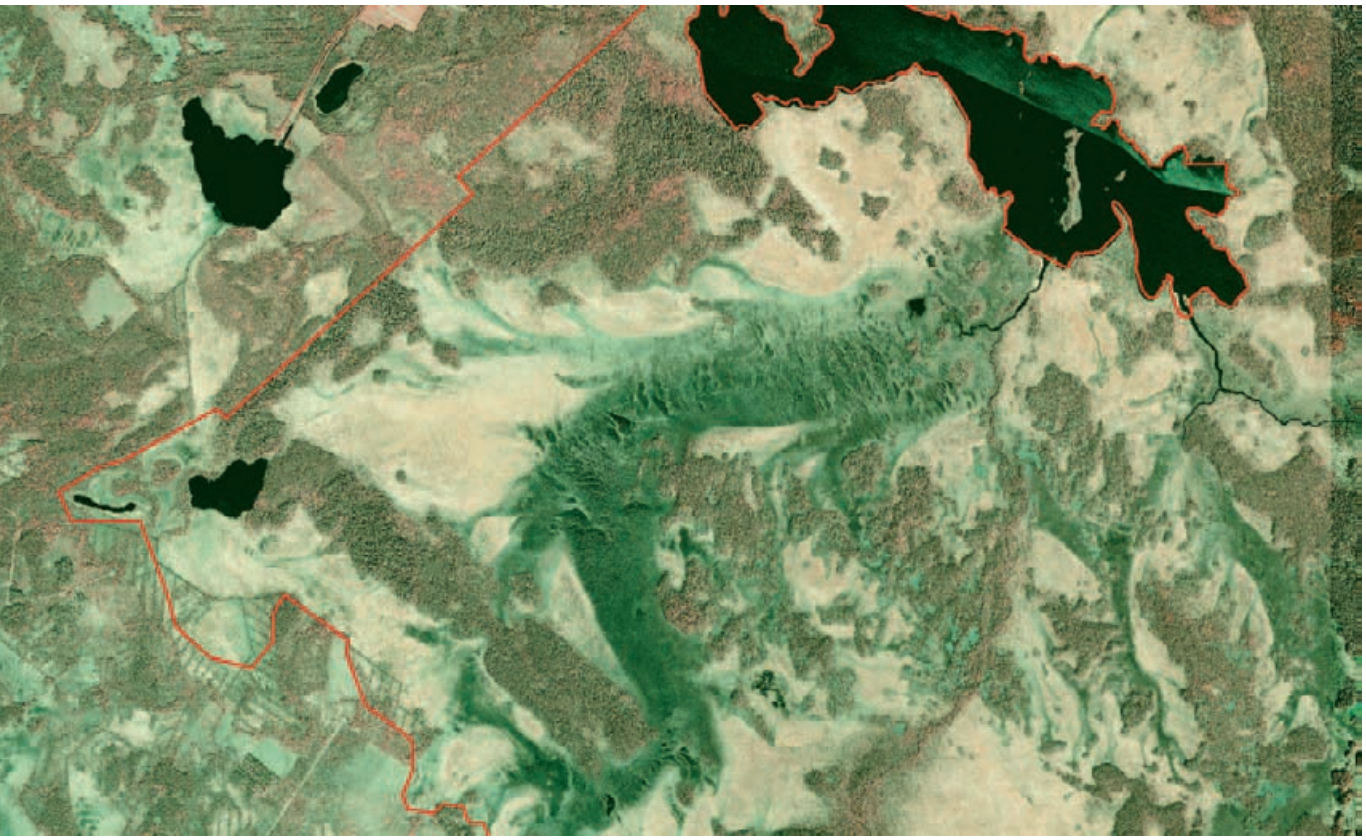
Salamajärvi National Park was founded in 1982 and it extends over an area of 62 km^2. Connected in the south to the National Park lies the 15 km^2 wide Salamanperä Strict Nature Reserve, which was founded already in 1956. These protected areas comprise a NATURA 2000 area, in which an additional 900 ha area is included. Located in southern Finland, the Salamanjärvi area comprises an unusually large and representative wilderness complex of mires, forest and lakes. The most important function of the national park is to protect the wild character of the area. It has a special value for wilderness fauna preservation.

Salamajärvi is located at the Suomenselkä watershed area (*Suomenselkä = 'Finland's back'*). At the Suomenselkä area, the northern element reaches southwards and the area has sometimes been called the finger of Lapland. The landscape of Salamajärvi National Park is dominated by mires because of the location on a watershed where differences in altitude are small and flow of water is weak. Characteristic to the area are large open fens, as well as the occurrence of smaller mires in a mosaic with forests. The bedrock in the area consists mainly of acidic granodiorite.

Mire massifs and vegetation

Salamajärvi belongs to the southern aapa-mire zone and within it to the subzone of the Suomenselkä aapa mires. In general, the aapa mires of this zone are comparably dry in their central parts. Typically, lawn fens are more dominant than flark fens. In the Salamajärvi Park, the largest aapa mires are exceptionally wet, however (Salminen 1980). Especially the greatest aapa massif, Heikinjärvenneva mire has a vast central flark fen area with open water surfaces and sparse strings. Typical plant species of the central flark fens in Heikinjärvenneva are *Carex chordorrhiza, Rhyncospora alba, Utricularia intermedia* and *Menyanthes trifoliata* (Liedenpohja & Luttinen 1984). In the strings, *Sphagnum papillosum, Sphagnum pulchrum, Molinia caerulea* and *Carex lasiocarpa* are dominant. Some more demanding species include *Sphagnum subsecundum, Sphagnum subnitens, Carex livida, Carex dioica, Dactylorhiza incarnata, Juncus stygius* and *Selaginella selaginoides*. Thus, the flark fens are moderately poor to intermediate fens. East of the Heikinjärvenneva, several smaller mire basins are located on the water divide, and the minerogenous water flows do not reach them. These mires have developed into unpatterned bogs, often with *Sphagnum fuscum*-bog vegetation type.

In the north-western corner of the National Park, there is another wide aapa massif, the Salmineva. The Salmineva is a more typical case of southern aapa mires. It is poorer in vegetation and more monotonous in landscape than the Heikinjärvenneva. Large areas in the Salmineva are low-sedge fens with the lawn surface often dominated by *Sphagnum papillosum*. *Sphagnum fuscum* hummocks are common and in some areas also ombrotrophic *Sphagnum*-lawns and flarks occur. In the centre, some wetter areas with mud-bottom flarks are found. The Salmineva is a classic locality to mire ecology, as it was one of the model sites in the development of the Finnish mire site types by A.K. Cajander (1913).



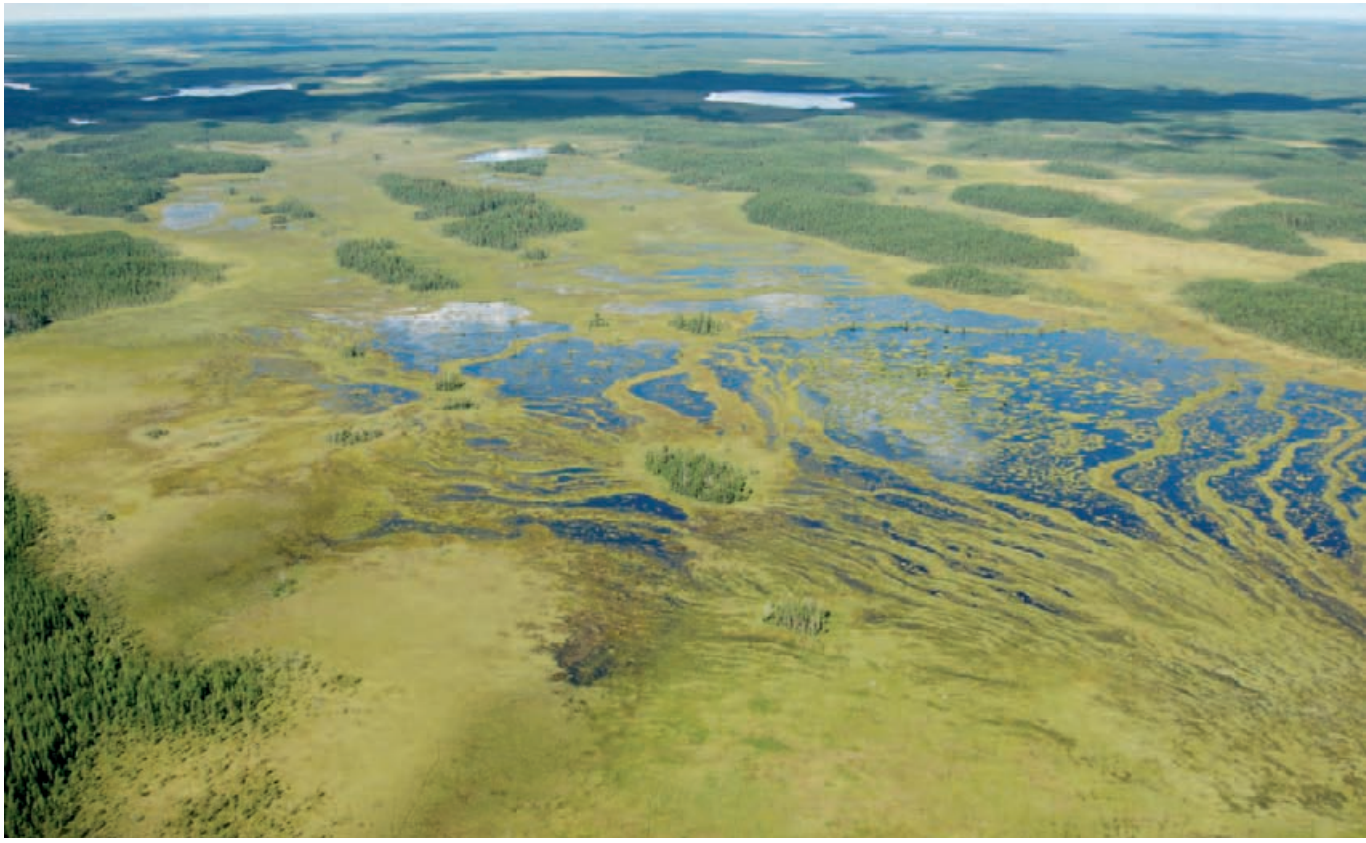
False-colour infrared aerial photograph of Salmineva mire in Salamajärvi national park. The red line shows the boundary of Natura 2000 area. Salmineva was A.K. Cajander's model area for an aapamire. © National Board of Survey, permission no. 7/MYY/06.

Forests

There are some remarkable old-growth forests in the Salamajärvi National Park and especially in the Salamanperä Strict Nature Reserve**.** One impressive old-growth forest of the national park is located in the Koirajoki forest area in the northern part of the park. It has been protected since the beginning of the 1900s by decision of Metsähallitus. Most of the forests in the area have been in commercial use before the National Park was established, however.

Bird fauna

Heikinjärvenneva is the most remarkable of the mires in the National Park as a bird area (Salminen 1980). On the edge of the mire there is an observation tower, where the many wader species can be observed. The commonest are the Common Snipe (*Gallinago gallinago*), the Wood Sandpiper (*Tringa glareola*), the Ruff (*Philomachus pugnax*), the Common Greenshank (*Tringa nebularia*) and the Jack Snipe (*Lymnocryptes minima*). Many duck and gull species nest in the puddles of the fen. Also the Crane (*Grus grus*), the Bean Goose (*Anser fabalis*) and the Whooper Swan (*Cygnus cygnus*) live in the mires of the National Park. The most abundant bird species living in the forests are the Chaffinch (*Fringilla coelebs*), the Willow Warbler (*Phylloscopus trochilus*), the Spotted Flycatcher (*Muscicapa striata*), the Brambling (*Fringilla montifringilla*) and the Rustic Bunting *(Emberiza rustica).*



An oblique aerial view over Heikinjärvenneva mire towards the northeast. In the centre there is a well developed string-flark pattern. On the background a mosaic of forests and mires. Photo Hannu Vallas.

Mammals

The Wild Forest Reindeer (*Rangifer tarandus fennicus*) has been reintroduced in the area. It was extinct in Finland for decades in the beginning of the 1900s. In 1979, two males and eight females were transferred from Kuhmo, eastern Finland, and since then the population of the Wild Forest Reindeer has increased in the Suomenselkä area to over 1000 individuals. Also the Wolverine (*Gulo gulo*) is reintroduced to the park. Wolverines were transferred to Salamajärvi from Lapland in the 1990s. Wolves (*Canis lupus*) wander into the area occasionally. The Moose (*Alces alces*) is numerous and, of course, the Bear (*Ursus arctos*) and the Lynx (*Lynx lynx*) belong to the large mammals of the National Park.

Hydrology

The special values of the Heikinjärvenneva are connected with its peculiar hydrology. The central part of the mire gathers water from a wide drainage area and it is richly flooded following the snow melt. Its catchment lies mostly in the southwest and there is a water divide in the wet centre of the mire. The wet mud-bottom flarks in the centre are very wide, the largest of them alone covers almost 30 ha. The water-flow pattern is quite special for an aapa mire, as it is distinctly divergent. The surface water flow takes courses from the mire centre both to the southeast, to Lake Heikinjärvi, and to the north and northwest through several fen stripes that slope down to the Ukonkivenneva

A view over Heikinjärvenneva mire. Sedge fen in the foreground, and flark fen behind the mineral soil islands. Photo Tapio Lindholm.

mire. The surface patterns are distinct and indicate the directions of water flow. Minerogenous water input from the drainage area is very important to the hydrology of the Heikinjärvenneva. Drainage or other disturbances in the drainage area, which is partly outside the national park could severely disturb the hydrology of the mire.

Restoration

Recently, restoration has been carried out in the forests and mires of Salamajärvi National Park. In 1985 a master plan for the National Park was established, and restoration of mires was carried out under an EU Life project in the 1990s by filling ditches and cutting trees. In the previously cultivated forests, where diversity is low, more space for deciduous trees have been made by clearing and burning over the woodland. The few drained mires of the National Park have been restored by cutting some of the trees and blocking the ditches, so that the mire vegetation could grow back. Altogether, 151 ha of mires have been restored.

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Clearing and burning mires to make them arable fields

Agriculture in the mires of the river valleys of western Finland

Raimo Heikkilä & Tapio Lindholm

The clearing of mires along the rivers of western Finland for agriculture started in small scale already in the 14th century in Isokyrö, lower reaches of the river Kyrönjoki. Large scale agriculture started much later, in the end of 18th century along the rivers Kyrönjoki and Lapuanjoki, when ditching techniques had developed. In other river valleys the cultivation started a little later. By 1920s, all minerotrophic fens and swamps along the rivers were taken into agriculture, and a great deal of bogs also.

The river valleys were characterized by thousands of log barns for hay. A lot of them were left up to the 1970s, but after that most of them have been destroyed, and the scenery has turned to much more monotonous than earlier. Spring floods were regular in April-May up to the early 1980s. The last wide flood, covering altogether more than 10 000 hectares of fields, was in 1984. Construction of reservoirs and embankments for the regulation of the discharge has since then prevented floods. As a consequence, need for fertilization has increased, but on the other hand, it is nowadays possible to grow also wheat, sown in the autumn, in the river valleys.

Topographic map of the cultivated Lapuanjoki river valley. The fields marked with yellow colour have originally been mires, mostly fens. In the east there are some remnants of bogs left, drained for forestry. The squares in the map cover 1 km^2.

The clearing of fens for cultivation was done simply by drying them. First a few large ditches were made with state support, and then the landowners drained their areas by digging smaller ditches. All the work was done with shovels, before the time of excavators. The riverside fens were regularly flooded in spring, and sometimes in other times of the year also. Therefore they were originally used only for haymaking. Only in the 1900s started the cultivation of barley and oats sown in May after the spring flood. The floods brought to the fields sediments, which fertilized them. Therefore the crops were good.

A view over the cultivated floodplain fens in Ilmajoki along the river Kyrönjoki in November 1976. There were still numerous barns for hay left. Photo Raimo Heikkilä.

The cultivation of bogs was more complex and labourious. After ditching the surface had to dry up a couple of years, after which the surface peat was burnt. Typically also clay was mixed with the peat to improve the soil quality for cultivation. When the crops started to decrease after a few years, the ditches were made deeper, and the surface was burnt over and over again. Finally, in many cases the whole peat layer was burnt, and the clay subsoil was revealed. In the river valleys, the clays were deposited in the Litorina Sea with much higher salinity than in the present Baltic. Therefore the sedimentation process resulted in a high sulphide content in the clay. Therefore the clays are acid. They also contain salts, and up to the 1930s there were in places along the rivers Kyrönjoki and Lapuanjoki vegetationless salt patches in the fields. The cultivation of the acidic clay plains has also been harmful for the water quality of the rivers. The first mass death of fish due to acidity was recorded in the river Kyrönjoki already in 1834.

There is only little knowledge about what kind of mires there were on the riversides. Especially the fens are poorly known. Lindberg (1905) described the last remnants of the fens in Ilmajoki in the middle reaches of the river Kyrönjoki. He mentioned only a few characteristic species like *Carex diandra* and *Sphagnum teres*. Thus it is evident

High spring flood in Ilmajoki in May 1977. Numerous farmhouses were isolated by the flood for a couple of weeks in the springs of exceptionally high floods. Photo Raimo Heikkilä.

that the fens largely were rather rich when compared with the present pristine mires in the region. Probably most of the fens were moderately poor or intermediate. It is evident that there also were rich fens, most probably rich birch fens. The records of *Saxifraga hirculus* in Tervaneva mire near the river Kyrönjoki in Isokyrö in 1945 as well as recent relict populations of *Carex diandra* and *Stellaria crassifolia* in some clay pits and river bank springs give indication about that. In the plain along the river Kyrönjoki there is still in large areas more than one metre of Bryales-*Carex* peat left, which also indicates that there have been more or less rich fens.

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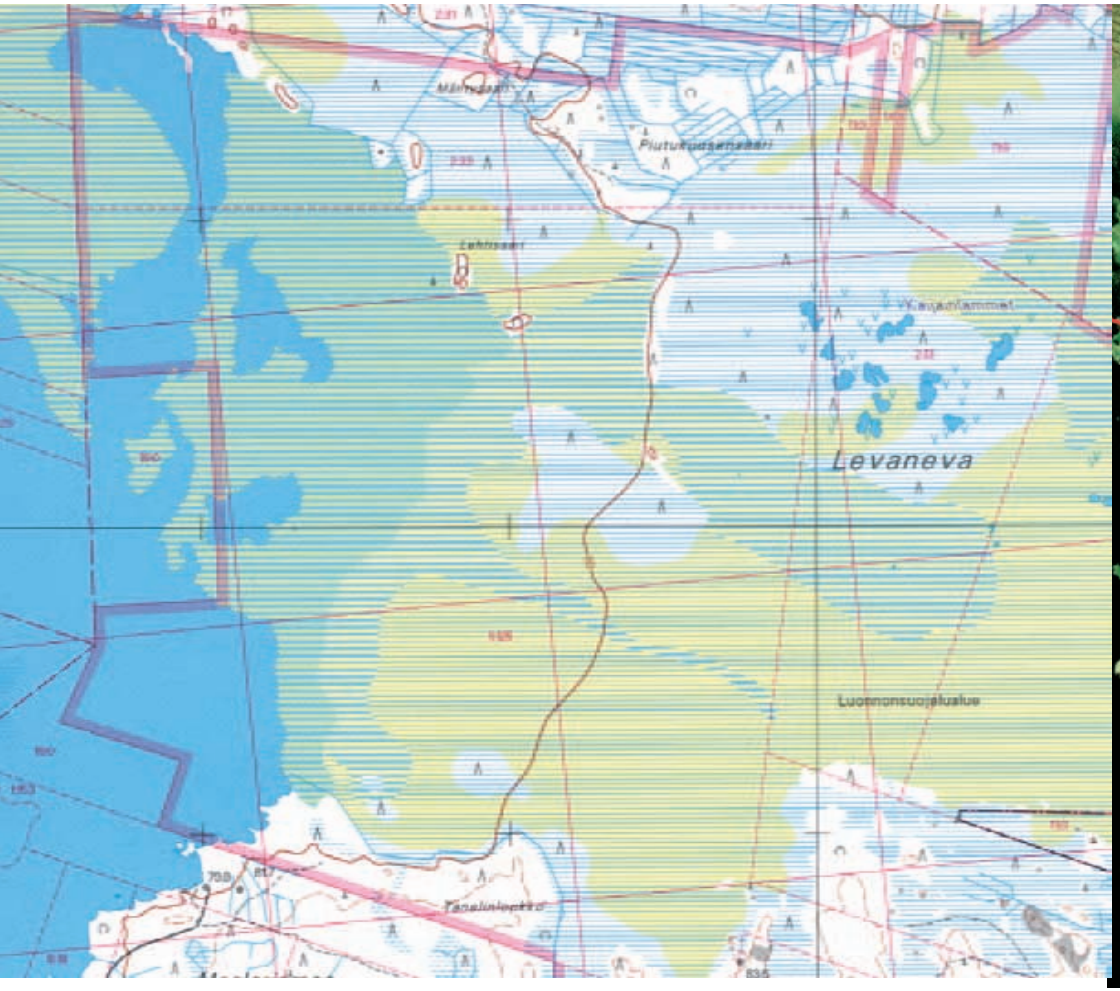
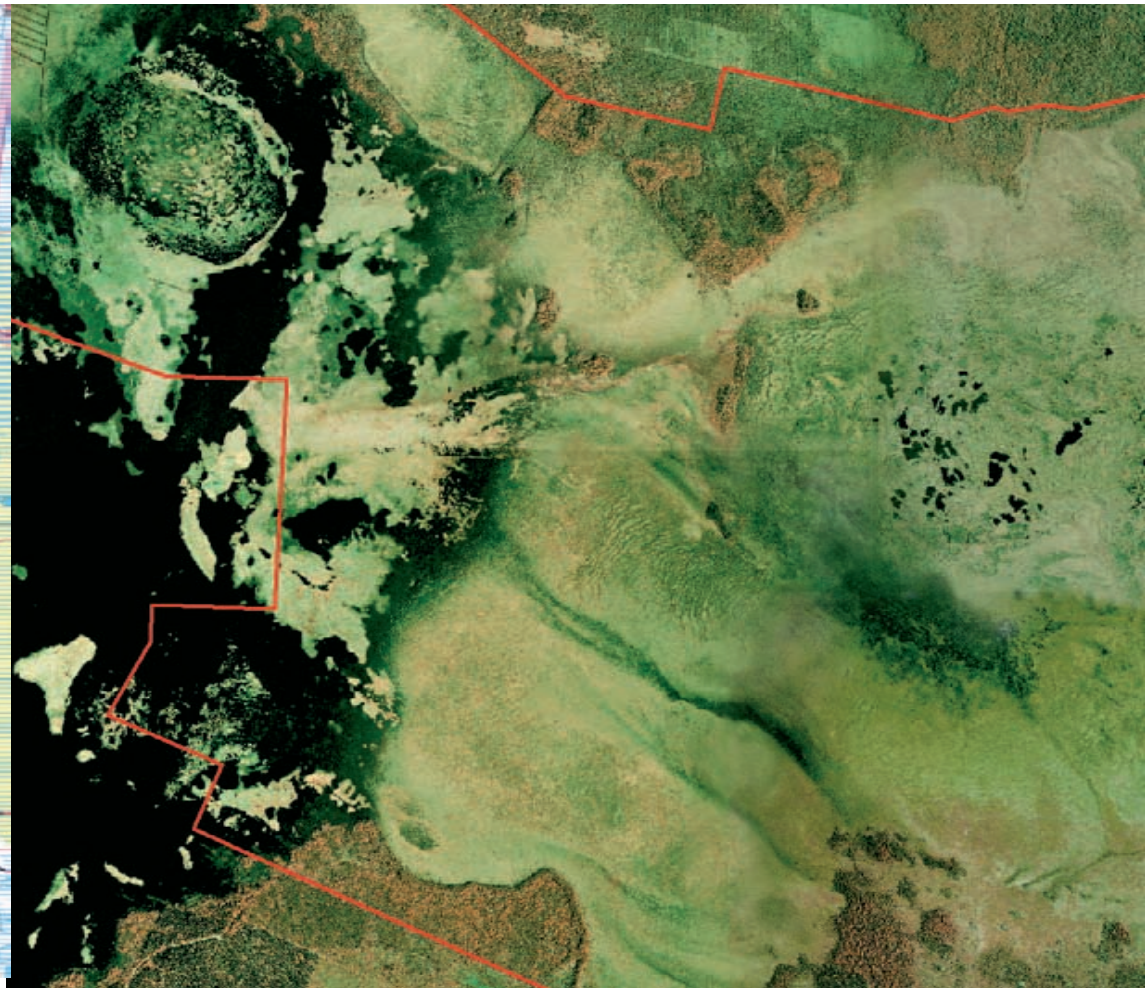


Topographic map of the the western part of Levaneva mire and Kivilampi-Levalampi reservoir. Each grid square is 1 km^2.



False-colour infrared aerial photograph of the western part of Levaneva mire and Kivilampi-Levalampi reservoir. The red line shows the boundary of Natura 2000 area.

Three mire reserves in western Finland

Levaneva mire reserve

Raimo Heikkilä

Mire system and massifs

Levaneva mire system consists of three large mires, Levaneva, Vähä Levaneva (Small Levaneva) and Kuuttoneva. Vähä Levaneva, covering some 400 hectares, is a typical example of a northern concentric bog. In the centre there are numerous small bog pools, and the hummock ridges and hollows have a clear pattern.

Levaneva is a very large (about 1200 hectares) bog system, which consists of *Sphagnum fuscum* bogs, eccentric bogs and a very large patterned central bog. It is not a typical concentric bog, but the structure resembles more a plateau bog. There are not yet enough data of the grossforms of the bog to make a final conclusion. In the western part of Levaneva there is an aapamire, which has been partly drowned in Levalampi water reservoir. Within the aapamire there has been two concentric bogs, which have been totally drowned.

Kuuttoneva is a large (about 1000 hectares) aapamire, but in the centre there is also a concentric bog. It is a massif above a massif, the bottom of the bog pools is formed of *Carex* peat, and in the margins of the pools there grow plant species which demand minerotrophic conditions. In the southern part of Kuuttoneva mire there are also *Sphagnum fuscum* bogs, eccentric bogs and a concentric bog.

In the patterned bogs, the hummock ridges and hollows have sharp margins, and hummocks rise up to 50 cm from the hollows. In eccentric bogs the patterns are not so distinct, and the height difference of hollow and hummock surfaces does not exceed 30 cm. Bog pools can be found only in the largest concentric bogs in Vähä Levaneva and Kuuttoneva, as well as the plateau bog of Levaneva. Altogether there are almost 100 pools. In the central parts of these bogs there are in addition numerous mud bottom hollows. In the margins of these bogs and in eccentric bogs as well as small concentric bogs *Sphagnum* hollows dominate. In the central parts of the aapamire in Kuuttoneva there is a string-flark pattern, but the strings rise only about 10 cm above the flarks. The aapamire is very wet and difficult to cross.

Vegetation and flora

In the hummocks of bogs, the dominating site type is *Calluna - Sphagnum fuscum* pine bog. In some places also *Empetrum nigrum* ssp. *nigrum* is abundant in the field layer. In the hollows *Sphagnum balticum, S. majus, S. jensenii, S. lindbergii* and *S. cuspidatum* dominate. *S. balticum* is dominant in the driest hollows, and the other species dominate in more wet sites. In the margins of hollows *S. papillosum* is typical. In the sparse field layer of hollow vegetation there grow *Carex limosa, Scheuchzeria palustris, Rhynchospora alba, Drosera longifolia* and in the margins *Carex pauciflora*.

An oblique aerial view over Levaneva mire area towards the northwest. In the foreground the concentric bog of Vähä Levaneva mire, and behind the forest strip the western part of Levaneva mire. The reservoir is in the left margin, and the bog centre on the right. Between them, to the west of the small forest islets there is a fen area. Furthest on the left there is a concentric bog, drowned in the reservoir, the water table of which was unusually low when the photo was taken. Photo Hannu Vallas.

In the central parts of the aapamire in Kuuttoneva, poor flark fens and poor sedge fens dominate. In the flarks there is sparse vegetation with *Carex limosa, C. chordorrhiza, Menyanthes trifoliata* and *Utricularia intermedia*. The sparse ground layer is dominated by *Sphagnum majus* and *S. jensenii*. In the margins of flarks and on the low strings there are wide *Sphagnum pulchrum* surfaces, which is not a very common feature. In the northern part of Kuuttoneva mire there is also a wide intermediate fen, through which a large amount of water flows, forming finally a stream in the northernmost tip of the mire. There grow e.g. *Dactylorhiza incarnata* ssp. *incarnata, Molinia caerulea, Peucedanum palustre, Rhamnus frangula, Salix lapponum, S. myrtilloides, Sphagnum inundatum, S. platyphyllum* and *S. subsecundum*. In the southwestern part of Kuuttoneva there is another intermediate fen with e.g. *Hammarbya paludosa*.

In the marginal parts of the mire system there are mainly poor fens and sedge swamps as well as *Ledum* pine bogs. Between Kuuttoneva and Levaneva mires there are also intermediate sedge swamps. There the dominating tree species is *Alnus glutinosa* together with *Salix pentandra*, and in the field layer *Carex vesicaria, C. acuta, Lysimachia thyrsiflora, Potentilla palustris* and *Rubus saxatilis* are abundant. The

ground layer is dominated by *Sphagnum centrale* and *S. fimbriatum*. Around mineral soil islands there are numerous small patches of spruce mires with e.g. *Angelica sylvestris*, *Calla palustris*, *Carex vesicaria*, *C. acuta*, *Pyrola minor*, *Rubus arcticus*, *Salix cinerea*, *S. myrsinifolia*, *S. pentandra*, *Calliergon cordifolium*, *Plagiomnium ellipticum*, *Polytrichum swartzii*, *Rhizomnium punctatum*, *Sphagnum centrale* and *S. squarrosum*.

In the western part of Levaneva mire just under the marginal slope of the large bog there is an intermediate rich spruce mire with a lot of ferns and grasses. There grow e.g. *Carex diandra*, *Corallorhiza trifida*, *Athyrium filix-femina*, *Paris quadrifolia*, *Salix pentandra*, *S. repens*, *Calliergon cordifolium*, *Helodium blandowii*, *Pseudobryum cinclidioides* and *Sphagnum teres*. Between the spruce mire and Levalampi reservoir there is an intermediate sedge fen with an interesting flora, e.g. *Carex diandra*, *C. livida*, *Eriophorum gracile*, *Cicuta virosa*, *Sphagnum obtusum*, *Helodium blandowii*, *Pseudobryum cinclidioides* and *Calliergon richardsonii*. A rare mushroom *Sclerotinia caricis-ampullaceae* also grows there as well as in the intermediate fen in Kuuttoneva mire.

In the easternmost margin of the mire reserve there is a very small rich spruce fen patch. Its flora contains e.g. *Bistorta vivipara*, *Potentilla erecta*, *Angelica sylvestris*, *Geranium sylvaticum*, *Valeriana sambucifolia*, *Viola riviniana*, *Paris quadrifolia*, *Melica nutans*, *Pyrola rotundifolia*, *Bryum pseudotriquetrum*, *Helodium blandowii*, *Sphagnum teres* and *S. warnstorfii*.

Altogether 129 vascular plant species and 57 species of mosses have been recorded in the area. The numbers are not high, but the species list covers most of the species of bogs and poor fens in western Finland.

Bird fauna

The bird fauna of Levaneva mire system is rich in species, and there are also several rare and threatened bird species. Also peregrine falcon was nesting in the mire, but it disappeared in the middle of 1970s. Waders and waterfowl are the most important groups in the bird fauna of Levaneva area. A breeding newcomer in the fauna is black-tailed godwit *(Limosa limosa)*, which is very rare in Finland. Red-throated diver *(Gavia stellata)*, Whooper swan *(Cygnus cygnus)* and Slavonian grebe *(Podiceps auritus)* also belong to the breeding fauna. The Levalampi reservoir has added suitable sites for waterfowl, even though it was destructive for the western part of the mire system. Altogether there are 22 bird species belonging to the Annex I of the European Union Bird Directive, breeding in the Natura 2000 area. There are also threatened bird species.

Development history of the mire system

Levaneva mire system is located 50 km from the Gulf of Bothnia, 80 metres above the sea level. The bedrock is formed of acidic granodiorite, mica schist and migmatite, and the Quaternary deposits under the peat and around the mire are gently sloping moraines. The area rose up from the Litorina Sea about 7000 years BP. The peat layers are not very thick, the mean peat depth is 2,7 metres. The deepest peat depth is 5,5 metres. In Levaneva mire, 90 % of the peat is *Sphagnum* dominated and 10 % *Carex* dominated. In Kuuttoneva there is 78 % *Sphagnum* dominated and 22 % *Carex* dominated peat (Toivonen 1997).

The centre of Kuuttoneva mire in January 1976. In the foreground a pair of traditional mire skis, which hunters used to cross wet mires. In the centre of the mire there was a small hut of hunters. Photo Raimo Heikkilä.

Land use history and state of nature

Levaneva area was in earlier centuries known as an area for hunting. The first inhabitants came in the area around 1830, when altogether four small farms were established inside the present Natura 2000 area. The farms had small fields around the houses, just a few hectares. In addition to agriculture, also tar extraction and charcoal production from pine wood was a source for income. Särkinen household between Kuuttoneva and Vähä Levaneva mires was abandoned in 1955. One can still find the basements of two houses, which were built side by side, and the fields are partly still open meadows. The Kivilampi farm was abandoned in 1964 due to the construction of the reservoir. Maalari farm was abandoned earlier, and the remnants cannot be seen any more. In general, the influence of old-time land use is minimal in the area.

A reservoir was built in the western part of Levaneva mire system in 1964, covering originally 365 hectares. The main purpose was to protect arable fields along the river Närpiönjoki from floods. The water table was raised by 3 metres in 1976 to regulate the discharge for the needs of a pulp mill built in the river mouth. The area of the reservoir grew to 922 hectares, and it drowned the small lakes Kivilampi and Levalampi as well as two concentric bogs and a wide aapamire with intermediate fens.

Modern forestry came in the area in 1960s, when the first clearcuts were made in the forests surrounding the mire area. Due to the lack of roads in the area, loggings came later than in general in the region. In the 1970s and 1980s most of the forests in the area were logged. Winter roads of snow and ice were constructed in the mires for timber transport. In the 1970s marginal parts of the mire area were drained especially in the northern and southwestern margins of the area. The large Havinneva mire to the east of the Natura 2000 area was totally drained in 1977. It was a big damage for the biodiversity of the area, because there were large areas of intermediate fens and some rich fens also.

An intermediate sedge fen in the western part of Levaneva mire. *Vaccinium oxycoccos* in bloom in the foreground. *Salix lapponum* indicates surface water influence. Photo Raimo Heikkilä.

Conservation

The first proposals for the conservation of Levaneva area were made by the provincial administration in 1973, when a regional mire conservation plan was compiled, and in 1977, when the National Park Committee proposed the mire system to be protected. Levaneva mire area was included in the National Mire Protection Programme in 1981, and in the 1990s it was included in Natura 2000 programme, covering altogether 3343 hectares. The area was privately owned, and there were about 100 land owners. At the moment, almost all the territory has been acquisited to the state, and it has been established as a nature reserve. At the moment, a hiking route is being built, with wooden boardwalks, to make it easy to see the real mire wilderness. For the protection of the birds, it is forbidden to step outside of the marked path during the breeding season of birds between 15th February and 30th June. Hunting is nowadays forbidden in the area, excluding elk hunting in late autumn.

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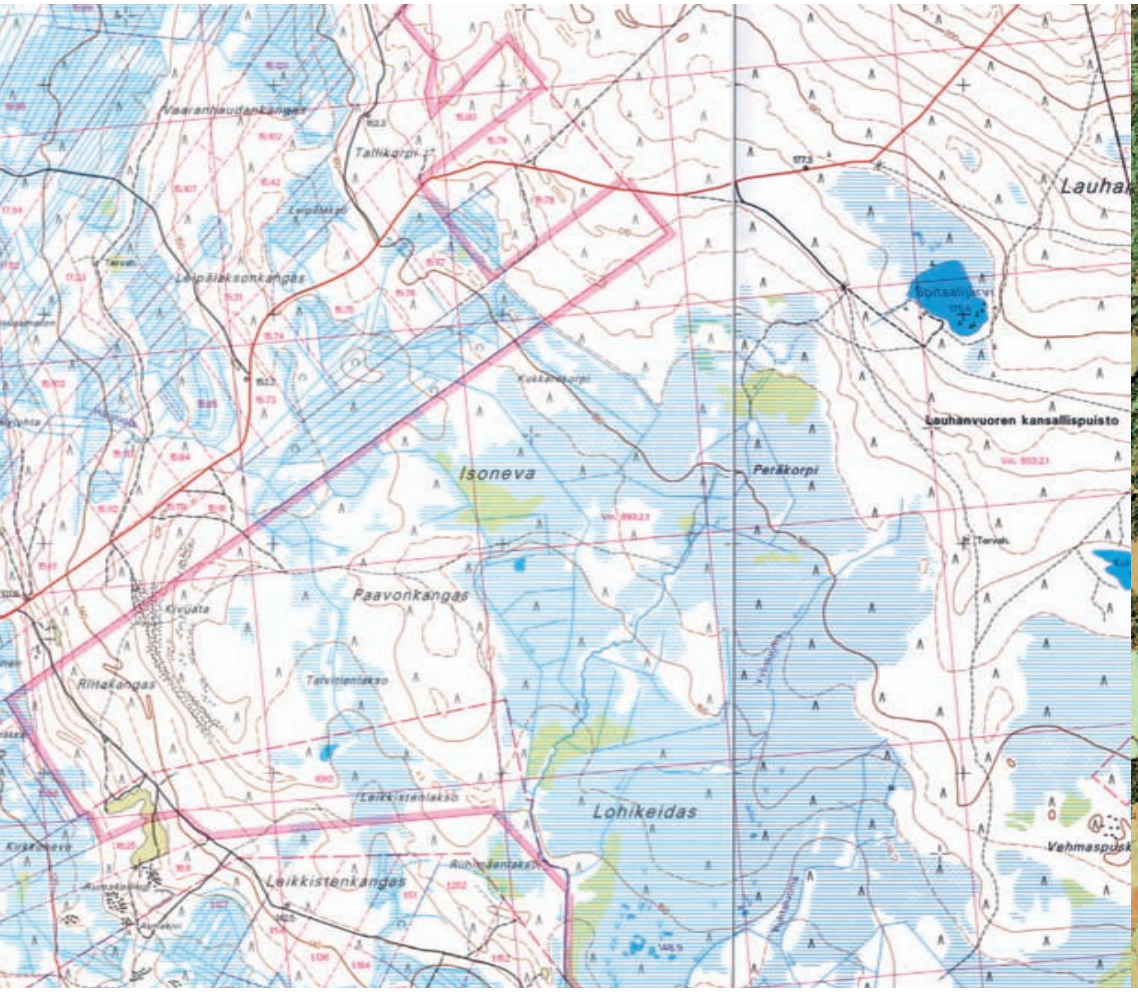

Topographic map of the the southwestern part of Lauhanvuori National Park. Each grid square is 1 km^2.

False-colour infrared aerial photograph of the southwestern part of Lauhanvuori National Park.

Lauhanvuori national park

Raimo Heikkilä

Introduction

Lauhanvuori hill is the highest point of the western Finnish lowland, rising up to 231 m above the sea level. It is about 100 metres higher than the valleys of the rivers Kauhajoki in the east and Isojoki in the southwest, but the slopes are very gentle. The Cambrian 600 million years old sandstone bedrock of Lauhanvuori is unique in the region where Archaean granites and gneisses dominate. The sandstone formation covers about 60 km^2, and its thickness above porphyritic granite is not more than 50 metres. Sand and gravel are the dominating quaternary deposits of the hill. In the sandy soils a large amount of ground water is formed, and below the slopes there are numerous springs.

In the end of the Ice Age, the ice sheet melted in Lauhanvuori area 9300 years ago. Lauhanvuori was then a small island in the Ancylus Lake stage of the Baltic Sea. The highest shoreline is at present 203 metres a.s.l. The land uplift was quick during the first 1000 years after the Ice Age, and within 700 years the whole Lauhanvuori emerged from water. Due to the land uplift, numerous beach ridges and stone belts were formed on the slopes. Especially on the western slope there are also numerous sand dunes, which were formed immediately after the Ice Age, and then very quickly bound on their sites by the developing vegetation (Palomäki 1991, Salomaa 1982).

The forests in Lauhanvuori are predominantly pine-dominated dry heath forests with a sparse field layer dominated by *Calluna vulgaris*, and a lichen dominated ground layer. Only on the hilltop above the highest shoreline there is mixed forest with pine *(Pinus sylvestris)*, spruce *(Picea abies)* and birch *(Betula pendula)*. In the field layer *Vaccinium myrtillus* forms dense stands, and the ground layer is dominated by bryophytes *(Pleurozium schreberi, Hylocomium splendens, Ptilium crista-castrensis and Dicranum* spp.*)*. Similar forest vegetation can be found in small areas also lower on the slopes in mire margins where ground water comes to the surface.

Land use history

Lauhanvuori area was long time, up to 1600s, a wilderness, which was an important hunting area for people from Satakunta province. Later, when villages were established in the surroundings, the local inhabitants used the area for hunting. The top of Lauhanvuori hill, where the soil was good, and the high altitude kept night frosts away, was used for potato growing from the beginning of 1800s up to 1930s (Laine 2000). The sandstone of Lauhanvuori was used for making millstones in the 1800s, but this industry ended in 1905.

The lower slopes have been used in slash and burn cultivation occasionally, but due to the poor soil it was not extensive. The pine forests were intensively used for tar extraction from the 1700s to the 1880s. In the middle of the 19th century, 50% of the income in the region was obtained from tar extraction (Laine 2000).

Timber logging was intensive in Lauhanvuori area from 1850s. Sowing of pine seeds in logging areas was started already in 1870s. Forest fires were common, and a big problem in forestry was to start regeneration of tree stands in the burnt areas. For example in 1925 there was a forest fire of 225 hectares in the northern part of the present national park. The western part of Lauhanvuori was private land, while the

An oblique aerial view towards the north over Peräkorpi mire on the southwestern slope of Lauhanvuori hill. A wooden boardwalk crosses a groundwater-influenced fen. In the background small ponds, which dry completely during dry periods. They can be regarded as 'aro' wetlands. Photo Hannu Vallas.

eastern part was state forest. The state bought also the western part in 1936. Loggings continued in most of the area up to 1970s, and ended completely, when the national park was established in 1982 (Laine 2000).

The mires were used as pastures up to the 1930s. Inhabitants of nearby villages brought their cattle and sheep to graze in minerotrophic mires. In the 1800s there were tens of mire meadows, which were used for haymaking, up to early 1900s (Laine 2000).

Forestry drainage of mires started on state land in 1917, but most mires were regarded as too poor for timber growth. In the private land in the western part of the area large-scale drainage was made in the 1920s using a steam engine excavator. Wider ditchings were made in the 1970s, especially in private land. In state land mire drainage did not cover large areas.

Lauhanvuori was known as a popular site for excursions from approximately the year 1900. There was also popular midsummer celebrations on the hilltop. Hikers found Lauhanvuori in the 1950s, and nowadays there are about 25 000 visitors annually. There is now an observation tower on the hilltop as well as nature trails and places for rest.

A large groundwater spring with clear water in Peräkorpi mire. The large fern is *Athyrium filix-femina*. The discharge from the spring is over 1000 m^3 per day. Photo Raimo Heikkilä.

Mires of Lauhanvuori

In the gentle lower slopes of Lauhanvuori hill the degree of paludification is high. The largest mires are Kärkikeidas, Likolammit and Majaletto on the northern slope, Isoneva and Lohikeidas on the SW slope and Siioninkeidas on the southern slope. In addition, there are numerous small depressions with mires.

In Likolammit, Majaletto and Kärkikeidas there are concentric raised bogs. Especially in Likolammit there are large bog pools. In addition, there are mud-bottom hollows and *Sphagnum* hollows. The hummock ridges rise almost one metre higher than the hollows. A specialty in Kärkikeidas mire is the growth of *Sphagnum pulchrum* in the hollows. On the southern and southwestern slopes of Lauhanvuori hill there are large eccentric bogs. There are also small aapamires in Kärkikeidas, Majaletto and Siioninkeidas mires.

Due to the thick sand layer on the hill, large amounts of ground water is formed. There are numerous springs and seepage areas, especially in the margins of mires. In the spring-fed areas there is a rich vascular plant and bryophyte flora. In the springs there is an interesting highly specialized benthic invertebrate fauna. In connection with springs and along small streams flowing from the springs there are intermediate rich spruce mires with large ferns.

An 'aro' wetland (Laitinen & al. 2005) on the southeastern slope of Lauhanvuori hill. Typical plants in these sites in Lauhanvuori area are *Juncus filiformis*, *Carex lasiocarpa* and *Polytrichum commune*. In some places also *Carex panicea* and *Rhynchospora fusca* can be found. Photo Raimo Heikkilä.

Due to the high permeability of the soils there are numerous seasonally wet depressions, which dry out in the summertime. Laitinen & al. (2005) have described this kind of vegetation in northern Ostrobothnia using a term 'aro' wetland according to the local people's dialect. In Lauhanvuori region these depressions are locally called as 'lakso'. Typical plants in these sites in Lauhanvuori area are *Juncus filiformis, Carex lasiocarpa, Molinia caerulea* and *Polytrichum commune*. In some places also *Carex panicea* and *Rhynchospora fusca* can be found. The moss layer is always sparse, and the peat layer typically only a few centimetres.

Mire sites are mostly poor in Lauhanvuori area. Most typical are bogs with sparse pine stands and open poor fens. In spring-fed areas e.g. in Kärkikeidas mire to the north of the hilltop there are also small rich fens with e.g. *Tomentypnum nitens*.

Development of mires

The formation of mires started in the lower parts of the hillslopes almost 9000 years ago. Originally the mires were minerotrophic, but some 5000 years ago they started to develop into bogs. At present, Lauhanvuori belongs to the zone of concentric bogs (Raikamo & Kokko 1982).

Flora

Even though the forests and mires in Lauhanvuori national park mostly represent poor site types, due to groundwater influence there is a rather rich flora. Altogether almost 300 species of vascular plants have been found in the area, of which about 200 are indigenous species (Suominen & Varkki 1984). The most remarkable species are

the northern *Tofieldia pusilla*, and the southern *Carex paniculata* and *Diphasiastrum complanatum* ssp. *chamaecyparissus*.

In some springs and spring-fed mires there grow a number of rare plants like *Carex paniculata, Epipogium aphyllum, Chrysosplenium alternifolium,* and a strange kind of *Dactylorhiza,* the vegetative parts of which resemble *D. fuchsii,* but flowers are different. In some places also *Hammarbya paludosa, Juncus stygius, Carex panicea, C. livida, Lycopodiella inundata* and *Dactylorhiza incarnata* have been found. Among the bryophytes, *Sphagnum molle*, which is vulnerable in Finland, is characteristic of the thin-peated seepage mires of Lauhanvuori. *Plagiomnium undulatum* and *Trichocolea tomentella* have their most northern localities in western Finland along a spring stream under the western slope of the hill (Helin & Leivo 2000).

Conservation history and status of Lauhanvuori

Lauhanvuori area was proposed to be protected as a national park by provincial authorities in 1973 and by the national park committee in 1977. The state-owned core area was established as a national park in 1982, covering 2450 hectares. Private lands have been acquisited to form extensions, and the present Natura 2000 area in Lauhanvuori covers 4992 hectares, 73 % of which is protected at the moment.

Rhynchospora fusca in an 'aro' wetland in the northern margin of Peräkorpi mire. Photo Raimo Heikkilä.

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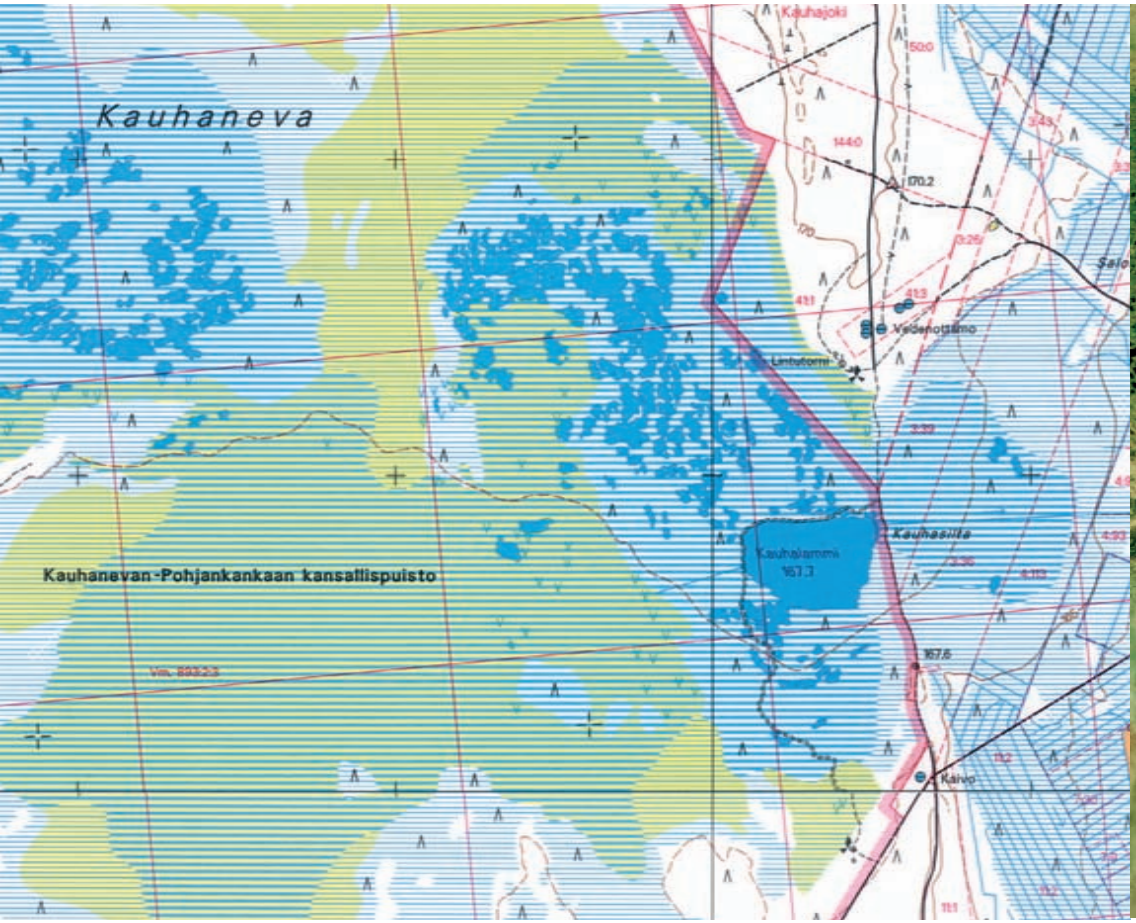
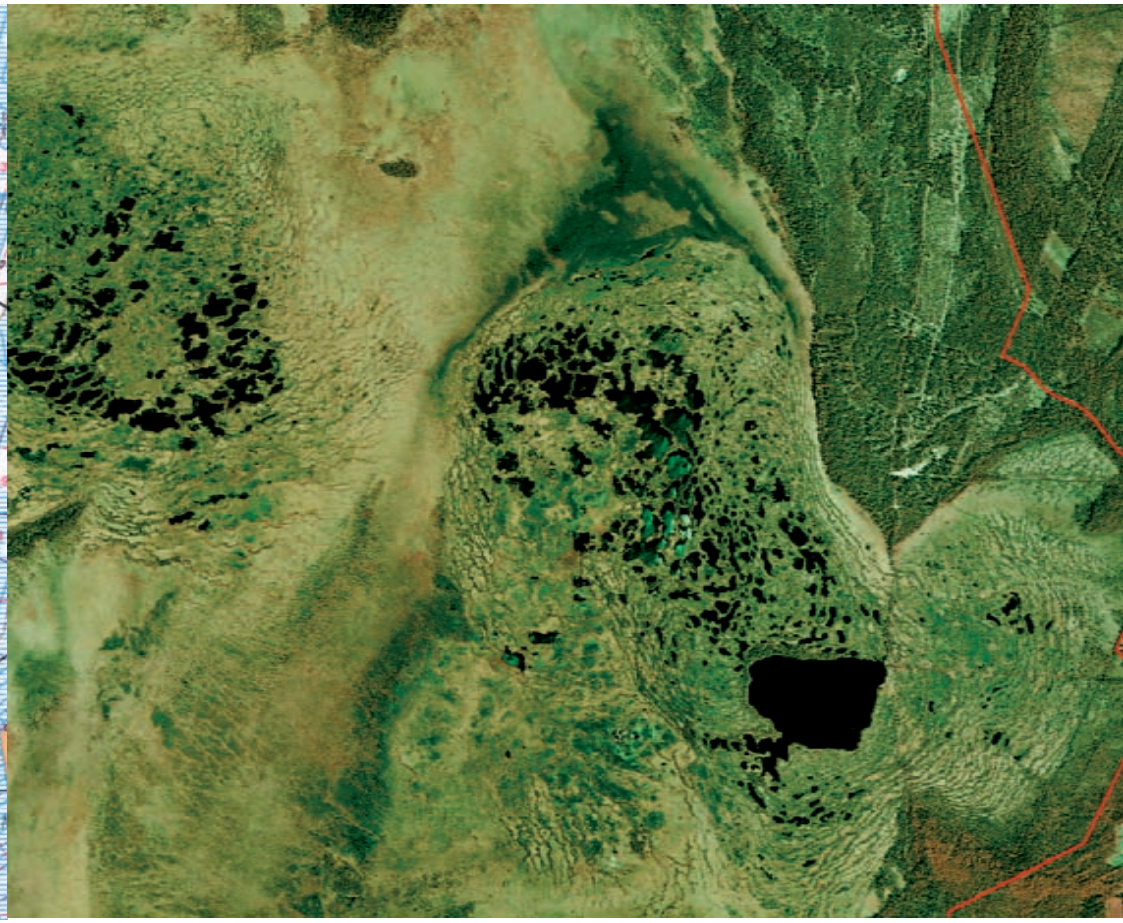


Topographic map of the the northeastern part of Kauhaneva mire. Each grid square is 1 km2.



False-colour infrared aerial photograph of the northeastern part of Kauhaneva mire.

Kauhaneva-Pohjankangas National Park

Raimo Heikkilä

Introduction

Kauhaneva-Pohjankangas national park consists of several large mire massifs and parts of the chain of Pohjankangas esker. Kauhaneva mire system forms the core area of Kauhaneva-Pohjankangas national park.

Kauhaneva is situated in the middle boreal forest zone, and its mires belong to the concentric bog zone, in the subzone of Western Finland (Ruuhijärvi 1988). Mire complexes in the area are usually concentric bogs. Aapamires are not very common and they are mostly unpatterned poor fens.

Kauhaneva is one of the largest and most representative examples of raised bogs in Southern Ostrobothnia and thus one of the key areas for protecting ombrotrophic bogs (Aapala & Lindholm 1995). It has also international value, as it is both a Ramsar (Finnish Environment Institute 1996) and Natura 2000 site (Ympäristöministeriö 1996).

Kauhaneva-Pohjankangas was included in the national park programme (Tallgren & al. 1976) and it was established in 1982. The total area of the present national park is 3 264 ha. Most of this area is mires (2 878 ha), of which Kauhaneva mire system covers approximately 87% (2 506 ha). With extensions for the national park, the Natura 2000 area covers 6 865 ha. The extensions consist of areas included in the National Mire Protection Programme (Maa- ja metsätalousministeriö 1981), areas bought to the state for conservation purposes, and extension areas proposed by Heikkilä (1986) and western Finland Regional Environment Centre. Forestry drainage, agricultural use and peat mining in mires in the surroundings of Kauhaneva is very intensive. In the drainage basin of the river Kyrönjoki only 8% of the original mire area is in natural state (Heikkilä 1999).

The bedrock in the Kauhaneva-Pohjankangas national park is poor. It belongs to an extensive area of archaean rocks of Middle-Finland and it is formed of porphyric granite (Sederholm 1909). The bedrock is covered by a thick layer of loose quaternary deposits, gravel and sand in most parts of the park, mainly overlain by peat. Soils are very poor and on dry places dominated by pine forests (*Calluna*-type, *Cladina*-type, *Vaccinium*-type). These pine dominated forests and extensive concentric bogs are characteristic to the watershed area. Waters are mainly humic small ponds and brooks. Springs and places with groundwater influence with more rich vegetation types (spruce mires and rich fens) are rather common near the Pohjankangas esker.

Pohjankangas-Nummikangas esker lines the national park and its mires in the east. The esker has developed during the last ice age between two lobes of ice sheet. Several beach ridges and dunes can be found beside the esker. The landforms have developed during the deglaciation, which occurred ca. 9400 years B.P. (Salomaa 1982). After a short period, the Ancylus Lake retreated due to the land uplift, and Kauhaneva area was above the water level ca. 9000 years B.P. (Salomaa 1982). These dates are not calibrated, and probably the deglaciation and retreat of Ancylus Lake occurred ca. 1000 years earlier.

Hydrological patterns of the mire

The main slope in Kauhaneva is from north to south and southwest. The total altitude difference in the mire system is approximately 15 m (from 175 m a.s.l. in the north to 160 m a.s.l. in the south, distance being 7 km). From the northeastern part of the mire complex most of the surface waters flow to the south between the two easternmost concentric bogs. Part of the waters from the easternmost concentric bog flow to the river Kauhaluoma in the east. Most of the surface waters from the southern part of the mire complex flow to the river Aunesluoma.

Pitkäviita forest functions as a water-divide in the northern part of the mire. To the west of Pitkäviita, surface waters flow towards northwest to brook Katikanluoma. There is some groundwater seeping into the mire from the esker in northeastern soligenous part of the mire system, and flowing between the two eastern concentric bogs, since the track between the two bogs has remained minerotrophic. Some groundwater inflow, in a form of small springs, has been detected in few places in the middle of the mire between the two large concentric bogs. Runoff from surrounding mineral soils is reflected in the occurence of minerotrophic mires at the edges of the complex.

In the eastern part of the mire, there is a flowless primary lake, Kauhalampi. The lake, however, has typical characteristics of a pool in an ombrotrophic bog. Probably deposition of peat on the bottom of the lake prevents contact to the mineral soil and minerogenic waters.

Site types and their relation to mire massifs

Altogether 45 site types according to the Finnish mire site classification have been indentified in Kauhaneva mire system.

The general structure of the three concentric bogs in Kauhaneva is typical for the region; broad, irregularly shaped pools on the flat domes, narrow, linear hummocks and hollows on steeper slopes surrounding the central plateau and poorly developed minerotrophic lagg (Eurola 1962, Aartolahti 1965). There are differences in the extent and distribution of site types between these three bogs. The bog complexes get smaller and drier towards west. The centre of the eastern bog is covered with *Fuscum* hollow bog with open water pools or mud bottom and *Sphagnum* hollows. Towards west the open water pools and mud bottom hollows are replaced with drier site types, e.g. short-sedge bogs.

The site type variation at the eccentric bogs of Kauhaneva is not very diverse. The most clearly eccentric part is always *Sphagnum* hollow bog with *S. balticum* dominating at the hollows in most of the cases, and *Calluna-Fuscum* bog at hummocks. The rest of the complex is covered by *Calluna-Fuscum* bog, paludified pine forest or short-sedge pine fen. Only in the northenmost eccentric bog, a minerotrophic lagg with different types of fens can be distinguished.

Aapamires in the southern part of Kauhaneva have not developed string-flark patterns but are instead rather uniform *S. papillosum* fens, which is a typical feature for the southern aapamires (Ruuhijärvi 1960, Eurola 1962). In the central part of the largest aapamire, a pattern of strings and flarks is clear. This is one of the southernmost sites in Finland, where a patterning can be distinguished in aapamires.

Distinguishing between minerotrophic aapamires and ombrotrophic bogs is not always easy. Especially in the northern parts of Kauhaneva, aapamires include also ombrotrophic sites. They seem to be in a transition into ombrotrophy.

An oblique aerial view towards the north over the eastern part of Kauhaneva mire. On the right there is the historical Kyrönkangas summer road from the middle ages. Kauhalampi pond in the centre, surrounded by a concentric bog with large bog pools and wet hollows. Photo Hannu Vallas

Minerotrophic mire sites

Spruce mires are very rare in the study area and they form clearly less than one percent of the whole mire area. Four different spruce mire types were found. Spring spruce mires are the most species rich habitats in the whole study area. Tree layer is dominated by spruce and shrub layer by *Alnus glutinosa, A. incana, Salix* species and *Betula pubescens*. In the field and ground layers grow several nutrient-demanding species, e.g. *Carex dioica, Pedicularis palustris, P. sceptrum-carolinum, Helodium blandowii, Rhizomnium punctatum* and *Warnstorfia exannulata*.

Pine mires are poor, sometimes partly ombrotrophic mires where pine *(Pinus sylvestris)* is the dominant tree species. Height of the pine trees is 6 - 10 m. Field layer is dominated by dwarf shrubs *(Ledum palustre, Vaccinium uliginosum, Chamaedaphne calyculata, Betula nana, Empetrum nigrum, Calluna vulgaris)*, or in some cases by *Carex globularis* or *Eriophorum vaginatum*. Different *Sphagnum* species *(Sphagnum angustifolium, S. capillifolium, S. fuscum, S. magellanicum, S. russowii)* with some forest mosses *(Dicranum polysetum, D. bergerii, Pleurozium schreberi, Polytrichum strictum)* and *Cladina* lichens are characteristic for the ground layer.

Pine mires are especially common at the margins of the studied mire area. Six different pine mire site types cover altogether 4% of the whole mire area. In most pine mires in the study area, tree cover is very sparse and *Sphagnum fuscum* hummocks are typical.

A sedge fen in Punttukeidas mire to the south of Kauhaneva mire. *Cares rostrata* and *C. lasiocarpa* dominate in the field layer, *Sphagnum fallax* in the ground layer. *Salix pentandra* grows in the centre. Photo Raimo Heikkilä.

Fens are common site types in Kauhaneva and they cover 30% of the total mire area. Twelve different site types were found. Extensive tall-sedge fens are typical in the aapa-mire between the large ombrotrophic bogs of the Kauhaneva mire system. They occur also in the laggs of the bogs. Most of the tall-sedge fens are *Sphagnum fallax* tall-sedge fens, but also *S. papillosum* tall-sedge fens and *S. papillosum* sedge fens with flarks are common. Somewhat more rare are tall sedge fens with *S. fuscum* hummocks or with surface water effect. Typical dominant tall sedges in these fens are *Carex lasiocarpa* and *C. rostrata*.

Another common group of fens are low-sedge fens of which the most common site types are low-sedge fens and *S. papillosum* low-sedge fens, typically dominated by *Carex pauciflora, C. limosa* and *Eriophorum vaginatum* in the field layer.

The third large group of fens are flark fens. The most common flark fen types are *Sphagnum* -flark fens. In addition, some patches of mud bottom flark fen and intermediate mud bottom flark fens occur.

There is only one, small, rich spring fen patch (0,1 ha) in the western part of Kauhaneva. Several demanding species grow in this spring fen, such as *Tomentypnum nitens*, *Carex diandra*, *Poa alpigena*, *Carex dioica* and *Pedicularis sceptrum-carolinum*.

A midsummer night view over the bog pools in Kauhaneva mire. Photo Raimo Heikkilä

Combination site types are formed as a combination of spruce/pine mire types at hummock level and of fen/rich fen mire types at intermediate–flark level. Most of the combination site types in Kauhaneva–Punttukeidas have pine mires in the hummock level and oligotrophic fen at the flark level. There are thirteen different combination site types covering 15% of the total mire area.

Ombrotrophic bogs

Ombrotrophic bogs include forested and open mires as well as their combination types. Height of the pine trees in ombrotrophic bogs is 3-5 m. Bogs are very common in Kauhaneva and they cover 50% of the whole mire area. Nine different ombrotrophic site types were found.

Sphagnum fuscum hollow bogs are the most common mire types in Kauhaneva. At the centres of the concentric bogs, flark level is dominated by hollows and pools, and at the margins and in the eccentric bogs by drier, short-sedge bogs.

S. fuscum bogs are also very common in Kauhaneva. They occur both in mire margins and center, but the most extensive *S. fuscum* bogs are in the center. Both *Calluna*- and *Empetrum-Fuscum* bogs can be found.

Short-sedge bogs are common and extensive mire type in the bog parts of Kauhaneva area. Most of the short-sedge bogs have some *Sphagnum fuscum* hummocks. On carpet level they are dominated by *S. angustifolium*. There are also some individual hollow bogs, although they usually occur as a part of a *S. fuscum* hollow bog combination type. Dwarf-shrub pine bogs, usually dominated by *Ledum palustre*, are rather common at the mire margins. Dominance of *Ledum palustre* is characteristic for the southern dwarf-shrub pine bogs.

Flora

Altogether 173 vascular plant species and 68 moss species have been found in Kauhaneva mire system. Many of the frequent species are also abundant, being the most important formers of peat and determining the ecological status of the present habitat. Some of the abundant species are forming large stands or carpets where they are dominating, e.g. *Andromeda polifolia, Betula nana, Carex lasiocarpa, C. rostrata, Eriophorum vaginatum, Ledum palustre, Rubus chamaemorus, Scheuchzeria palustris, Sphagnum angustifolium, S. balticum, S. fallax, S. fuscum, S. majus* and *S. papillosum*, while other abundant species have a scattered but continuous distribution, e.g. *Drosera rotundifolia, Aulacomnium palustre, Dicranum bergerii, D. polysetum, Polytrichum strictum, Sphagnum compactum, S. magellanicum, S. capillifolium, S. russowii* and *S. tenellum*.

The number of plant species in Kauhaneva mire system is not very high. The most representative species group is mosses. 29 of Finland's 38 species of *Sphagna* have been found in the mire system.

Several rare plant species have been found in Kauhaneva. *Rhynchospora fusca* and *Juncus stygius* were found in Kauhaneva. The former one was also found in the southwestern part of Punttukeidas mire in the southern part of Kauhaneva mire system. *Pedicularis sceptrum-carolinum* is abundant in a spring-fed spruce-mire in the northwestern part of Kauhaneva. *Carex dioica, C. diandra* and *Poa alpigena* grow in a rich spring fen in Lähdespuska, northwestern part of Kauhaneva. *Carex panicea* forms a large stand in a thin-peated mesotrophic sedge fen in Punttukeidas. *Sparganium hyperboreum* grows in a little pool in Punttukeidas in one of its southernmost locations in Finland.

One of the most notable species in Kauhaneva mire system is *Sphagnum molle*, which has been found in eight 1 km^2 quadrats (Heikkilä & Lindholm 1988, 1989, Heikkilä & al. 2001). In July 1994, during an extremely dry period, *Sphagnum* moss carpets were typically very dry and brown in Kauhaneva. Only stands of *S. molle* had been able to preserve water, and they were very easy to find because of the green colour, even though the patches are rather small, typically less than one square metre. Other regionally rare moss species in Kauhaneva are *Helodium blandowii, Tomentypnum nitens* and *Paludella squarrosa*, which grow in the rich spring fen in Lähdespuska and in spring-fed spruce mires.

In the flora of the Kauhaneva mire system boreal features are dominating. Even though the southern species *Carex paniculata* has its globally northernmost natural occurrence adjacent to Kauhaneva, northern species are typical especially in mire flora. For example *Betula nana, Pedicularis sceptrum-carolinum* and *Sphagnum lindbergii* have a boreal and arctic distribution.

Sphagnum molle (green) together with *S. rubellum* (red) in a lawn level bog near Kauhalampi pond. Photo Raimo Heikkilä.

Sphagnum pulchrum seems to have a rather wide ecological amplitude in Kauhaneva, although in Finland it is usually regarded as a minerotrophic species (e.g. Eurola & al. 1994). In Kauhaneva *S. pulchrum* grows with *S. majus* and *S. papillosum* in typical ombrotrophic hollows in the central parts of the raised bogs. Because its macrofossils have been found only in the top 10 cm of the peat, *S. pulchrum* has probably come to the bogs of Kauhaneva rather late. The recent occurrence might be due to atmospheric deposition of nitrogen, but there is no direct evidence to support this hypothesis. *S. pulchrum* occurs in ombrotrophic bog vegetation also in Mustaisneva mire in Kauhajoki and Kärkikeidas mire in Lauhanvuori national park in Isojoki (Heikkilä & Lindholm 1989).

Genesis and stratigraphy of Kauhaneva mire system

Genesis and stratigraphy of Kauhaneva mire system has been studied along two transects (Heikkilä & al. 2001). The central part of Kauhaneva mire system has developed as a result of paludification of two shallow depressions. Two radiocarbon datings from the bottom peat and sapropel layer of the eastern depression, show that paludification started 7940 ± 110 years B.P. (LU-3417) and 8080 ± 80 years B.P.(LU-3416). Datings are not calibrated.

The study transects cross the two easternmost concentric bogs and part of the aapamires. Deepest peat deposits, 4,5meters, or with gyttja layer 4.7 metres, are in the concentrig bogs. The thickness of the minerotrophic peat below the ombrotrophic layer varies between 0,5m to 2,7m, and the thickness of the ombrotrophic peat varies between 1,0 – 2,9 m. The peat layer of aapamires is considerably thinner, only 1-3 metres.

In present hollows the current plant cover is formed by *Scheuchzeria palustris* together with several *Sphagnum* species *(S. majus, S. papillosum, S. balticum, S. rubellum, S. lindbergii)*. In their stratigraphy, lake sediments were found only at the bottom of one core, from the deepest point in the eastern kettle. At the time (7940 ±110 B.P., LU-3417) when this kettle was filled up with shallow water, *Equisetum fluviatile* dominated the herb vegetation. In addition, remains of *Typha* sp., *Schoenoplectus lacustris, Potamogeton* sp., *Scorpidium scorpioides* and *Calliergon giganteum* were found in the bottom (20 cm) sapropel layer.

The shallow water body gradually filled in and there was, probably a rather fast, succession of vegetation towards more drier communities. First, a short-living quaking mire with *Menyanthes trifoliata-Sphagnum subsecundum + S. teres* community developed, and after that a sedge-*Sphagnum (Carex lasiocarpa-Sphagnum centrale)* community formed.

The sedge-*Sphagnum* community gave way to a more flooded sedge- *Menyanthes trifoliata* community and then to the sedge- *Sphagnum majus* community. In the peat formed by the latter, remains of minerotrophic plants were found for the last time. At that time the mire surface was 164,2 metres above sea level. When the ground water supply from the adjacent mineral soils stopped, the ombrotrophic phase of the mire development began. Increase of *Scheuchzeria palustris, Sphagnum papillosum, S. balticum* and *S. rubellum* and the disappearance of minerotrophic species (e.g. *Menyanthes trifoliata, Carex rostrata* and *Carex lasiocarpa)* indicate the transition to the ombrotrophic stage of development. The stratigraphy shows that the hollows are primary. In their development hummock stages with *Sphagnum fuscum* are absent.

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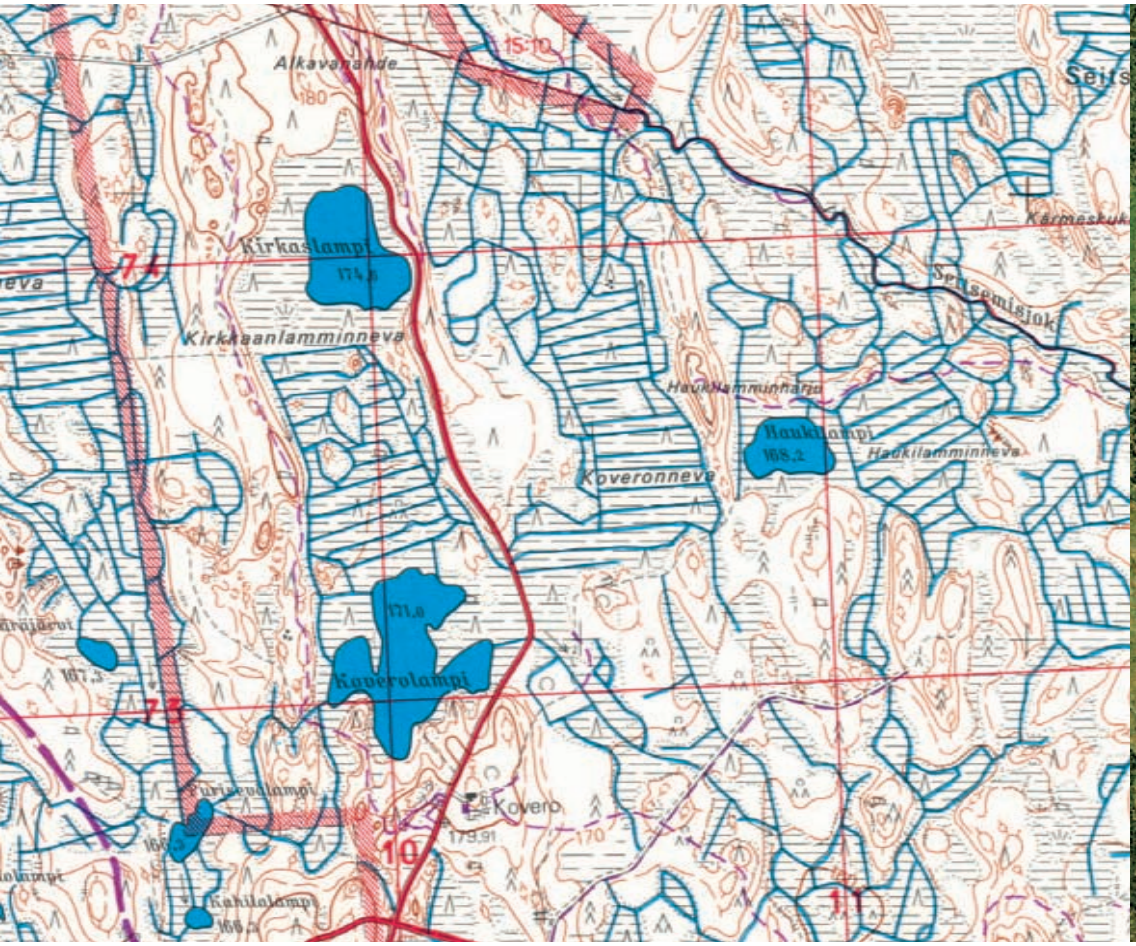

Topographic map of the the southwestern part of Seitseminen National Park. Each grid square is 1 km^2.
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False-colour infrared aerial photograph of the southwestern part of Seitseminen National Park. The restored Kirkkaanlamminneva mire is in the centre, to the northwest from the old Kovero forest guard's house. The red line shows the boundaries of Natura 2000 area.
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Mire restoration as a tool to make a national park

Seitseminen National Park

Teemu Tahvanainen, Pekka Vesterinen, Tapani Sallantaus & Raimo Heikkilä

Conservation history

Seitseminen National Park was established in 1981. It was extended in 1989 by the inclusion of a 900 ha area to the southeast of the original park. A further extension of 380 ha was added in 2004. The total area today is 45.5 km^2, almost half of which consists of mires. There are four strictly protected areas in the park (546 ha) where hiking is allowed on marked trails only. Elsewhere in the park it is allowed to walk and to pick berries and mushrooms in the forests and mires. Most of Seitseminen National Park area was forestry land before conservation. Old-growth forest is found only in the Multiharju area in the southern part of the park, which had been protected by the decision of Metsähallitus already before the establishment of the national park. Elsewhere the forests have been managed. Also, more than half of the mire area in Seitseminen had been drained before conservation. Today, the restoration of mires and forests is an important part of the management of the park. In 1996, the Seitseminen National Park was awarded with the European Diploma of Protected Areas of the Council of Europe.

Natural background

Seitseminen is located in the southern part of the Suomenselkä watershed. Typical for the area are nutrient poor and dry pine-dominated forests, as well as many small *Sphagnum* mires and narrow spruce mire strips in depressions between small hills and eskers. Many small lakes and rivers are mostly brown-coloured by humic substances. The bedrock consists mainly of acidic silicaceous granitoids. The soils are sorted and shaped by the phenomena of the Weichselian Glacial. The Seitsemisharju esker is the most impressive of the several eskers created by glacial rivers. Outcrops of the bedrock are rare in Seitseminen.

Mire massifs, vegetation and flora

The mires in Seitseminen are mostly small, dry and *Sphagnum fuscum* dominated forest bogs. In the southeastern part of the national park there are also open *Sphagnum fuscum* bogs. Kivineva mire in the northern part of the national park is a large eccentric bog. A lot of the mires in Seitseminen are narrow spruce mire strips, which cannot be counted to belong to any mire massif type. Most of the mires are poor. Moderately poor or intermediate fens are very rare and cover altogether only a few hectares of the approximately 2000 hectares of mires altogether (Leivo & al. 1989).

The most common pristine mire site types in Seitseminen National Park are poor pine bogs. The drained mires have mostly been various spruce mires and pine mires. The few pristine spruce mire patches are the most species-rich mire sites in Seitseminen. Open bogs are common in the largest mires, but open fens are rare and cover only a few per cent of the mire area (Leivo & al. 1989).

The vascular plant and bryophyte flora of the mires in the national park is not rich in species, due to the poor sites dominating. There are no rare or threatened species in the flora. In the mires there grow only about 90 species of vascular plants, which is a very low figure for an area of more than 4000 hectares (Leivo & al. 1989).

Mire utilization

Drainage of mires was very extensive in the area in 1960s and 1970s, like in most parts of southern Finland. In the vicinity of Seitseminen, the parishes of Ikaalinen and Kuru, about 88% of all mire area was drained by 1987. Within the ten-year period from 1977 to 1987, the volume of tree stands in the drained mires had increased by 47% (Paavilainen 1989). Typically, the proportion of deciduous species, especially of birch *(Betula pubescens)*, has increased following drainage. The history of extensive mire drainage is quite recent in Seitseminen. By 1963, only some mire areas had a few ditches that were meant to stop the lateral expansion of mires rather than to promote tree growth. Most of the mires in Seitseminen were in their natural condition, or close to that, in 1963 (Heikkilä & Lindholm 1994). In addition to drainage, fertilizers were applied routinely.

Restoration of drained mires

As the result of the heavy management, 60% of all of the mire area was drained, when the national park was established in 1981. Mires cover 50% of the park and, thus, the restoration of mires became a major task for the management of the park. The methods of mire restoration most importantly include the rewetting of the mire surface by blocking the ditches. In Seitseminen, also clearing of trees has been applied extensively in the mire-restoration areas. The goal of restoration is not to bring back the original ecosystem but to direct the ecosystem into a new balance shaped by the same ecological factors that had shaped the natural ecosystem (Heikkilä & Lindholm 1994).

A detailed plan for the restoration of mires in the Seitseminen National Park was presented by Heikkilä & Lindholm (1994). Already before this plan, restoration had been started in some mires. The first experiences of mire restoration were not all promising. The ditches of the Kirkkaanlamminneva mire, south of the small Lake Kirkkaanlampi in the southwestern part of the park, were filled in 1992. When the tree stand was removed during the restoration, the left-over twigs were used with peat for filling of the ditches. The wood material, covered with peat, made the ditches function as covered drains. The rewetting of the mire was insufficiently completed and as a consequence there was a rich growth of new pine seedlings. Now, 14 years after the restoration work, Kirkkaanlamminneva shows signs of successful restoration, however. The ground layer of the mire is well over-grown by *Sphagnum* and other mire species are thriving as well, although the pine stands are still alive and dominate the general appearance of the site. Another pioneering case of restoration is the nearby Koveronneva mire. At this site, there was a more severe failure in the rewetting of the mire. The hydrology of the mire had not been taken into account in sufficient detail and the dams were misplaced. The restoration had to be reassessed and it was complemented in 1996. Koveronneva mire has a small drainage area and, thus, the water supply is limited. In such cases, the effective blocking of the ditches is very critical to the rewetting.

Kirkkaanlamminneva mire in 1998, six years after restoration. *Sphagna* are growing well, but birch saplings are taking over the mire. Photo Raimo Heikkilä.

The examples of Kirkkaanlamminneva and Koveronneva underline the hydrological basis of mire restoration. Problems similar to those experienced in Koveronneva still arise in many cases, despite more careful planning. Although straightforward in the basic application, successful restoration is very challenging. The balanced hydrological state of mires is quite delicate, in general, and forestry drainage is a very strong disturbance to this balance. Although restoration may easily stop the effective drainage, the ditches usually remain different from the intervening surfaces in their hydrological properties. The water table after restoration may lie only slightly deeper in peat than in natural situations, but even few centimetres can be critical to some processes like the establishment of tree seedlings or growth of mire species. It is not fully understood, as yet, to which extent the success of mire restoration is dependent on time or the methods of restoration. The many different restoration sites in Seitseminen provide a chance for the assessment of restoration success in a wide variety of hydrological situations, ranging from richly minerogenous spruce-swamp stripes in sloping forest hills to flat poor fens and bogs with small drainage areas.

There are several mires in Seitseminen where restoration was conducted in late 1990s. At these sites, it is perhaps possible already to get a picture of the results of restoration. During the summer 2005, I made several excursions to the restored mires of Seitseminen in order to observe the hydrological state of the mires. I collected data on vegetation, peat growth and water chemistry, to be compared with data from pristine mires and restoration sites elsewhere. Clearly, a steady succession towards a new hydrological balance, vegetation and peat accumulation is taking course at the restoration sites. Some sites have quite natural appearance already, while at other sites the disturbed characters of vegetation still govern the scenery.

Vegetation monitoring in the northern part of Koveronneva mire before restoration. Pin-point method was used for monitoring, but because it is very labourious, cover percentage estimation is used nowadays. Photo Raimo Heikkilä.

There seems to be a general correlation between the restoration success and the mire types. Spruce mires are often located in narrow zones of sloping depressions of the forests that are richly fed with minerogenous waters. The large amount of water makes it easier to raise the water table. In restoration of spruce mires, the tree stands have usually not been cleared. Especially the spruce *(Picea abies)* suffers and dies easily because of increased wetness. Within a few years after restoration, the amount of dead wood increases, promoting biodiversity, and light penetration to the ground increases in a patchy pattern, typical of natural spruce mires. Some typical bryophytes of spruce mires, such as *Sphagnum girgensohnii* and *Plagiomnium ellipticum* have re-colonised the restoration sites within a period of less than ten years. At some sites, where the moss cover is not complete as yet, one can see round patches of bryophytes growing on the wetted detritus. After these patches have met one another, a spruce mire soon looks quite natural at a quick glance. Since the trees, including the birch, have not been cut down, there are usually no especial blooms of growth in the field layer or of new tree seedlings and shoots. In short, the restoration of spruce mires in Seitseminen seems to have succeeded comparably well. In the most successful sites, the water table has settled to around 10 to 15 cm depth, with considerable spatial variation typical of spruce mires, and the new moss layer has formed a surface peat layer of five to ten centimetres thickness.

A round patch of *Sphagnum girgensohnii* has appeared in Löytynsuo mire after restoration. Photo Teemu Tahvanainen.

After restoration the water chemistry in spruce mires sometimes shows peculiarities, such as very dark colour due to high dissolved organic carbon concentrations. In the summer 2005, some water samples were gathered from the oldest restoration sites in spruce mires of Seitseminen and these samples did not indicate especially deviant chemistry. In two poor spruce mires, characterised by *Sphagnum girgensohnii*, DOC was 28 and 29 mg/l, phosphate very low (2 and 10 µgP/l) and pH 4.3 and 4.2, respectively. Another site with richer indicator species, *Sphagnum squarrosum*, *Rhizomnium punctatum* and *Plagiomnium ellipticum*, and representing a strongly ground-water influenced type, had high pH (6.1) and moderate alkalinity (0.175), low phosphate (8 µgP/l) and no signs of elevated DOC (3 mg/l). In these cases, the water chemistry does not deviate from natural mires. In open mire restoration sites, water chemistry, as well as some vegetation features, indicated a less balanced state.

There are promising cases of restored open mires in Seitseminen as well. At many sites, a new surface peat layer up to 20 cm has been formed by *Sphagnum* and *Eriophorum vaginatum*. Sometimes this new surface peat reaches the water table, which could be considered as a critical phase in the development towards the self-regulating and peat-accumulating dynamics of the mires. Most of the open mires under restoration had been poor fens (e.g. low-sedge fens) prior to the drainage. The tree stands, developed during the about 30 years of drainage, were rather weak but in many cases the vegetation had changed towards the peat-forest stage with abundant

forest mosses, such as *Pleurozium screberi* and *Dicranum polysetum* replacing *Sphagnum*. In the surface peat, a more humified, blackish layer of forest detritus, pine needles and such can be found as indicating the peat-forest stage. Often the first layer formed after restoration is formed by *Eriophorum vaginatum*, which dominates in many restoration sites for a few years before the other mire species wake up. Today, at some of such sites in Seitseminen, the bloom of *Eriophorum* growth is over, while that of *Betula pubescens* continues.

There is a rich growth of shoots from the stumps of birch in places where it has been cut down as a part of the restoration management. Birch is much more tolerant to the water-logging than spruce and it may survive in considerably wet conditions. The number of restoration sites where birch has died is almost zero. Sometimes the birch shoots form dense bushes at sites with otherwise favourable development of vegetation and surface peat. Some role of the vegetation development may be played by the fertilizers added after drainage. At least in some areas the phosphorus and potassium fertilization had been repeated. A part of the added nutrients have leached away or were removed with the clearing of the trees, while a considerable amount of nutrients were deposited with the leftovers from the clearing, some of which were burned at the mires. Also nutrients stored in peat may have become more mobile after the rise of water. Very high concentrations of phosphate-phosphorus (36 and 83 µgP/l) were found in two water samples from open restoration sites.

Restored mire in Konisalo. *Eriophorum vaginatum* is abundant, and *Sphagna* grow well, but the growth of *Betula pubescens* saplings is not desired. Photo Teemu Tahvanainen.

Services of Seitseminen

There is a visitor centre within the National Park. There is a permanent exhibition about the nature of the park as well as up-to-date information. Seitseminen National Park provides many services for short visits or for a few days' hiking. There are almost 40 km of marked trails for hiking and a visitors' centre with restaurant and guidance. In addition to the natural sights, history of forestry in the area is presented at the Pitkäjärvi house and in the Kovero farm, one can familiarize with life in the wilderness one hundred years ago.

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Old-growth forests in Seitseminen National Park

Reijo Penttilä

Haploporus odorus growing on the stem of goat willow *(Salix caprea)* in Multiharju old-growth forest. Photo Reijo Penttilä.

The old-growth forest area of Multiharju is among the finest examples of pine-dominated natural forests in the whole southern Finland. Very old pines with thick reticulate bark, silvery grey dead pines and high amount of robust decaying trunks on ground characterize the Multiharju forest and support a high diversity of polypores growing on pine, including many threatened species. Multiharju is one of the southernmost localities of the endangered *Antrodia crassa*. Examples of vulnerable species in Multiharju include *Antrodia infirma*, *Postia lateritia* and *Skeletocutis lenis*. *Antrodia albobrunnea* is one species in need of monitoring that is especially abundant in Multiharju. Polypores growing on deciduous trees are represented in moderate diversity in Multiharju. Threatened species include *Antrodia mellita* and *Antrodia pulvinascens* that grow on aspen, and *Haploporus odorus* which grows on Salix caprea. The species growing on spruce are less abundant in Multiharju, but also in this group some threatened species are found, including *Skeletocutis brevispora*, *Phellinus ferrugineofuscus*, *Perenniporia subacida* and *Skeletocutis odora.*

Polypore inventories have been conducted in Multiharju in three occations, in 1986, 1996 and 1998. The 1986 data consists of two one-hectare wide sampling areas, where all tree trunks were checked for polypores. In 1996, a 3-4 ha area, which covered the 1986 sites, was mapped during one day, and only the trunks most probably bearing polypores were checked. Similar one-day mapping was conducted in 1998, on a 7 ha area that covered the previous sampling area. Taking into account that the inventories have covered only few hectares, the number of all polypore species (73) is high in Multiharju. Particularly the numbers of threatened species (10) and species in need of monitoring (9) are considerable.

Siberian jay. Photo Antti Leinonen.

Siberian jay *(Perisoreus infaustus)*

Mari Pihlajaniemi

Siberian jay is classified as an endangered species in Europe. In Finland Siberian jay is classified as near threatened (NT). Because Siberian jay is still quite abundant in northern parts of the country, Siberian jay is not considered as an endangered species in Finland (Rassi 2000). Finland has a special responsibility to protect Siberian jay, because over 10 % of its European population breeds in Finland (Pimenoff 2000).

The biggest change in Finnish forest environments has especially in the latest decades been the decrease of mature forests. Because of this, populations of bird species which have specialized in living in mature forests have also declined, and populations of generalized bird species have increased. Siberian jay is considered as a mature forest specialist (Väisänen & al. 1998). Although in northern parts of Finland Siberian jay population has remained stable, the population in southern parts of the country has declined considerably in the last few years. Observation numbers have declined in southern Finland in the last decades, even though observation efficiency has increased (Kemppainen & Kemppainen 1991).

In 1973–1977 inventories the population size was estimated as 40 000–52 000 pairs in Finland. In 1998 population size is estimated only as 30 000–50 000 pairs (Väisänen ym. 1998). Siberian jay density in northern Finland has been estimated to be tenfold compared to southern Finland (Virkkala & Rajasärkkä 2000).

The distribution area of Siberian jay covers the northern parts of Finland, from Tornio-Kainuu to the Norwegian border. Greatest densities have been reported in the eastern parts of Lapland (Vaisänen & al. 1998). South of the Province of Oulu the strongest populations are found in North-Karelia. Siberian jay observations have been reported regularly also in Ostrobothnia, Central Finland and Savo. In these areas populations consist of small 2-5 pair subpopulations (Väisänen & al. 1998).

Habitat selection of Siberian jay has been researched mainly in Lapland. According to these studies the best environment for Siberian jay seems to be a broad, old pine forest dominated area, where also brushy spruce trees with lichens can be found. (Kaisanlahti–Jokimäki & al. 2005).

Siberian jay seems to prefer bilberry dominated forests (Väisänen 2004, Kaisanlahti-Jokimäki & al. 2005). It has been found out that when landscape level variables are considered from the Siberian jay point of view, the size of the forest area is not as important as the proportion of old forest inside the area and the abundance of forests in the surrounding area. If the surrounding forest is heavily fragmented, the area is not suitable for Siberian jay (Louhia 2001). In southern Finland, environmental demands for Siberian jay have been researched in Suupohja area in Ostrobothnia with radiotelemetry. Results show that in Suupohja Siberian jay seems to favour old spruce dominated forests (Lillandt 2002, 2000).

Effects of forest fragmentation have been discovered to be the most harmful to species that favour old forests. Especially the populations of non-migratory birds in taiga areas have declined due to forest fragmentation (Helle & Järvinen 1986, Virkkala 1991). When suitable environment becomes fragmented, different populations of the species become separated from each other and become vulnerable to harms of inbreeding. It has been found out that in Suupohja area inbreeding has already affected negatively to Siberian jay breeding potential and population development (Lillandt 2000).

Because dispersal distances of Siberian jay are short on average, pairs located far away from each other cannot sustain a viable population in southern Finland. In the future it will be important to find out which subpopulations are so called source populations, whose breeding success is better than in other areas, and which can possibly maintain other populations in the surrounding areas. It is also important to find out what routes Siberian jay uses when dispersing from these source areas to other areas. These source populations and dispersal routes are vital for the Siberian jay population to remain in southern Finland. Another important question in future research is to find out which areas function as "channels" between northern Finnish stable populations and southern Finnish highly fragmented populations. The small population in southern Finland needs reinforcement from the north to remain viable. Especially the role of North Ostrobothnia, North Savo, North Karelia and Kainuu as dispersal channels has to be clarified as soon as possible. In these areas it is important that an adequate number of suitable forests for Siberian jay remain in order to make the dispersal of Siberian jay from north to south possible also in the future.

Siberian jay is a good indicator when evaluating the condition and changes of forest nature. Because Siberian jay is a non-migratory bird, changes in its population also express changes in the environment of species. Declining of the Siberian jay population is a sign of changes in forest environments.

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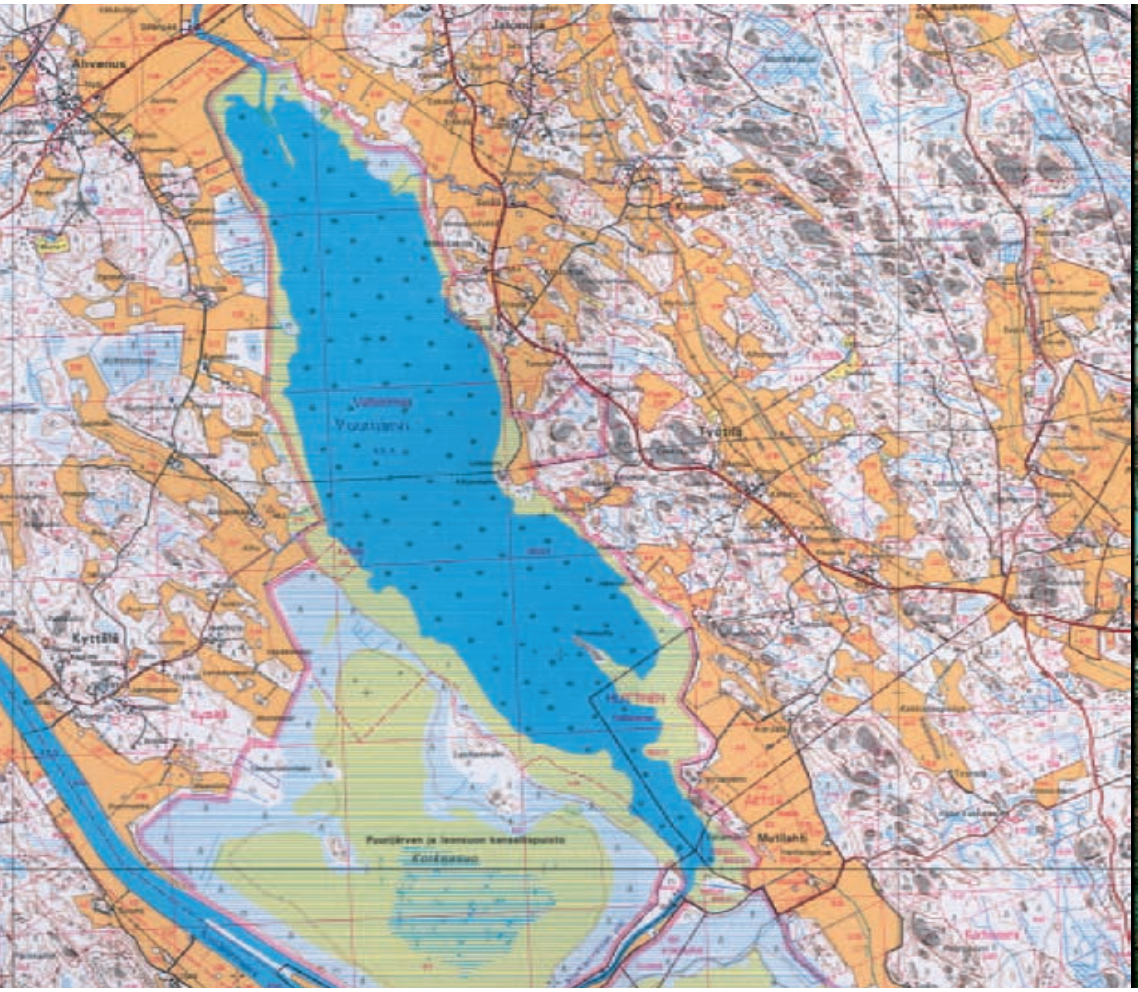
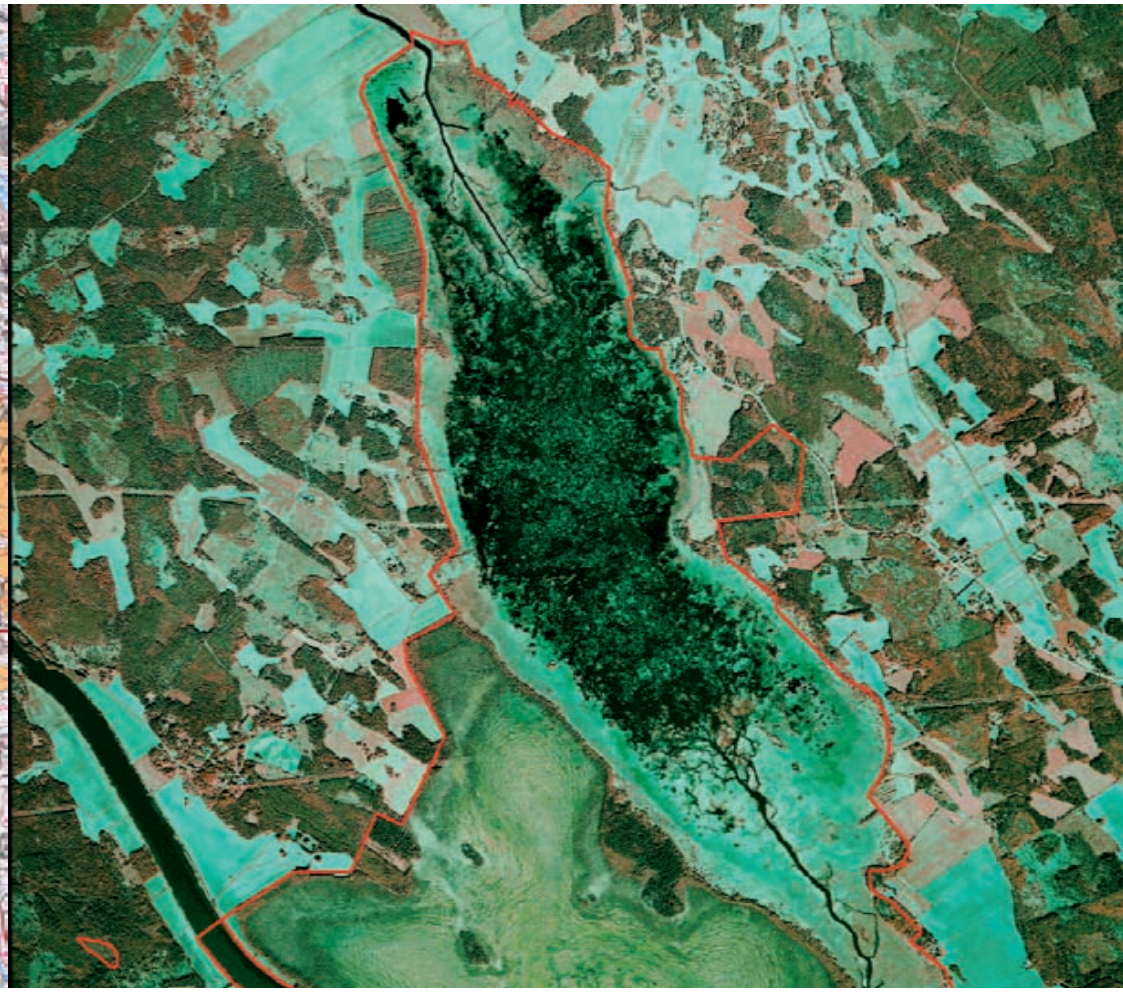


Topographic map of the northern part of Puurijärvi – Isosuo National Park. Each grid square is 1 km^2.



False-colour infrared aerial photograph of the northern part of Puurijärvi – Isosuo National Park. The red line shows the boundaries of Natura 2000 area.

Cases of raised mires: concentric and plateau mire massifs

Puurijärvi-Isosuo National Park

Teemu Tahvanainen

Land use history and conservation

Puurijärvi-Isosuo National Park was founded in 1993. Lake Puurijärvi is one of the important bird habitats in Finland (FINIBA), and it has been proposed for inclusion in the Ramsar List of Wetlands of International Importance. In addition, the National Park includes five raised bogs: the Korkeasuo, Isosuo, Aronsuo, Kiettareensuo and Ronkansuo bogs.

The Park covers 2 700 ha, of which only 70 ha is on mineral land. In fact, the borders of the park quite closely follow the mire margins and the Puurijärvi shore line. The Puurijärvi-Isosuo National Park is thus a true wetlands reserve. The lineation of the park has a historical background. While the mires represent pristine natural environments, the rest of the landscape has been under management for centuries. All suitable areas are cultivated, including most lagg-zones of the bogs. Agriculture began here already in the early 13th century, while the fields extended until the mid 19th century to their present area (Grahn 1994).

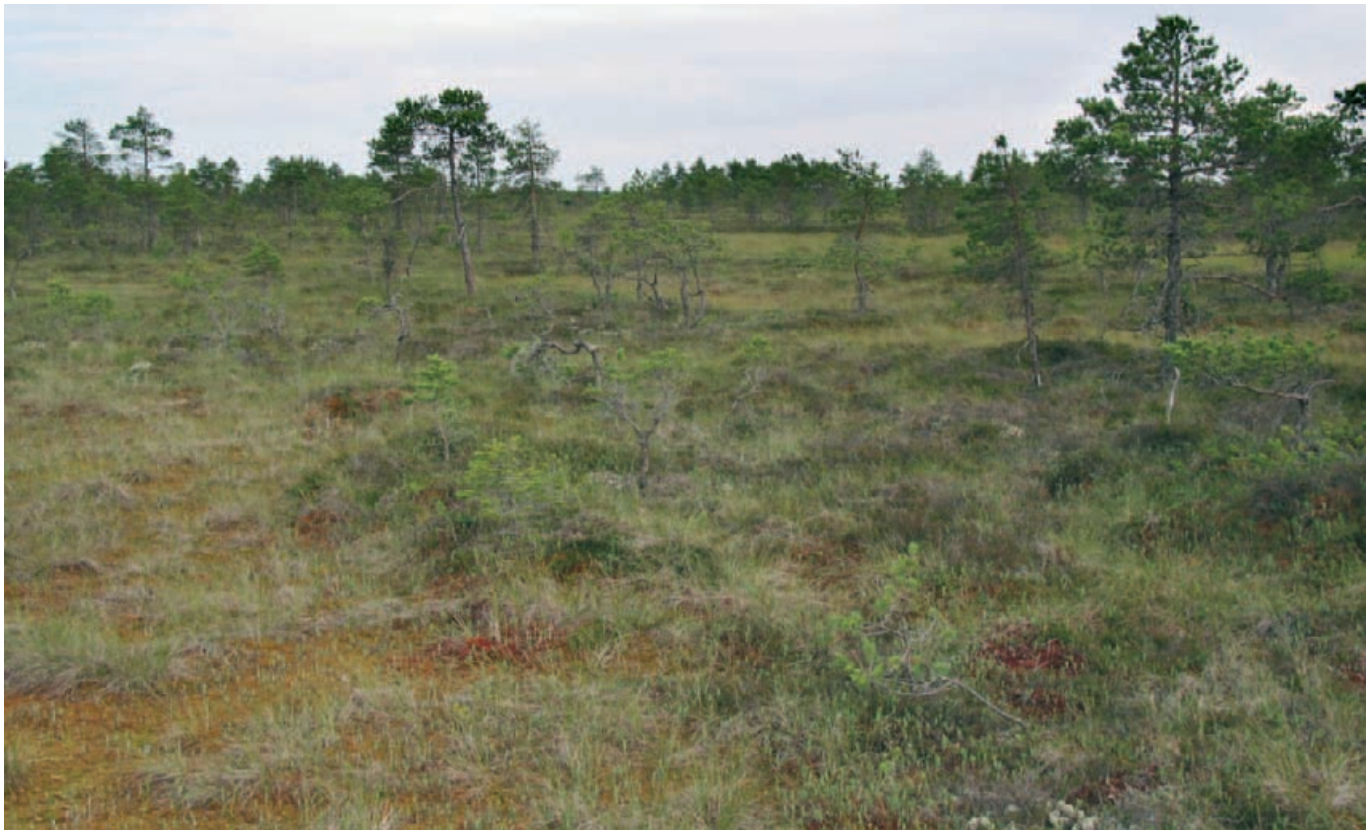
The 450 ha wide Lake Puurijärvi is a haven to more than one thousand nesting pairs of about 35 bird species (Heinonen & al. 1994). The avifauna of the lake is rich but it has been under constant change due to the rapid succession of the lake. In the 1700s, Lake Puurijärvi had clear water, sparse vegetation and much poorer avifauna than today. The oligotrophic nature of the lake was considered unfortunate at the time, since the fish catches were poor. The river clearings and mire drainage around the lake in 1826, 1870s and 1880s then lowered the water level considerably and gave start to the eutrophication and terrestrialisation development of Puurijärvi. The fish stocks were rich in the early 1900s, and the Puurijärvi fish were sold daily in the markets of Tampere in 1910s. At the same time, the number of waterfowl had increased markedly.

Because the lake is so shallow, the landscape of the Lake Puurijärvi changes greatly depending on the water level. During dry spells, only little ponds of open water can be seen. There is a threat of the whole lake becoming overgrown and swampy. The challenge for the next few years is to restore the bird habitat of the lake. The shore meadows (80 ha) are managed by the traditional method of pasturing. This area is one of the largest traditional landscape sites in the region. Managing the landscape improves the conditions for the shore birds and the insects living on the open meadows on the shores.

A view over Lake Puurijärvi from the bird watching tower. The amount of open water in late July is small, and the lake is mainly dominated by helophyte vegetation. Photo Tapio Lindholm.

Bird fauna

Today, Lake Puurijärvi is an important resting place for migrating water birds, such as geese and swans. In the spring, it is possible to see almost 400 Whooper Swans *(Cygnus cygnus)* and hundreds of Bean Geese *(Anser fabalis)* in the lake. The Bittern *(Botaurus stellaris)* and the Marsh Harrier *(Circus aeruginosus)* belong to the nesting species, as well as the rare Black Tern *(Chlidonias niger)*. The most abundant bird species in Puurijärvi include the Eurasian Coot *(Fulica atra)*, the Mallard *(Anas platyrhynchos)*, the Sedge warbler *(Acrocephalus schoenobaenus)*, the Black-headed gull *(Larus ridibundus)*, the Shoveler *(Anas clypeata)*, the Teal *(Anal crecca)* and the Red-necked grebe *(Podiceps griseigna)*. In night time in early summer one can hear the singing of the Grasshopper Warbler *(Locustella naevia)*, the Reed Warbler *(Acrocephalus scirpaceus)* and the Nightingale *(Luscinia luscinia)*, as well as the less musical calls of the Water Rail *(Rallus auqaticus)* and the Spotted Crake *(Porzana porzana)*. The lake is also an important preying area for many birds nesting in the surroundings, such as the Osprey *(Pandion haliaetus)* and the Northern Hobby *(Falco subbuteo)*. Also the White-tailed Sea Eagle *(Haliaeetus albicilla)* can be seen above the lake preying on Muskrats *(Ondatra zibethica)* or fish.



Isosuo bog to the southwest of Lake Puurijärvi. The structure is less pronounced than in more northern concentric bogs e.g. in Kauhaneva – Pohjankangas National Park. Photo Tapio Lindholm.

Bogs in the National Park

The raised bogs of the Puurijärvi-Isosuo National Park are representatives of the South-Finnish raised bogs. The bog massifs are mostly concentric but some bog plains lack distinct surface patterns and can be classified as plateau bogs or intermediate forms. Bog pools are found in few bogs, including the Isosuo bog, which is the largest (742 ha) pristine bog in the area. The Geological Survey of Finland has conducted a basic inventory of Isosuo (Stén 1997). The peat layer in the deepest part in the centre of the bog is six metres thick, five metres of which is *Sphagnum* peat. Of all peat in Isosuo, 90 % is *Sphagnum* peat. The development of the bog started by terrestrialization of a lake. The lake sediment layer below the peat is 10 to 100 cm thick and it is found in about 76 % of the present bog area. Remains of fruits of *Trapa natans*, a species that does not belong to the present Finnish flora, are found in the gyttja stratum of Isosuo. *T. natans* had existed in the area during the warm period at 5000-4500 BP. Other macrofossils recognised in association with *T. natans* include such aquatic plants as *Alisma plantago-aquatica, Schoenoplectus lacustris, Numphar lutea, Nymphaea alba* and *Nymphaea candida*. In the *Equisetum-Carex*-peat layer above the gyttja, remains of *Carex canescens, Carex pseudocyperus, Iris pseudacorus, Lysimachia thyrsifolia, Potentilla palustris* and *Menyanthes trifoliata* are found. The bog has expanded by paludification of forests with 25 % (Stén 1997).

Radiocarbon datings and a pollen diagram are available from Loimansuo bog, outside the national park (Vuorela 1975, 1983). The change from *Carex* peat to *Sphagnum* peat was coincident with the arrival of spruce *(Picea abies)* and dated back to 3400 BP. Similarly as in Isosuo, the ombrotrofication started early in the mire development. The appearance of cultural influence indicating pollen was dated to 1970 BP and intensive agriculture was indicated at 420 BP.

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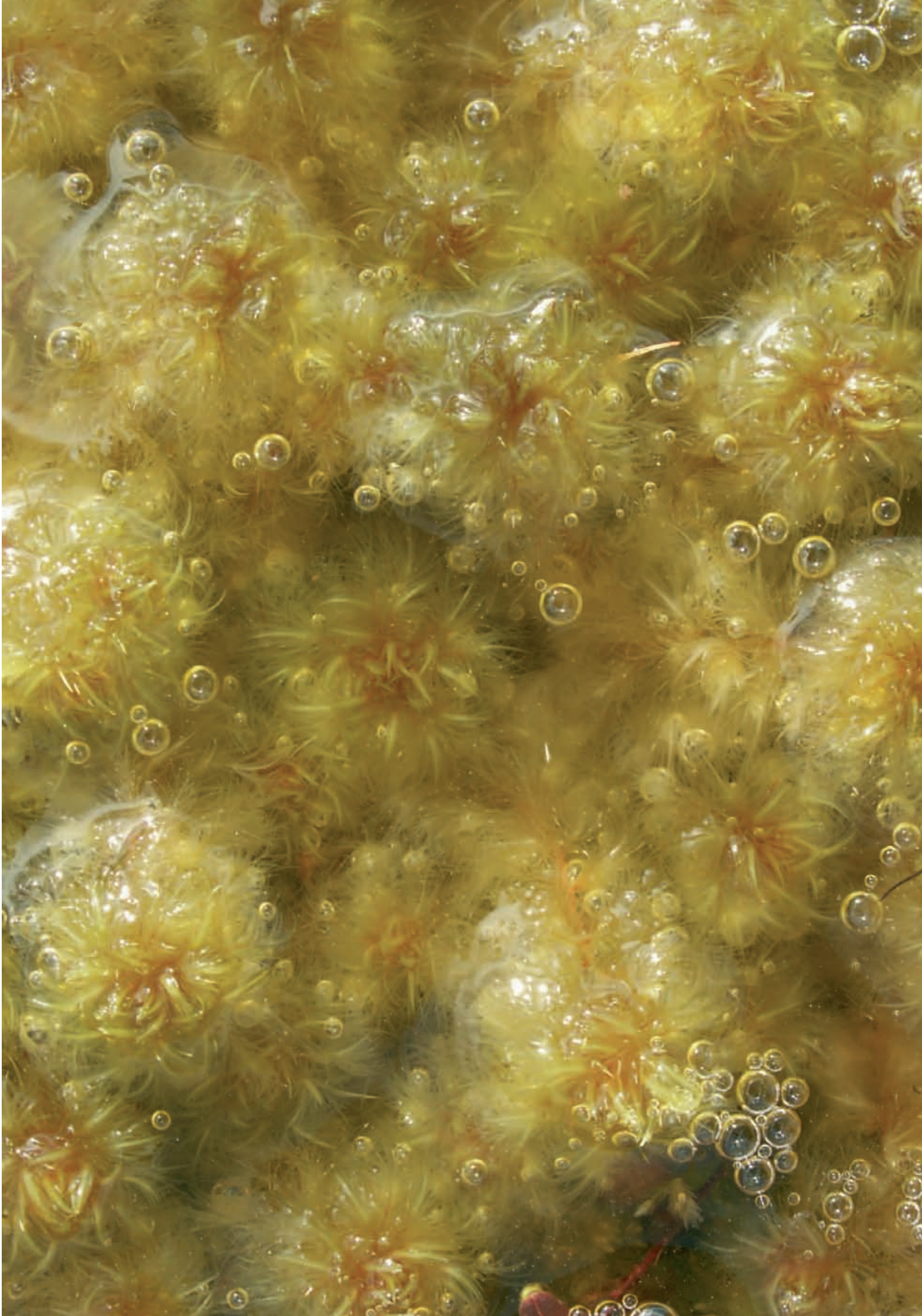
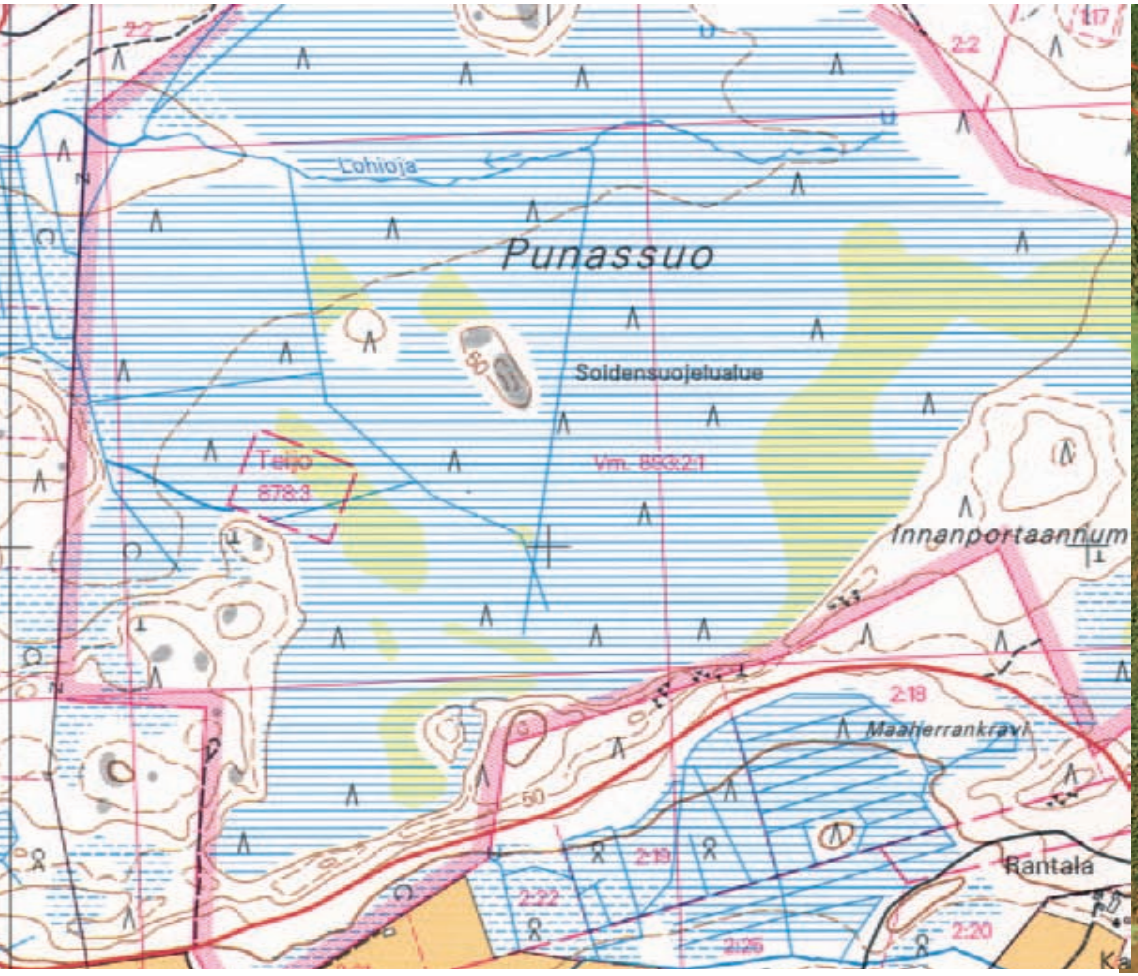
Photograph on page 123: *Sphagnum cuspidatum* is a typical species of bog hollows in southwestern Finland, but uncommon in other parts of Finland. Photo Teemu Tahvanainen.





Topographic map of Punassuo mire reserve. Each grid square is 1 km².
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False-colour infrared aerial photograph of Punassuo mire reserve. The red line shows the boundaries of Natura 2000 area.
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Punassuo - a coastal plateau bog of southernmost Finland

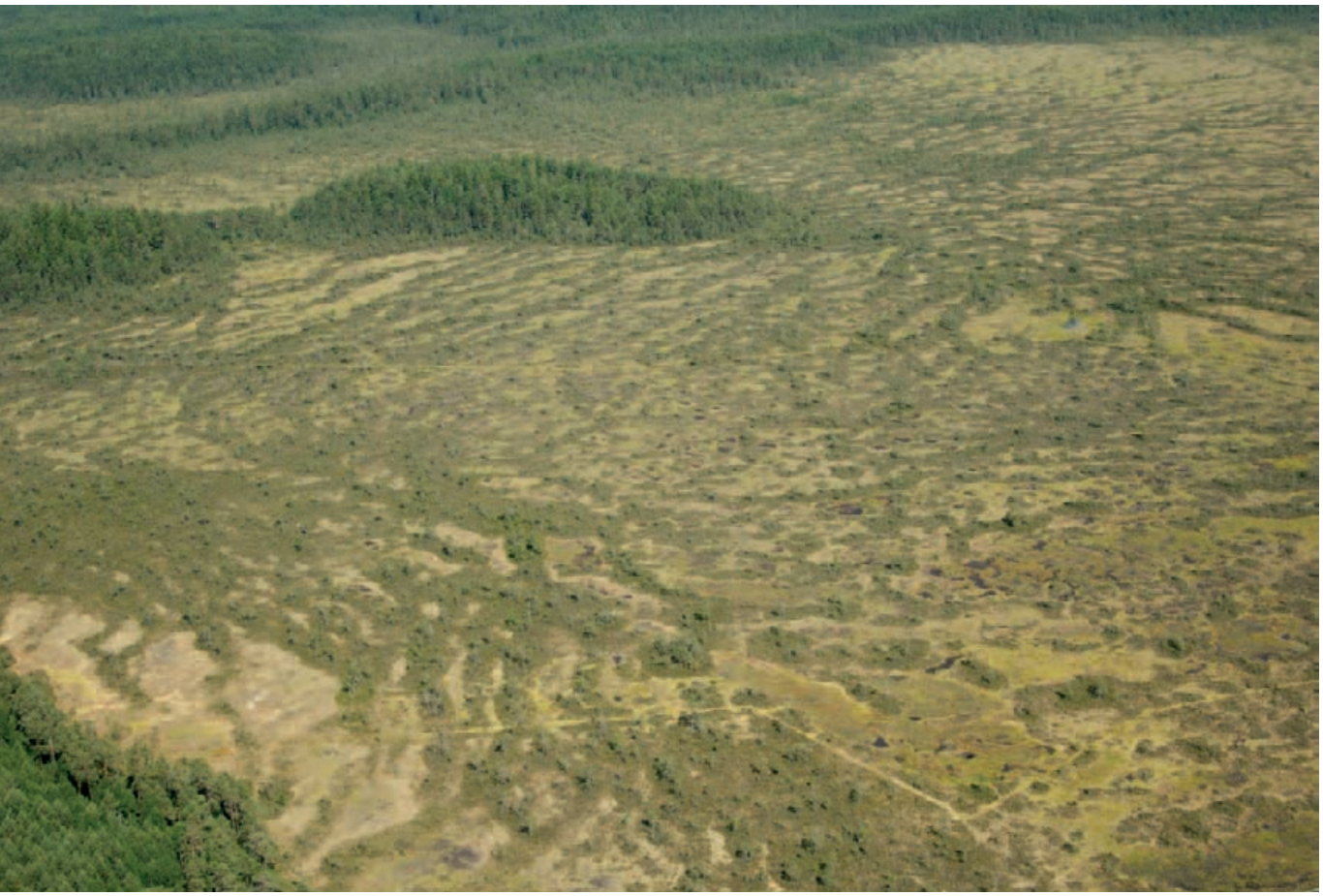
Teemu Tahvanainen & Kimmo Tolonen

Mire massif

The Punassuo mire is a raised bog massif, located in the coastal plateau bog zone, in south-western Finland. Punassuo belongs to the Finnish National Mire Protection Program with an area of 239 ha. The area is also included in the NATURA 2000 program. It is protected as a nature reserve.

Punassuo lies on a depression in a landscape with complex glaciofluvial formations. Although the region is rather flat, the mire basin has an irregular form and it is disrupted by bedrock outcrops that today are forest islands of the bog. In the south, the raised bog massif is bordered by a steep glaciofluvial ridge that has prevented the lateral expansion of the bog in this direction. In the north, the bog massif is stopped by the Lohioja stream, which naturally makes a great difference to the hydrology of the marginal zones. Due to these special conditions, the gross forms and surface patterns of Punassuo are quite variable in different parts of the massif and it is hard to decide which complex type it represents. Eurola (1962) considered Punassuo as a representative of coastal plateau bogs. Following Eurola, Seppälä (1986) wrote: "Punassuo represents the plateau raised bog type of the Archipelago region. Its centre is flat but distinctly higher than its margins. The hollows and hummocks form an indeterminate network". Korhola (1992a) concluded as follows: "Punassuo cannot by any means be classified as a plateau raised bog in terms of its gross-form features, for its surface is practically horizontal and in parts markedly eccentric, and the hummocks and hollows show a clear alignment over most of its area." Korhola considered the Punassuo massif as a "horizontal ombrotrophic bog".

The surface of the Punassuo raised bog massif slopes slightly towards northwest and in the northwestern part, west of the forest islands, there are clear eccentric patterns, indicating a unidirectional water-flow pattern. The water-flow pattern of the whole massif is quite divergent, however. A part of the hydrology of Punassuo is probably played by seepage through the glaciofluvial ridge in the southern mire margin. Typical marginal slopes and lagg fens are hardly found. In the southern mire margin, there are almost no marginal zones at all. In other places, like in the eastern part, around the head of the glaciofluvial ridge formation, the slope and lagg zones are distinct, however. The hummocks are low in the central parts of the Punassuo. They are clearly aligned in the eccentric parts, but quite irregular elsewhere. In fact, the bedrock-outcrop islands probably are the factor causing the most distinct eccentric patterns, as they force the water flow into narrower zones at certain localities. The central bog plain is horizontal, which is typical to plateau bogs, while the eccentric patterns and the lack of typical marginal zones are caused by special local hydrological conditions. Thus, the Punassuo massif can be classified as a plateau bog, although it is not a very typical one when compared with certain smaller horizontal raised bogs in the vicinity (Brödtorps mosse, Pakapyölinsuo and Dragsfjärds Storemosse). The more typical plateau bogs all have much higher cover of *Sphagnum tenellum* than Punassuo and no clear orientation of the surface patterns. The occurrence of regular surface patterns in some parts of the bog massif, often in marginal areas, is common in plateau bogs, however. Large plateau bogs may have wide distinctly patterned circular ridge-hollow zones around the flat middle plain (Hochfläche). An example of such case is found in Munasuo (in Pyhtää, southeastern Finland), which has a very flat central plain with irregular orientation of the surface elements (Tolonen and Seppä 1994).



An oblique aerial photograph over Punassuo mire towards the northeast. The pattern of hummock ridges and hollows is not very clearly oriented, which is a typical feature in the plateau bogs of the southern coast of Finland. Photo Hannu Vallas.

Vegetation

The vegetation in the centre of the Punassuo bog massif is a combination of *Sphagnum fuscum* bog and *Sphagnum*-hollow bog. In the margins, there are *Ledum* dominated dwarf-shrub pine bogs and sedge pine mires. In the northern margin, along the Lohioja stream, there are narrow strips of *Myrtillus*-spruce mires, where the typical species include *Sphagnum girgensohnii, Pyrola minor, Gymnocarpium dryopteris, Lysimacia thyrsiflora, Maianthemum bifolium, Potentilla palustris, Lycopodium annotinum, Solidago virgaurea, Dactylorhiza maculata, Galium palustre* and *Lysimachia vulgaris.* The Lohioja is a ground-water stream originating from a spring in the eastern margin of Punassuo. Some spring vegetation is found along the stream. Ground-water influence is met also north of the Lohioja stream, where species such as *Alnus glutinosa, Dactylorhiza maculata, Potentilla erecta, Viola palustris, Equisetum pratense* and *Athyrium filix-femina* indicate ground-water influence. The bog plain is poor in the number of plant species. The dominant species in the hummocks of the bog plain are *Pinus sylvestris, Calluna vulgaris, Rubus chamaemorus, Sphagnum fuscum, Sphagnum rubellum* and *Cladina* spp. The broad, wet hollows are dominated by *Carex limosa, Rhynchospora alba, Scheuchzeria palustris, Sphagnum tenellum, S. magellanicum, Sphagnum cuspidatum, Sphagnum balticum* and *Sphagnum majus.*

Hummock ridges and hollows in the central part of Punassuo mire. Photo Tapio Lindholm.

Mire development

The development of the Punassuo massif was studied in detail by Korhola (1992a, 1992b). The maximum peat depth is 6.75 metres, found in the centre of the mire. Below the peat there is a clay layer, rich with shells typical to the Ancylus phase of the Baltic *(Bithynia* and *Valvata genera)* and fresh water diatom assemblages indicating the same phase *(Aulacosira islandica* ssp. *helvetica, Gyrosigma attenuatum* etc.*)*. According to the pollen staratigraphy, this shell bed was deposited before the rise of ALNUS pollen, i.e. before c. 8300 BP. Rapid alterations were found in the diatom assemblages indicating that the basin had only a narrow and non-stable connection to the Baltic. Eventual isolation from the Baltic connection took place before the start of peat formation.

Valovirta (1962) studied the macrofossils and found remains of freshwater plants, such as *Potamogeton natans, Ceratophyllum demersum* and *Carex pseudocyperus*. After this, *Najas marina* and *Schoenoplectus lacustris*, indicators of brackish water appeared. The peat formation started by terrestrialization at around 7200 to 7000 BP, based on several radiocarbon datings of the basal peat (Korhola 1992a). The initial peat layer is a 0.2-0.4 m thick *Carex*-peat layer, composed by remains of *Carex pseudocyperus*, *C. vesicaria, C. diandra, Phragmites* and *Equisetum*. Above the basal layer, there is a 0.4-1.1 m thick layer of *Carex* peat with remains of *Betula* spp., *Salix* spp., *Menyanthes trifoliata,*

Scheuchzeria palustris, and *Andromeda polifolia*. Most of the upper peat is *Sphagnum* peat with remains of *Eriophorum* and dwarf shrubs. The macro-fossil stratigraphy shows a sequence from *Sphagnum sect. Squarrosa* and *Sphagnum sect. Subsecunda* to *Sphagnum sect. Cuspidata (S. riparium, S. fallax, S. angustifolium)* and then to *Sphagnum magellanicum* Simultaneously to the appearance of *S. magellanicum* at the depth of 380 cm, occurred large amounts of *Eriophorum* remains and this change was interpreted as the switch to ombrotrophic conditions. The ombrotrophication started a little before the rise of *Picea* in the pollen diagram, which dates back to 3000-3200 BP in the area.

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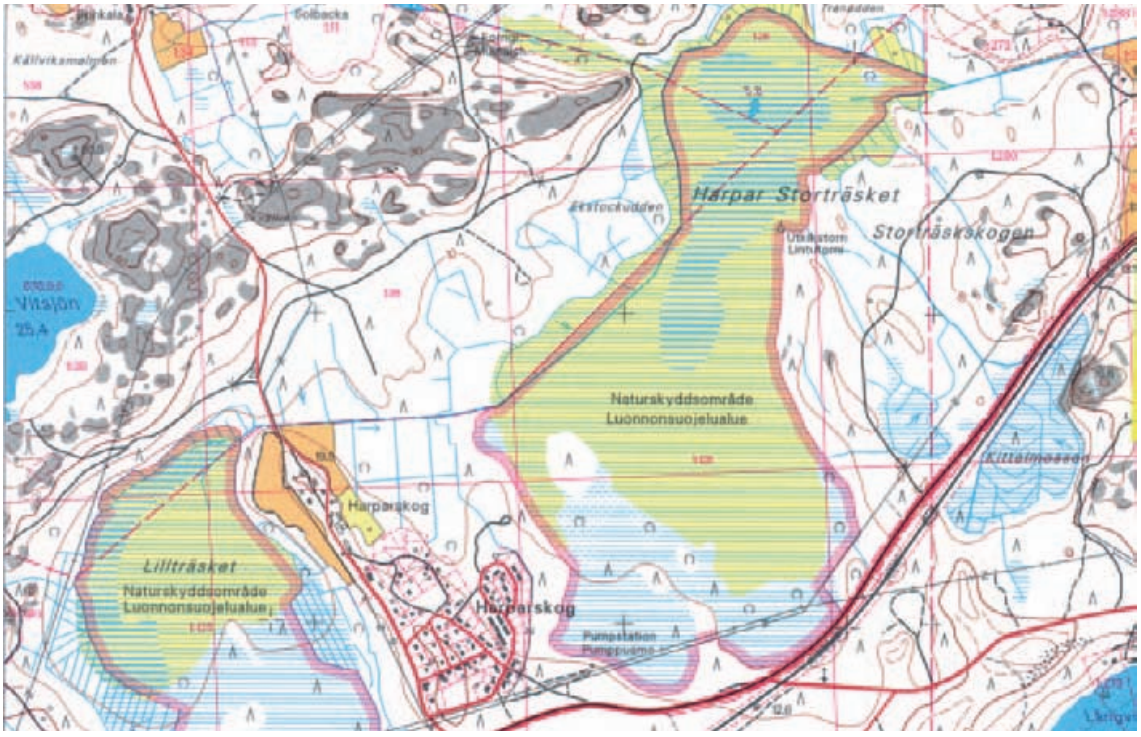
Central European or hemiboreal swamp?

Harpar Storträsket – hemiboreal swamps on the southern coast of Finland

Raimo Heikkilä (ed.)

Harpar Storträsket is a young mire in the southern coast of Finland, covering 170 hectares. Its surface is only 5,8 to 7 metres above the sea level, and the bottom in central parts 3 metres above the sea level. Thus the area has risen from the Baltic Sea only about 1000 years ago. In the marginal parts there are small bog areas 10-12 metres asl. Harpar Storträsket was originally a lake, but due to infilling it was developing into a mire. The development was accelerated around the year 1850, when the water table of the lake was lowered in order to obtain meadows for haymaking. Due to the near Tvärminne zoological station of Helsinki University, the bird fauna of Harpar Storträsk has been studied already from the 1920s. Due to the location, Harpar Storträsket is also important for university education. Destruction of the area by ditching was a threat in the early 1970s, and to save the mire, thorough biodiversity studies were conducted in 1973. The articles below are mainly based on unpublished reports of those studies in Finnish and in Swedish.



Topographic map of Harpar Storträsket mire reserve. Each grid square is 1 km².

Sedge swamp growing over by *Alnus glutinosa* in the southern part of Harpar Storträsket. *Myrica gale* is abundant. Photo Raimo Heikkilä.

Vegetation and flora of Harpar Storträsket

Rauno Ruuhijärvi, Ahti Mäkinen, Björn Federley, Timo Koponen, Kalevi Keynäs, Hanna Kondelin & Raimo Heikkilä

Harpar Storträsk is a young mire in an early stage of its succession. Its centre is in southern Finnish conditions an exceptionally wide open fen, and in the marginal parts there are narrow strips of spruce mires and black alder swamps. In the southern and southeastern margins there are also spring-fed spruce mires. Between the open fen and the margins there is a belt of *Alnus glutinosa* fen, where *Myrica gale* is very abundant. *Alnus glutinosa* is spreading, and the open fen is now clearly smaller than in the late 1980s. *Myrica gale* growing over the whole mire and black alder growing in fen habitats instead of *Betula pubescens* are southern characteristics connected with the Baltic republics and southern Sweden. In this respect Harpar Storträsket is unique in Finland.

The open fens of Harpar Storträsket are intermediate and rich fens. pH observations vary between 5,2 and 6,3. A common feature is strong surface water influence, which is reflected by the occurrence of water and shore plants in the mire. It is caused by spring flood, and probably also the thin (20-30 cm) peat layer and gyttja below it. In the central parts there are two small open water areas with e.g. *Typha angustifolia, T. latifolia, Schoenoplectus lacustris, Eleocharis palustris, Hydrocharis morsus-ranae, Lemna minor, Nuphar lutea* and *Nymphaea alba*.

Open intermediate sedge fen in the southern part of Harpar Storträsket. Elks *(Alces alces)* are common and abundant in the area. Photo Tapio Lindholm.

The accurate classification of vegetation is complicated due to the uniqueness of the habitats and the successional stage of the mire. Most common relicts of aquatic communities in the fens are *Phragmites australis*, *Typha latifolia* and *Carex acuta*. In addition to them, abundant plants are *Myrica gale*, *Vaccinium oxycoccos*, *Carex chordorrhiza*, *C. diandra*, *Agrostis canina*, *Cicuta virosa*, *Thelypteris palustris*, *Lycopus europaeus*, *Lysimachia thyrsiflora*, *Menyanthes trifoliata*, *Peucedanum palustre* and *Potentilla palustris*. In the ground layer there are *Sphagnum* species favouring swamp and fen conditions: *S. fallax*, *S. flexuosum*, *S. obtusum*, *S. platyphyllum*, *S. riparium*, *S. squarrosum*, *S. subsecundum* and *S. teres*. In addition, *Bryum pseudotriquetrum*, *Calliergon cordifolium*, *C. giganteum*, *C. richardsonii*, *Calliergonella cuspidata*, *Campylium stellatum*, *Cinclidium stygium*, *Warnstorfia exannulata* and *Pseudobryum cinclidioides* are common. *Vaccinium oxycoccos* grows very abundantly especially in the western part of the open fen. In 1973 the best hectare crops were about 700 kg, and mean crops 400-500 kg per hectare.

Vegetation of a black alder swamp in the southwestern part of Harpar Storträsket. *Calla palustris* dominates in the field layer.
Photo Tapio Lindholm.

The black alder swamps are very well developed in Harpar Storträsket. The maximum height of the trees is over 20 metres, and the breast level diameter can exceed 30 cm. The black alder stands have originally started to grow on sand soil, but now there is some 30 cm of loose peat, formed mainly of litter. The wet surfaces between the hummocks, on which the trees grow, are difficult to cross, and they retain their wetness all through the summer. Most abundant species in the understorey vegetation are *Athyrium filix-femina* and *Dryopteris expansa* on the hummocks. In the wet surfaces, *Calla palustris, Lysimachia thyrsiflora, Potentilla palustris, Peucedanum palustre* and *Equisetum fluviatile* dominate. Common and locally abundant species are also *Carex aquatilis* and *Calamagrostis purpurea*. Due to small-scale variation in moisture, the moss flora is diverse. Most mosses grow on hummocks or fallen trees. Abundant species are e.g. *Brachythecium rivulare, Calliergon cordifolium, Helodium blandowii, Herzogiella seligeri, Mnium hornum, Plagiomnium ellipticum, Polytrichastrum formosum, P. longisetum, Rhizomnium pseudopunctatum, Tetraphis pellucida, Sphagnum girgensohnii, S. fimbriatum* and *S. squarrosum*.

In the southwestern part of the mire there are older mire parts without swamp influence. There are spruce-hardwood fens with *Betula pubescens, Carex lasiocarpa, C. rostrata, Rhynchospora alba, Sphagnum angustifolium, S. fallax, S. magellanicum* and *S. majus*. In the margin there is typical Ledum pine bog. In the southernmost part of the mire there is also a small typical *Sphagnum fuscum* pine bog.

In Harpar Storträsket some regionally threatened or rare plant species have been found: *Drosera intermedia, Eriophorum latifolium, Hammarbya paludosa, Eriophorum gracile* and *Juncus stygius*.

Peat studies in Harpar Storträsket

Veikko Valovirta

In 1973, the Geological Survey of Finland made peat corings in Harpar Storträsket systematically in 38 points. In addition, 6 corings were made in the black alder swamps. The mire was also levelled along transects. Also pH measurements were made in situ in each point.

The thin peat layer (20-40 cm) of the mire is eutrophic *Sphagnum-Carex* peat, which often contains remnants of *Alnus glutinosa*, and especially in the northern part of the mire *Typha latifolia* and *Thelypteris palustris*. In the southwestern bog part of the mire, the thickness of peat exceeds one metre. It is wood-*Sphagnum* peat, which in deeper parts is well humified, but in the surface only weakly humified.

Below the peat in the central parts of the mire there is greenish gyttja, which contains remnants of *Alisma plantago-aquatica, Chara* spp., *Eleocharis palustris, Equisetum fluviatile, Najas marina, Potamogeton natans, Sparganium erectum* and *S. simplex*. There are also diatom species, which are characteristic for brackish water, e.g. *Amphora ovalis var. pediculus*, *Campylodiscus echeneis, Epithemia zebra var. porcellus, Melosira jürgensi, M. westi, Nitzschia punctata* and *Synedra tabulata*. Below the gyttja there is gyttja clay and finally sand in the depth of 1,5 m from mire surface.

The surface peat is acid in the southern bog, but in the open fen pH varies between 5,8 and 6,3. In the black alder swamp the pH of the thin peat layer varies between 4,6 (driest places) and 6,1.

Harpar Storträsket represents greatly the swamps, which have been described e.g. along Lake Vanajavesi in southern Finland, from the Holocene warm period about 5000 years B.P., and which nowadays occur only in central and southern Europe.

Bird fauna of Harpar Storträsket

Kalevi Keynäs

Studies on the bird fauna of Harpar Storträsket have been conducted since the 1920s (Sundström 1927, Ruthke 1938). The mire has been used as a teaching object in the field courses of vertebrate ecology in Tvärminne zoological station since the 1950s. The bird fauna is rich both in the migration time and in the summer. The number of breeding bird species in 1973 was 75, including the marginal forests of the mire. In addition, 16 species have been observed as breeding earlier. The most remarkable breeding species are *Tetrao urogallus, Bonasa bonasa, Grus grus, Rallus aquaticus, Porzana porzana, Lymnocryptes minimus* (southernmost breeding couple in Finland), *Circus aeruginosus, Falco subbuteo, Anas querquedula, Aythya ferina, Anas acuta, Columba oenas, Asio flammeus, Picus canus, Dendrocopos minor, Lullula arborea, Aegithalos caudatus, Certhia familiaris, Ficedula parva* and *Lanius collurio*. The breeding bird densities are very high especially in the marginal parts of the mire. In 1973, in a thorough mapping of breeding birds, the density of nesting couples in the black alder swamp was 1500 pairs per km^2, including 23 species in a 4 hectare study area. The most abundant species were *Phylloscopus trochilus* and *Fringilla coelebs*.

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Excursion in the black alder swamp in Harpar Storträsket. In the foreground Pekka Salminen from the ministry of the environment and professor Rauno Ruuhijärvi, pioneers of Finnish mire conservation. Photo Tapio Lindholm 2005.

Conservation history of Harpar Storträsket

Kalevi Keynäs

In spring 1973 Fiskars company, which owns Harpar Storträsket, planned forestry drainage in the area. The idea was to make ditches around the whole mire. Due to the threat, a memorandum about the conservation value of Harpar Storträsket and other mires in the region was prepared and distributed widely to scientists, municipal and state authorities, nature conservation associations as well as Fiskars company. After that in April 1973 there was a meeting between the landowner, numerous scientists as well as representatives of nature conservation and regional planning organizations. It was agreed that the ditching will be postponed to make it possible to make surveys of the mire as a basis for decision making.

The ministry of agriculture and forestry made a proposa in May 1973 to Metsähallitus to start actions to buy the area to the state for nature conservation purposes. In the autumn, scientific societies Societas pro Fauna et Flora Fennica, Finnish biological society Vanamo and Finnish ornithological society appealed Fiskars company to cancel the ditching plans on the basis of the results of the inventories.

In November 1973 there was a meeting in Tvärminne zoological station. Metsähallitus had estimated the economical value of the are and proposed to buy it to the state. Fiskars company was not willing to sell the land, but they proposed to limit the ditching only in the tree covered marginal parts of the mire. If this could not be done, the company demanded for compensation of the losses. In the meeting, a compromise was made so that Fiskars company could clear the old ditch through the northwestern part of the mire and ditch the northern part between the main ditch and the margin. The state promised to compensate the economic losses of the company.

In March 1974 the board of Fiskars company decided to accept the compromise. In July 1974 the boundaries of the area to be protected were marked in the field. After all, the state was not yet able to compensate the financial losses of the company in 1977, due to very limited nature conservation funding at the time. However, the mire was not drained more than was agreed in 1973, and finally the mire was protected on the basis of the application of Fiskars company as a private nature reserve in 1987 on the decision of county administration. Then also the compensation was paid. However, the company made logging of forest inside the reserve in an area of about one hectare in winter 1987, due to a misunderstanding of the rules of the reserve. Since then, Harpar Storträsket nature reserve has been left intact.

Topographic map of Torronsuo National Park. Each grid square is 1 km2.

False-colour infrared aerial photograph of Torronsuo National Park. The red line shows the boundaries of Natura 2000 area.

When several units make one large bog massif

Torronsuo – Finland's largest raised bog massif

Teemu Tahvanainen

Conservation

With the area of about 26 km^2, Torronsuo mire is the largest raised bog in Finland. It is the greatest bog in three dimensions also, as the mean depth of peat in Torronsuo is as much as six metres. The Torronsuo National Park was established in 1990 with an area of 24 km^2. With minor extensions, the area belonging to the park is today 26.7 km^2, including the raised bog, and in the northern part of the park, Lake Talpianjärvi, which has a lowered water table and has grown into a marsh. Only very small areas in the park are forests on mineral ground (26 ha). The Torronsuo area was included in the National Mire Protection Programme (1981) and in the plan of Finnish National Parks (1979), as a site of both national and international significance. Earlier, there had been interest in the utilisation of the peat resources. Aartolahti (1965) reviewed the possibilities of utilisation but stated in clear terms that Torronsuo should be considered as a most valuable site of natural heritage in the national level. Today, the area is a part of the NATURA 2000 network. It is also included in the Ramsar list (Ramsar site no. 1536). Most of the Torronsuo area is in its pristine state but the marginal lagg fens are partly cleared into fields. Only minor parts have been drained (ca. 160 ha) and these have been restored under an EU Life project in 1997-1998.

Mire system

Torronsuo is located in the zone of concentric raised bogs. Its gross forms, surface patterns and vegetation are typical of the area, although the large size of the basin makes the bog system more complex (Aartolahti 1965). There are several more or less distinct bog massifs interconnected in the Torronsuo system. Clear concentric, cupola forms are seen in the western part of the system, while the eastern part is more level. Torronsuo lies on a comparably dry watershed area. The mire system has a small drainage area and minerogenous hydrological influence is very weak in the whole system level.

A remarkable feature of the concentric bog massifs in the Torronsuo system is the occurrence of multiple pine-bog slopes in a stepwise, concentric pattern. In a way, there are lesser bog massifs on top of larger massifs. Such patterns are seen in the Kakarlampi bog massif, in the westernmost part of the system, and in the Vehkasuo bog massif, the northern lobe of the system. Both of these two massifs also have very distinctly concentric patterns of hollows and hummocks. Concentric patterns and multiple pine-bog slopes are found in the central part of Torronsuo as well, but there

An oblique aerial view towards the east over the eastern part of Torronsuo mire. Photo Hannu Vallas.

another typical feature is perhaps even more characteristic. These bog plains are patterned with hundreds of pools, often round in shape and several metres deep. Some pools reach in depth to the underlying *Carex* peat and in such cases *Nuphar lutea* is abundant. Elsewhere as well, numerous pools of varying depth and form are found and altogether there are more than one thousand bog pools in the Torronsuo system. In addition, wet hollows with open water surface are abundant in central bog plains. The richness of different surface patterns is a very significant factor to the diversity of the fauna, particularly of birds and insects.

Vegetation

The vegetation of Torronsuo is typical of south-western Finnish raised bogs. A detailed inventory of vegetation is provided by Kotiluoto & al. (1996). The dominant bryophyte of the hummocks is by far *Sphagnum fuscum*. In lower hummocks, also *Sphagnum angustifolium, Sphagnum magellanicum* and *Sphagnum rubellum* are abundant. In the intermediate water-level surfaces, *Sphagnum tenellum* is common and in the hollows, *Sphagnum balticum* and *Sphagnum cuspidatum* are typical. The commonest dwarf shrubs of the kermis (the ombrotrophic hummock ridges) are *Calluna vulgaris, Vaccinium uliginosum, Ledum palustre* and *Betula nana*. Also *Andromeda polifolia, Vaccinium oxycoccos* and *Eriophorum vaginatum* are common. In contrast to bogs in eastern Finland, *Chamaedaphne calyculata* is very rare in Torronsuo, being found only in one locality, which is among the south-westernmost sites of the species. Among the vascular plants, *Scheuchzeria palustris* and *Rhynchospora alba* are characteristic in the hollows,

An oblique aerial view of a concentric bog over a bog in the eastern part of Torronsuo mire. Photo Hannu Vallas.

sometimes also *Carex limosa*. Typical species of narrow, flooded lagg fens are *Potentilla palustris, Menyanthes trifoliata, Carex canescens, Carex echinata, Eriophorum angustifolium, Peucedanum palustre* and *Lysimachia thyrsiflora*. In some places, wider lagg fens are poor sedge fens with *Carex lasiocarpa, Carex rostrata* and sometimes *Carex chordorrhiza*. Only in the southern margins of the central parts of the system, some ground water influence is found. There, in small areas, species like *Potentilla erecta, Carex panicea, Carex vaginata, Carex dioica, Carex flava, Scirpus sylvaticus, Trichophorum alpinum, Sphagnum warnstorfii, Sphagnum teres* and *Scorpidium scorpioides* are found (Kotiluoto & al. 1996).

Bird fauna

The Torronsuo bog system hosts a valuable bird fauna and is an important staging area during migration periods (Salminen 1980). The number of Cranes *(Grus grus)* has peaked up to one thousand individuals during the autumn migration. Local specialities include the Willow Grouse *(Lagopu lagopus)*, and the Red-throated Diver *(Gavia stellata)* that are very rare in southern Finland. There is a rich presentation of waders, gulls and waterfowl. The Mallard *(Anas platyrhynchos)* and the Teal *(Anas crecca)* are numerous, while the Northern Pintail *(Anas acuta)* a distinctly northern species is also found. The Curlew *(Numenius arquata)* and the Lapwing *(Vanellus vanellus)* are typical waders, but also more northern species such as the Wood Sandpiper *(Tringa glareola)* and the Ruff *(Philomachus pugnax)* nest in Torronsuo. A coastal element among the waders is represented by the Common Redshank *(Tringa totanus)*. Several gull species nest in Torronsuo *(Larus ridibundus, Larus canus, Larus argentatus)* which

Hummock-hollow patterns from the eastern part of Torronsuo mire. The hummock ridges rise gently only some 20-30 cm above the hollow surfaces. Photo Raimo Heikkilä.

is rare in Southern-Finnish bogs. Among the Passerines, the Meadow Pipit *(Anthus pratensis)* and the Yellow Wagtail *(Motacilla flava)* are the most abundant and other typical species include the Skylark *(Alauda arvensis)*, the Wagtail *(Motacilla alba)*, the Whinchat *(Saxicola rubetra)*. Also the Great Grey Shrike *(Lanius excubitor)* is met in Torronsuo.

Lepidoptera

The Lepidoptera fauna of the Torronsuo is exceptionally diverse and interesting. The richness of the Lepidoptera is preserved thanks to the pristine state and the vast area of the bog. Altogether 50 species typical of mire environments have been found in Torronsuo and in an inventory in 1992, Järventausta (1996) found 45 of these species. There is an interesting mix of northern, eastern and southern elements in the species list. To the northern element belong species such as *Pyrgus centaurea, Clossiana freia, Chloroclysta infuscata, Lycia lapponaria* and the endangered species *Clossiana frigga*. The southern species include *Gynaephora selenetica, Chlorissa viridata, Perconia strigillaria* and the nationally endangered *Aspitates gilvaria*. Among the *Trichoptera* found in Torronsuo, *Limnephilus externus* is one species rare in South-Finland (Järventausta 1996).

Mire development

The development of the Torronsuo mire system was initiated by the terrestrialization of a shallow lake (Aartolahti 1965). Layers of clay and gyttja as well as some *Carex* peat at the base of the peat were deposited during the Boreal phase around 8500 BP in the light of the pollen stratigraphy. During the Atlantic Period indicated by pollen of *Quercus, Ulmus, Corylus* and *Tilia*, the peat accumulation was slow and yielded a layer of about one metre of *Carex* peat with variable amounts of *Equisetum* and wood remains. The *Carex-peat* phase ended right before the arrival of *Picea* in the area,

which took place at about 4500 BP. At this phase, in the switch from the Atlantic to the Boreal Period, there was a marked switch in vegetation and the accumulation of *Sphagnum* peat began (Fig. 1). Also the peat macrofossils were examined by Aartolahti (1965), and according to his conclusion, this switch from *Carex* to *Sphagnum* peat soon lead to ombrotrophic conditions and to the development of the mire into a raised bog. Above the 1.5 metres of basal gyttja and *Carex* peat there is five to six, in some places almost eight metres of *Sphagnum* peat, which give a range of 1.1 to 1.8 mm/yr for the long-term rate of peat accumulation.

Ecosystem services

Torronsuo National Park provides significant services such as maintenance of water quality, environmental education, scientific research, outdoor recreation and bird watching. Annually, there are more than 20 000 visitors in the Torronsuo National Park. Most visitors spend a day or few hours taking a walk along the wooden board walks and viewing the bog scenery from the observation tower. There are twelve kilometres of marked trails in the park and 200 metres is suitable for handicapped visitors also.

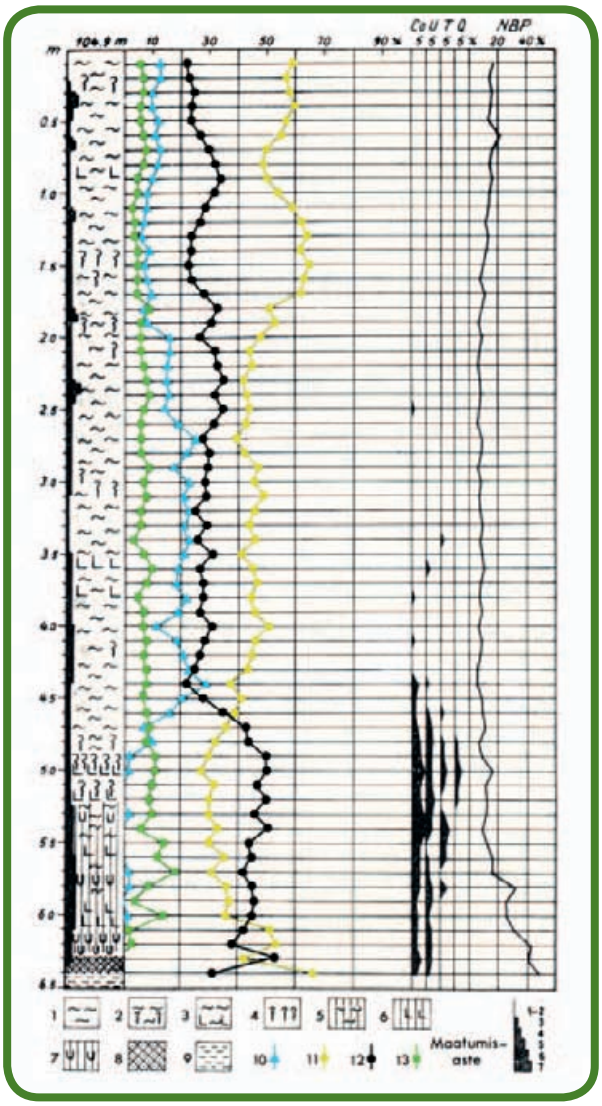

Figure 1. Pollen diagram of Torronsuo mire. Modified from Aartolahti (1965). 1 = *Sphagnum* peat, 2 = *Eriophorum vaginatum* – *Sphagnum* peat, 3. *Sphagnum* peat with abundant ligneous remains, 4 = *Eriophorum vaginatum* peat, 5 = *Sphagnum* – *Carex* peat, 6 = *Carex* peat with abundant ligneous remains, 7 = *Carex* peat with *Equisetum*, 8 = coarse detritus gyttja, 9 = fine detritus gyttja, 10 = *Picea*, 11 = *Pinus*, 12 = *Betula*, 13 = *Alnus*, C = *Corylus*, U = *Ulmus*, T = *Tilia*, Q = *Quercus*. Maatumisaste = Humification (von Post).

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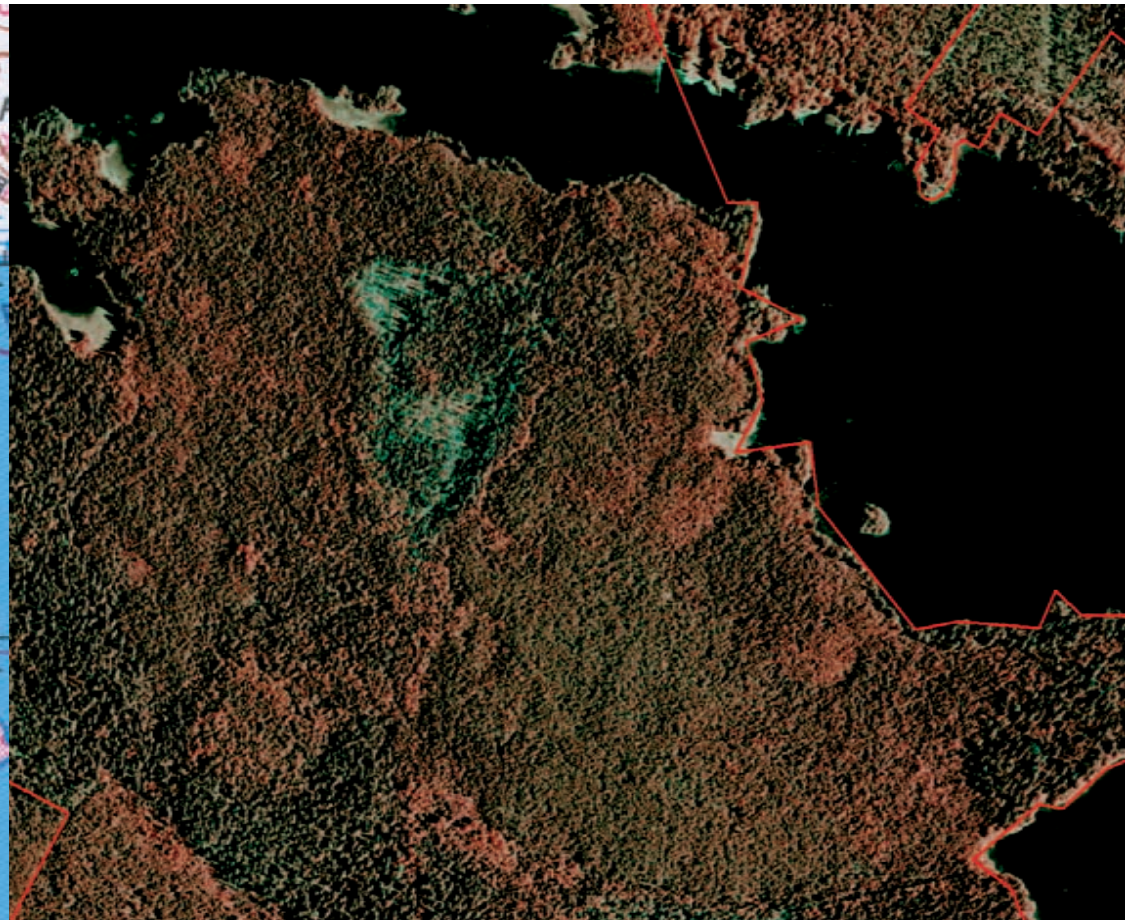
Topographic map of Soukonkorpi area in Liesjärvi National Park. Each grid square is 1 km2.



False-colour infrared aerial photograph of Soukonkorpi area in Liesjärvi National Park.
The red line shows the boundaries of Natura 2000 area.

Restoration of forest and mire mosaic

Liesjärvi National Park

Teemu Tahvanainen & Raimo Heikkilä

Introduction

Liesjärvi National Park was established in 1956, covering an area of 1.5 km^2. Some forests in the area had been protected since 1926, already. The park has been extended in several occasions. In 2005, the area of the park was doubled and the total area today is 22 km^2. There are old-growth forests in the older parts of the park, while most of the forests have been subject to variable forestry practices and, thus, there are forests with variable age structure in the park. However, over one-third of the forest is over 100 years old. In 1993, Metsähallitus began a project in order to restore forests to their natural state. They have been burnt in a way, which resembles natural forest fires, and trees have been felled so that there would be more decaying wood on the forest floor. Also most of the mires in the national park had been drained before the establishment and extensions of the park, and these mires are now under restoration.

Mires of Liesjärvi: vegetation and flora

The mires in Liesjärvi national park are very small. Typically they are narrow strips of spruce mires or pine mires between moraine hills. They do not form mire massifs. About two thirds of the spruce mires and practically all pine mires have been drained. Also the tree stands in mires have been logged. The ditching of mires started already in the beginning of 1900s, and the most active drainage period was in the 1930s. The last ditches were dug in 1964. Due to the long time after the ditching it is in most cases difficult to identify the original natural site type (Luttinen 1985). The pristine spruce mires are mostly fern-dominated thin-peated intermediate rich spruce mires. There are also some *Equisetum sylvaticum* spruce mires, which are more poor (Luttinen 1985).

The mire flora of Liesjärvi is rather poor, and there are no rare or threatened species. The most interesting vascular plants are *Carex disperma* and *C. loliacea. Hylocomium umbratum* is an uncommon indicator of ground water influence in spruce mires (Luttinen 1985).

Fauna

Several woodpeckers inhabit the forests of the national park, including the Black Woodpecker *(Dryocopus martius)*, the Great Spotted Woodpecker *(Dendrocopos major)*, the Three-toed Woodpecker *(Picoides tridactylus)*, Grey-headed Woodpecker *(Picus canus)* and the Lesser Spotted Woodpecker *(Dendrocopos minor)*. For the woodpeckers, the forest restoration activities are favourable and the woodpeckers in turn favour many other species that use their nest holes. One such species is the Siberian Flying Squirrel *(Pteromys volans)*.

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Restoration of the spruce mire Soukonkorpi in Liesjärvi national park

Kaisu Aapala & Harri Tukia

Drainage of spruce mires has been very extensive, especially in southern Finland, where 78 % of them have been drained. Less than 1 % of spruce mires in southern Finland have been protected and almost half of these have been drained, so there is an obvious need for restoration.

A large amount of dead spruce wood in the restored Soukonkorpi area. Photo Tapio Lindholm.

Dead *Hylocomium splendens* in a wet depression in the restored Soukonkorpi mire, being replaced by *Sphagnum*. In the upper left corner there is still living *Hylocomium* on a hummock. Photo Tapio Lindholm.

The study site, Soukonkorpi, is a 13 ha spruce mire situated in the Liesjärvi national park. It was drained in the 1930s. Liesjärvi national park was established in 1956 and extended substantially in 1981 when also this study site became a part of the national park. Soukonkorpi was restored in 1995 by damming the ditches with an excavator. In the northern part of the mire a 0.8 ha opening was made by cutting 1/3, girdling 1/3 and leaving 1/3 of the trees untouched. Otherwise the tree stand was left untreated. Monitoring the effects of restoration includes monitoring of water level, tree stand, vegetation, beetles and polypores. There are no pristine spruce mires in the vicinity to use as a reference area.

The water table level was monitored in five points from 1995 (before restoration) until 1998. In the northern part of the peatland, where the drainage had been most effective, the water level was c. 60 cm below surface throughout the growing season. After restoration the water table rose on average 40 cm. In the southern part of the peatland, where the drainage had had less effect, the restoration did not have much effect on water table level.

Tree stand monitoring is based on 19 sample plots (0.04 ha). Monitoring started in 1995, before restoration, and has been repeated three times. Before restoration the tree stand consisted of even-aged (85 yrs) and even-sized spruce and the average volume was 200-250 m^3/ha. The proportion of deciduous species was very low. The volume of snags was on average 5 m^3/ha and of logs 6 m^3/ha. The rise of the water table has

been detrimental to spruce in parts of the restored peatland, and a lot of trees have died, especially near the blocked ditches. The very wet summer in 1998 accelerated the process. Restoration has increased the amount of dead wood, so that in 2005 the volume of snags was on average 50 m^3/ha and the volume of logs 30 m^3/ha. Also natural disturbances, such as snow and storms, have increased the amount of dead wood.

Vegetation changes are monitored in two study sites (14 x 28 m) with 30 1m2 sample plots in each. First monitoring was made before restoration and so far monitoring has been repeated five times. In the northern part of the peatland the coverage of *Sphagnum* has increased from 50 % to 85 % and in the middle part of the mire from 75 % to 90 % in ten years (Aapala, unpubl. data). The total number and the total coverage of vascular plant species in study sites has increased.

The changes in beetle *(Coleoptera)* species assemblages are monitored in three sites with pit-fall and window traps and trunk window traps. Monitoring began in 1995 and has been repeated four times. The total number of beetle species has decreased from 220 to 120 in five years (Tukia, unpubl. data). The generalist forest species have disappeared and species favoring swamp forests have become more common. The increased volume of dead wood increased locally the amount of bark beetles in 1996-1998, but in 2000 the amount was already lower.

An inventory of the polypore species growing on dead wood was made before restoration. Altogether 24 species were found, of which three were nearly threatened (NT).

Flora and land bird fauna of the presented mire sites

Vascular plants and bryophytes of mires in the IMCG 2006 excursion sites

Raimo Heikkilä

Table: The vascular plants and bryophytes recorded in the sites visited by the IMCG 2006 excursion. The locations are as follows: 1 Teuravuoma, 2 Karhakkamaanjänkä, 3 Martimoaapa, 4 Ryöskäri-Ihanalampi, 5 Hirvisuo, 6 Olvassuo, 7 Hummasti, 8 Salamajärvi, 9 Levaneva, 10 Lauhavuori, 11 Kauhaneva, 12 Seitseminen, 13 Punassuo, 14 Harpar Storträsk, 15 Torronsuo, 16 Liesjärvi.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
TREES AND SHRUBS																
Alnus glutinosa				x		x	x		x	x	x	x		x	x	x
A. incana		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Betula nana	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Betula pendula		x	x		x	x	x	x	x	x	x	x			x	x
B. pubescens	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Daphne mezerum		x								x						x
Hippophaë rhamnoides				x			x									
Juniperus communis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Myrica gale				x			x							x		
Picea abies	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pinus sylvestris	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Populus tremula	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Prunus padus		x		x			x			x		x			x	
Rhamnus frangula			x	x	x	x	x		x	x	x	x	x	x	x	
Ribes nigrum		x								x						x
R. spicatum		x														x
Rubus idaeus			x			x	x	x		x		x	x	x	x	x
Salix aurita		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. caprea		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. cinerea		x	x	x	x	x	x	x	x	x	x	x	x		x	x
S. glauca	x	x														
S. hastata		x														
S. lapponum	x	x	x	x	x	x	x	x	x	x	x					
S. myrsinifolia		x							x	x	x	x			x	
S. myrsinites	x	x														
S. myrtilloides	x	x	x	x	x	x	x	x	x	x	x			x	x	
S. pentandra		x	x	x		x	x	x	x	x	x	x		x	x	x
S. phylicifolia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. repens				x	x		x		x	x	x	x		x	x	x
Sorbus aucuparia	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DWARF SHRUBS																
Andromeda polifolia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Calluna vulgaris		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chamaedaphne calyculata			x	x	x	x	x	x								
Empetrum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Ledum palustre	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x
Vaccinium microcarpum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
V. myrtillus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
V. oxycoccos	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
V. uliginosum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
V. vitis-idaea	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
SEDGE PLANTS																
Carex acuta		x	x			x	x	x	x	x	x	x				x
C. appropinquata		x														
C. aquatilis		x	x	x	x	x	x				x	x				
C. atherodes		x														
C. brunnescens	x		x		x	x	x	x		x	x	x			x	
C. buxbaumii								x								
C. canescens	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. capillaris		x		x												
C. capitata		x														
C. cespitosa		x	x	x	x	x	x					x				
C. chordorrhiza	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x
C. diandra	x	x	x	x	x	x	x		x		x			x		
C. dioica	x	x	x	x	x	x	x	x		x	x			x	x	
C. disperma				x		x	x			x					x	x
C. Echinata			x	x	x	x	x	x	x	x	x	x		x	x	x
C. elongata				x										x	x	
C. flava		x		x											x	
C. globularis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. heleonastes	x	x		x		x										
C. lapponica	x			x			x									
C. Lasiocarpa	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. laxa				x		x										
C. limosa	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. livida	x	x	x	x	x	x	x	x	x	x						
C. loliacea				x		x	x	x		x	x	x		x	x	x
C. mackenziei				x			x									
C. magellanica	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. nigra ssp. juncella		x	x		x	x	x			x					x	
C. nigra ssp. nigra		x	x	x		x	x	x	x	x	x	x	x	x	x	x
C. panicea		x						x		x					x	
C. paniculata										x	x					
C. pauciflora	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. rhynchophysa				x											x	
C. rostrata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. rotundata					x											

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C. vaginata		x	x	x		x	x	x	x	x		x			x	x
C. vesicaria	x	x		x		x		x	x	x		x	x	x	x	x
C. viridula var. bergrothii		x														
C. viridula var. viridula							x			x						x
Eleocharis palustris				x			x					x				x
E. quinqueflora		x		x			x									
Eriphorum angustifolium	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
E. gracile	x	x	x	x	x	x	x	x	x					x		
E. latifolium		x	x	x			x							x		
E. russeolum	x				x											
E. scheuchzeri			x													
E. vaginatum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Rhynchospora alba			x	x	x	x	x	x	x	x	x	x	x	x	x	x
R. fusca					x		x	x		x	x					
Schoenoplectus lacustris				x			x									
Scirpus sylvaticus															x	x
Trichophorum alpinum	x	x	x	x	x	x	x	x		x		x			x	x
T. cespitosum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
GRAMINEOUS PLANTS																
Agrostis canina		x	x	x	x	x	x	x	x	x	x	x		x	x	x
Calamagrostis canescens			x	x	x	x	x	x		x	x	x			x	x
C. epigejos		x	x		x	x	x	x	x	x	x	x			x	x
C. lapponica	x	x			x	x										
C. purpurea	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
C. stricta	x	x	x	x		x	x			x	x	x		x	x	x
Deschampsia cespitosa		x	x	x		x	x	x	x	x	x	x	x	x	x	x
D. flexuosa	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x
Elymus caninus							x									
Festuca ovina		x						x			x	x			x	x
F. rubra		x	x	x		x	x	x		x	x	x				x
Glyceria fluitans							x								x	x
Hierochloë hirta				x												
Juncus bulbosus							x			x	x					
J. filiformis			x	x	x	x	x	x	x	x	x	x	x	x	x	x
J. stygius	x		x	x	x	x	x	x		x	x					
Luzula pilosa	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
L. sudetica		x		x		x					x					
Melica nutans		x		x			x	x		x		x			x	x
Milium effusum		x		x			x		x	x		x		x		x
Molinia caerulea	x	x	x	x	x	x	x	x	x	x	x	x				x
Nardus stricta			x	x		x	x	x		x	x					
Phalaris arundinaceae		x	x			x	x	x		x	x	x		x		x
Phragmites australis		x	x	x	x	x	x	x	x	x	x	x		x	x	x
Poa alpigena				x		x					x					
P. palustris																x
Poa subcaerulea										x						
P. trivialis			x	x		x	x			x		x				x

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
HERBS																
Alisma plantago-aquatica				x		x	x							x		
Angelica sylvestris		x	x	x		x	x	x	x	x	x	x		x		x
Athyrium filix-femina			x	x		x	x	x	x	x	x	x		x	x	x
Bistorta vivipara		x		x		x	x		x	x	x	x				
Calla palustris	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Caltha palustris		x	x	x		x	x	x		x	x	x	x	x	x	x
Cardamine amara										x			x			
C. pratensis				x		x	x							x	x	
Chrysosplenium alternifolium										x						
Cicerbita alpina																
Cicuta virosa	x		x	x	x	x	x	x	x					x	x	x
Cirsium helenioides		x	x	x		x	x	x	x	x	x	x			x	x
C. palustre		x	x	x		x	x	x		x	x	x	x	x	x	x
Coeloglossum viride		x		x					x							
Convallaria majalis		x	x	x			x	x	x	x	x	x		x	x	x
Corallorhiza trifida		x	x	x	x	x	x	x	x	x		x		x	x	
Cornus suecica		x	x	x	x	x	x			x						
Crepis paludosa		x		x		x	x			x	x			x		
Cypripedium calceolus		x														
Dactylohiza fuchsii										x						
D. incarnata	x	x	x	x	x	x	x	x	x	x						
D. incarnata ssp. cruenta		x		x			x									
D. maculata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
D. traunsteineri		x		x			x									
Drosera longifolia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
D. rotundifolia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dryopteris expansa							x	x		x		x		x	x	x
D. carthusiana		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
D. cristata														x		
Epilobium angustifolium	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
E. davuricum		x														
E. hornemannii						x										
E. palustre	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Epipactis palustris		x														
Epipogium aphyllum								x								
Equisetum arvense		x	x	x	x	x	x	x	x					x	x	x
E. fluviatile	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
E. hyemale				x												
E. palustre	x	x	x		x	x	x	x	x	x	x	x		x	x	x
E. pratense		x														
E. sylvaticum	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
Euphrasia frigida				x												
Filipendula ulmaria		x	x	x		x	x	x		x	x	x		x	x	
Galium boreale				x			x					x			x	x
G. palustre		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
G. trifidum	x			x		x	x	x	x		x					

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
G. uliginosum		x	x	x		x	x		x	x		x		x	x	x
Geranium sylvaticum		x	x	x	x	x	x	x	x	x	x	x		x	x	x
Geum rivale		x	x	x		x	x	x	x	x		x		x	x	x
Goodyera repens								x		x						
Gymnadenia conopsea		x														
Gymnocarpium dryopteris		x	x		x	x	x	x	x	x	x	x	x	x		x
Hammarbya paludosa		x	x	x		x	x		x	x					x	
Hieracium Sylvatica -group		x	x			x	x			x	x	x	x	x		x
Hippuris vulgaris				x		x	x							x		
Huperzia selago		x		x		x				x	x				x	x
Impatiens noli-tangere														x		
Iris pseudacorus														x	x	
Lactuca sibirica				x												
Lathyrus palustris				x			x									
Linnaea borealis	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x
Listera cordata		x		x	x	x	x	x		x		x		x		x
L. ovata		x														
Lychnis flos-cuculi										x						
Lycopodiella inundata					x	x	x			x						
Lycopodium annotinum			x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lycopus europaeus														x		
Lysimachia thyrsiflora		x	x	x	x	x	x	x	x	x	x	x		x	x	x
L. vulgaris			x	x		x	x	x				x		x	x	x
Lythrum salicaria				x			x	x						x		
Maianthemum bifolium		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Melampyrum pratense	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
M. sylvaticum		x	x	x	x	x	x	x	x	x	x	x			x	x
Menyanthes trifoliata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Moneses uniflora		x		x		x	x	x		x	x					x
Montia fontana	x					x	x		x	x						
Nuphar								x	x					x	x	
Nymphaea								x			x			x		
Orthilia secunda		x	x		x	x	x	x	x	x	x	x	x	x	x	x
Oxalis acetosella		x					x	x		x				x	x	x
Paris quadrifolia		x		x		x	x	x	x	x	x	x		x	x	x
Parnassia palustris	x	x	x	x		x	x									
Pedicularis palustris	x	x	x	x	x	x	x	x		x	x			x		x
P. sceptrum-carolinum		x	x	x	x	x		x		x	x					
Petasites frigidus		x				x										
Peucedanum palustre	x	x	x	x	x	x	x	x	x	x		x		x	x	x
Phegopteris connectilis		x	x	x		x	x	x		x	x	x		x	x	x
Pinguicula vulgaris	x	x	x	x												
Potentilla erecta						x	x	x	x	x	x	x			x	x
P. palustris	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pyrola minor	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P. rotundifolia		x	x	x		x	x	x	x	x		x		x	x	x
Ranunculus acris		x		x		x	x	x	x	x	x	x		x		x

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
R. repens		x		x		x	x	x		x	x	x		x	x	x
Rubus arcticus		x	x	x	x	x	x	x	x	x	x	x		x		x
R. chamaemorus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
R. saxatilis		x	x	x	x	x	x	x	x	x	x	x		x	x	x
Rumex acetosa		x				x	x	x	x	x	x	x		x		x
R. aquaticus		x														
Saussurea alpina		x														
Saxifraga hirculus	x	x				x										
Scheuchzeria palustris	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Scutellaria galericulata				x		x	x							x	x	
Selaginella selaginoides		x	x	x		x		x								
Solanum dulcamara														x		
Solidago virgaurea	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sparganium hyperboreum				x						x	x					
Stellaria crassifolia	x	x		x		x										
S. longifolia		x					x			x				x		
S. nemorum				x												
S. palustris				x			x			x				x		
Succisa pratensis										x						
Thalictrum alpinum		x														
T. flavum				x												
Thelypteris palustris														x		
Tofieldia pusilla	x	x	x	x		x				x						
Trientalis europaea	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Triglochin palustris		x		x												
T. maritima				x												
Trollius europaeus		x		x												
Tussilago farfara								x		x					x	
Typha							x							x	x	
Utricularia intermedia	x	x	x	x	x	x	x	x	x	x	x			x	x	x
U. minor	x	x	x			x	x			x		x			x	x
U. vulgaris				x												
Valeriana sambucifolia		x		x			x		x	x				x		
Viola epipsila		x	x	x	x	x	x	x			x					
V. palustris		x	x	x		x	x	x	x	x	x	x	x	x	x	x
HEPATICAE																
Aneura pinguis		x	x			x	x			x				x	x	
Barbilophozia kunzeana		x														
Calypogeia (sphagnicola)										x						
Chiloscyphus polyanthos						x				x	x		x			
Cladopodiella fluitans			x			x	x		x	x	x	x	x	x	x	
Gymnocolea inflata			x			x	x		x	x	x	x	x		x	
Kurzia pauciflora										x						
Leiocolea rutheana		x														
Marchantia polymorpha			x			x	x		x	x	x			x	x	x
Mylia anomala		x	x			x	x		x	x	x	x	x		x	x
Odontoschisma elongatum																

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Pellia						x				x				x		
Ptilidium ciliare										x						
Scapania			x			x	x				x					
SPHAGNIDAE																
Sphagnum angustifolium		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. annulatum (incl. S. jensenii)		x	x	x	x	x	x	x	x	x	x	x				
S. aongstroemii			x	x	x	x		x								
S. balticum			x	x	x	x	x	x	x	x	x	x	x	x	x	
S. capillifolium		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. centrale		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
S. compactum			x	x	x	x	x	x	x	x	x	x		x		
S. contortum				x		x	x									
S. cuspidatum									x	x	x				x	
S. denticulatum				x	x	x	x		x	x	x			x		
S. fallax		x	x	x	x	x	x	x	x	x	x	x		x		x
S. fimbriatum			x	x	x	x	x	x	x	x	x	x		x		x
S. flexuosum			x	x	x	x	x	x	x	x	x	x		x		
S. fuscum		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. girgensohnii			x	x	x	x	x	x	x	x	x	x		x	x	x
S. lindbergii		x	x	x	x	x	x	x	x	x	x	x			x	
S. magellanicum		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. majus		x	x	x	x	x	x	x	x	x	x	x	x		x	
S. molle										x	x					
S. obtusum			x	x		x	x	x	x		x	x		x		
S. papillosum		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. platyphyllum		x	x	x	x	x	x	x	x	x	x					x
S. pulchrum			x		x	x	x	x	x	x	x	x				
S. quinquefarium								x				x				
S. riparium		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. rubellum			x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. russowii		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
S. squarrosum		x		x	x	x	x	x	x	x	x	x		x	x	x
S. subfulvum		x	x	x	x	x	x	x		x						
S. subnitens					x		x	x		x		x				x
S. subsecundum		x	x	x	x	x	x	x	x	x	x	x		x	x	x
S. tenellum			x		x	x	x	x	x	x	x	x	x	x	x	x
S. teres		x	x	x	x	x	x	x	x	x	x	x		x	x	x
S. warnstorfii		x	x	x	x	x	x	x	x	x	x	x		x	x	
S. wulfianum		x		x	x			x				x			x	
BRYIDAE																
Amblyodon dealbatus		x														
Aulacomnium palustre		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Brachythecium reflexum				x						x						x
B. rivulare				x		x		x	x	x	x					
B. rutabulum										x						
B. starkei										x						
Bryum neodamense		x														

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Bryum pseudotriquetrum		x		x		x	x		x					x		
B. weigelii						x				x	x					
Calliergon cordifolium		x	x	x	x	x	x	x	x	x	x	x		x	x	x
C. giganteum		x		x		x	x	x		x				x		x
C. megalophyllym				x												
C. richardsonii		x		x		x	x		x					x	x	
Calliergonella cuspidata		x		x		x	x			x	x			x	x	
C. Lindbergii				x		x	x									x
Campylium stellatum		x	x	x		x	x	x						x		
Catoscopium nigritum		x														
Cinclidium stygium		x		x		x	x							x		
C. subrotundum				x	x	x	x									
Climacium dendroides		x	x	x		x	x	x	x	x		x	x	x	x	x
Cratoneuron filicinum		x														
Dicranella cerviculata										x	x					
Dicranum angustum				x												
D. bergerii			x	x	x	x	x	x	x	x	x	x	x	x	x	
D. bonjeanii		x		x		x	x									
D. fuscescens							x			x	x			x		
D. leioneuron				x												
D. majus			x	x	x	x	x	x	x	x	x	x	x	x	x	x
D. polysetum		x	x		x	x	x	x	x	x	x	x	x	x	x	x
D. scoparium			x	x	x	x	x	x	x	x	x	x	x	x	x	
Drepanocladus aduncus		x		x			x									
Fissidens adianthoides		x		x		x	x							x		
F. osmundoides		x														
Fontinalis antipyretica						x		x		x	x		x			
Hamatocaulis lapponicus	x	x			x	x										
H. vernicosus	x	x		x				x								
Helodium blandowii		x	x	x	x	x	x	x	x	x	x	x		x		
Hylocomiastrum umbratum								x								x
Hylocomium splendens		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Loeskypnum badium		x	x	x	x	x	x	x		x						
Meesia longiseta		x		x	x		x									
M. triquetra		x		x		x	x									
M. uliginosa		x														
Paludella squarrosa		x	x	x		x	x	x		x	x			x		
Palustriella falcata		x														
Philonotis fontana				x		x		x		x						
P. seriata						x										
Plagiomnium elatum		x														
P. ellipticum		x		x	x	x	x	x	x	x	x			x	x	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P. medium				x		x	x	x				x		x		x
P. undulatum										x						x
Plagiothecium spp.						x	x			x	x			x	x	
Pleurozium schreberi		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pohlia nutans		x	x	x	x	x	x	x	x	x	x	x	x	x	x	
P. wahlenbergii								x								
Polytrichastrum formosum															x	
P. longisetum					x											
Polytrichum commune		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
P. strictum			x	x	x	x	x	x	x	x	x	x	x	x	x	
P. swartzii			x	x	x	x	x		x	x				x		
Pseudobryum cinclidioides		x	x	x	x	x	x	x	x	x	x	x		x	x	x
Pseudo-calliergon lycopodioides		x														
P. trifarium		x		x		x	x									
Rhizomnium magnifolium						x	x	x		x		x		x	x	x
R. pseudopunctatum		x		x	x	x	x	x				x				x
R. punctatum		x				x	x		x	x	x			x		x
Rhodobryum roseum							x	x		x				x	x	x
Rhytidiadelphus subpinnatus															x	
R. triquetrus		x			x	x	x	x	x	x	x	x		x		x
Sanionia uncinata		x		x		x	x			x		x		x	x	
Scorpidium cossonii		x		x		x										
S. revolvens		x	x	x	x	x	x	x		x					x	x
Scorpidium scorpioides		x	x	x	x	x	x	x						x	x	
Splachnum luteum		x	x	x		x	x		x		x					
Straminergon stramineum		x	x	x	x	x	x	x	x	x	x	x		x	x	
Thuidium recognitum				x												
Tomentypnum nitens		x		x		x	x	x		x	x					
Warnstorfia exannulata		x	x	x	x	x	x	x	x	x	x	x		x	x	
W. fluitans			x	x	x	x	x	x	x	x	x	x	x	x	x	
W. procera		x	x	x	x	x	x	x		x		x			x	x
W. sarmentosa		x	x	x		x		x		x						
W. tundrae				x		x	x									
LICHENS																
Cladonia, subgenus Cladina								x	x	x	x		x		x	
Cladonia, subgenus Cenomyce								x	x	x	x		x		x	
Cetraria ericetorum										x						
C. islandica									x	x	x		x			
Cetrariella delisei									x	x	x				x	
Icmadophila ericetorum										x	x					
Ochrolechia frigida										x						
Peltigera aphthosa										x						

Mire land birds of 14 Finnish mires and wetlands

Ari Rajasärkkä

Finnish Forest and Park Service (Metsähallitus) has started line transect censuses (Järvinen & Väisänen 1976) of land birds in Finnish nature reserves in 1981. In 25 years 1981-2005, census data has been collected in about 500 reserves, the total length of transects being about 15 000 km. Because the method is valid only for land birds, waterfowl, gulls and terns are not counted at all in these censuses. In each studied reserve transects were located so that the whole reserve is covered well with these transects. Therefore the results represent quite reliably the land bird fauna as a whole in each studied reserve.

The densities (pairs / km^2) of each land bird species were calculated from the original observation numbers by using species specific correction coefficients (see e.g. Järvinen & Väisänen 1983). These densities are the average densities per total land area of each reserve. Mire birds use only a certain part of all the habitats occurring in each reserve, avoiding forests. For each reserve the proportion of suitable habitat for mire birds can be calculated from the ratio between the area of open or semiopen sparsely wooded land and the total land area. For calculating the mire bird densities in suitable (semi)open habitats the original average densities of each species were divided by the proportion of the area of (semi)open land. The same was done for species of other open habitats, too.

The total density of birds of open areas is usually quite low in the mires of nature reserves when considering the whole mire areas of the reserves. The density of 14 IMCG excursion sites varies from 13 to 202 pairs / km^2, the highest density of these areas being found in Liminganlahti wetland. At Liminganlahti, a very rich bird fauna occurs in almost all open land (incl. reedbeds and other helophyte vegetation). In most nature reserves, the bird fauna of large areas of open mires and especially of sparsely wooded pine bogs is quite poor, the highest densities concentrating in only relatively small "hot spots". That lowers the bird density in the whole mire area in the reserves. The bird density in these "hot spots" may be manifold compared to the average density in larger mire areas.

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Järvinen, O. & Väisänen, R.A. 1976: Finnish line transect censuses. – Ornis Fennica 53: 115-118.

Järvinen, O. & Väisänen, R.A. 1983: Correction coefficients for line transect censuses of breeding birds. – Ornis Fennica 60: 97-104.

Table: From the IMCG field excursion sites 14 are nature reserves whose land birds are thoroughly censused. The mire bird fauna (incl. birds of other open habitats too) of these 14 reserves are presented in the following tables. The columns of the tables are: D = density in open and semiopen habitats (pairs / km^2), Min = estimate of minimum breeding population and Max = estimate of maximum breeding population. * = not a breeding species in the area. The Total row sums the densities and population size estimates. The actual total bird density in these mires is somewhat higher because only land birds were counted in the line transect censuses. In addition to land birds the diversity of waterfowl, gulls and terns may be high in many areas.

		D	Min	Max
TEURAVUOMA - KIVIJÄRVENVUOMA				
Willow Grouse	*(Lagopus lagopus)*	1,6	80	150
Crane	*(Grus grus)*	0,2	10	15
Broad-billed Sandpiper	*(Limicola falcinellus)*	1,0	50	45
Jack Snipe	*(Lymnocryptes minimus)*	0,1	5	9
Snipe	*(Gallinago gallinago)*	1,7	85	120
Whimbrel	*(Numenius phaeopus)*	0,0	2	3
Curlew	*(Numenius arquata)*	0,1	3	5
Spotted Redshank	*(Tringa erythropus)*	0,1	3	4
Greenshank	*(Tringa nebularia)*	0,3	13	18
Wood Sandpiper	*(Tringa glareola)*	6,6	330	500
Red-necked Phalarope	*(Phalaropus lobatus)*	0,2	8	12
Meadow Pipit	*(Anthus pratensis)*	7,5	370	550
Yellow Wagtail	*(Motacilla flava)*	10,8	550	850
Wagtail	*(Motacilla alba)*	0,3	17	27
Whinchat	*(Saxicola rubetra)*	0,4	21	31
Sedge Warbler	*(Acrocephalus schoenobaenus)*	0,3	14	23
Reed Bunting	*(Emberiza schoeniclus)*	5,8	290	430
Total		36,9	1900	2800
MARTIMOAAPA				
Willow Grouse	*(Lagopus lagopus)*	0,6	60	100
Crane	*(Grus grus)*	0,3	32	45
Golden Plover	*(Pluvialis apricaria)*	0,2	20	28
Lapwing	*(Vanellus vanellus)*	0,9	85	120
Broad-billed Sandpiper	*(Limicola falcinellus)*	0,9	85	130
Ruff	*(Philomachus pugnax)*	2,5	230	340
Jack Snipe	*(Lymnocryptes minimus)*	0,3	23	46
Snipe	*(Gallinago gallinago)*	2,2	200	280
Whimbrel	*(Numenius phaeopus)*	0,6	50	70
Curlew	*(Numenius arquata)*	1,1	100	140
Spotted Redshank	*(Tringa erythropus)*	0,2	19	27
Redshank	*(Tringa totanus)*	0,0	4	6
Greenshank	*(Tringa nebularia)*	0,5	48	65
Wood Sandpiper	*(Tringa glareola)*	8,2	750	1100
Red-necked Phalarope	*(Phalaropus lobatus)*	0,2	16	26
Skylark	*(Alauda arvensis)*	0,0	3	4
Meadow Pipit	*(Anthus pratensis)*	13,2	1200	1800

		D	Min	Max
Yellow Wagtail	*(Motacilla flava)*	15,8	1500	2300
Wagtail	*(Motacilla alba)*	1,0	90	140
Whinchat	*(Saxicola rubetra)*	0,4	39	60
Sedge Warbler	*(Acrocephalus schoenobaenus)*	0,7	60	100
Reed Bunting	*(Emberiza schoeniclus)*	4,0	360	550
Total		53,8	5000	7500
HIRVISUO				
Willow Grouse	*(Lagopus lagopus)*	0,5	20	35
Crane	*(Grus grus)*	0,4	16	23
Golden Plover	*(Pluvialis apricaria)*	1,6	60	85
Lapwing	*(Vanellus vanellus)*	0,1	3	5
Broad-billed Sandpiper	*(Limicola falcinellus)*	0,4	17	25
Ruff	*(Philomachus pugnax)*	0,8	32	48
Snipe	*(Gallinago gallinago)*	0,3	10	14
Whimbrel	*(Numenius phaeopus)*	1,4	55	75
Curlew	*(Numenius arquata)*	1,2	44	60
Spotted Redshank	*(Tringa erythropus)*	0,2	9	12
Greenshank	*(Tringa nebularia)*	0,3	12	17
Wood Sandpiper	*(Tringa glareola)*	3,0	120	170
Marsh Owl	*(Asio flammeus)*	0,1	5	8
Skylark	*(Alauda arvensis)*	0,1	4	6
Meadow Pipit	*(Anthus pratensis)*	23,9	900	1400
Yellow Wagtail	*(Motacilla flava)*	9,7	370	600
Wagtail	*(Motacilla alba)*	0,6	24	39
Whinchat	*(Saxicola rubetra)*	0,6	23	34
Reed Bunting	*(Emberiza schoeniclus)*	1,0	36	55
Total		46,4	1800	2700
OLVASSUO				
Hen Harrier	*(Circus cyaneus)*	0,0	2	3
Kestrel	*(Falco tinnunculus)*	0,1	14	21
Willow Grouse	*(Lagopus lagopus)*	0,5	100	180
Crane	*(Grus grus)*	0,8	150	210
Ringed Plover	*(Charadrius hiaticula)*	0,0	6	10
Golden Plover	*(Pluvialis apricaria)*	0,9	180	250
Lapwing	*(Vanellus vanellus)*	0,5	85	120
Broad-billed Sandpiper	*(Limicola falcinellus)*	0,2	34	50
Ruff	*(Philomachus pugnax)*	0,5	85	130
Jack Snipe	*(Lymnocryptes minimus)*	0,2	29	55
Snipe	*(Gallinago gallinago)*	2,0	380	550
Whimbrel	*(Numenius phaeopus)*	0,8	160	220
Curlew	*(Numenius arquata)*	1,1	210	290
Spotted Redshank	*(Tringa erythropus)*	0,1	20	28
Greenshank	*(Tringa nebularia)*	0,7	140	200
Wood Sandpiper	*(Tringa glareola)*	4,0	750	1100

		D	Min	Max
Marsh Owl	*(Asio flammeus)*	0,0	3	4
Skylark	*(Alauda arvensis)*	0,0	2	3
Meadow Pipit	*(Anthus pratensis)*	11,5	2200	3300
Yellow Wagtail	*(Motacilla flava)*	8,7	1600	2600
Wagtail	*(Motacilla alba)*	0,8	150	250
Whinchat	*(Saxicola rubetra)*	0,9	180	270
Wheatear	*(Oenanthe oenanthe)*	0,1	16	25
Sedge Warbler	*(Acrocephalus schoenobaenus)*	0,1	16	26
Red-backed Shrike	*(Lanius collurio)*	0,0	7	11
Little Bunting	*(Emberiza pusilla)*	0,1	10	16
Reed Bunting	*(Emberiza schoeniclus)*	1,3	240	360
Total		35,9	7000	10000
LIMINGANLAHTI				
Bittern	*(Botaurus stellaris)*	0,2	5	7
Marsh Harrier	*(Circus aeruginosus)*	0,7	16	23
Hen Harrier	*(Circus cyaneus)*	0,0	1	2
Crane	*(Grus grus)*	0,2	4	5
Oystercatcher	*(Haematopus ostralegus)*	0,1	3	4
Little Ringed Plover	*(Charadrius dubius)*	0,4	9	17
Ringed Plover	*(Charadrius hiaticula)*	0,2	6	9
Lapwing	*(Vanellus vanellus)*	3,0	75	100
Dunlin	*(Calidris alpina schinzii)*	0,4	10	15
Broad-billed Sandpiper	*(Limicola falcinellus)*	0,6	16	23
Ruff	*(Philomachus pugnax)*	16,3	390	600
Snipe	*(Gallinago gallinago)*	3,6	85	120
Black-tailed Godwit	*(Limosa limosa)*	0,9	23	32
Whimbrel	*(Numenius phaeopus)*	0,1	1	2
Curlew	*(Numenius arquata)*	3,7	90	130
Spotted Redshank	*(Tringa erythropus)* *	2,1	50	70
Redshank	*(Tringa totanus)*	4,8	120	170
Greenshank	*(Tringa nebularia)*	0,8	19	26
Wood Sandpiper	*(Tringa glareola)*	1,9	46	70
Turnstone	*(Arenaria interpres)*	0,2	5	8
Red-necked Phalarope	*(Phalaropus lobatus)*	1,1	26	42
Skylark	*(Alauda arvensis)*	2,1	50	70
Meadow Pipit	*(Anthus pratensis)*	5,0	120	180
Yellow Wagtail	*(Motacilla flava)*	7,3	180	280
Wagtail	*(Motacilla alba)*	1,2	29	46
Whinchat	*(Saxicola rubetra)*	4,0	95	150
Sedge Warbler	*(Acrocephalus schoenobaenus)*	109,4	2600	4200
Red-backed Shrike	*(Lanius collurio)*	0,3	6	10
Ortolan Bunting	*(Emberiza hortulana)*	0,7	16	25
Reed Bunting	*(Emberiza schoeniclus)*	30,7	750	1100
Total		202,0	4800	7500

		D	Min	Max
SALAMAJÄRVI				
Willow Grouse	*(Lagopus lagopus)*	0,6	28	50
Crane	*(Grus grus)*	0,4	17	24
Golden Plover	*(Pluvialis apricaria)*	0,7	33	46
Lapwing	*(Vanellus vanellus)*	0,5	23	32
Ruff	*(Philomachus pugnax)*	1,0	47	70
Jack Snipe	*(Lymnocryptes minimus)*	0,2	11	22
Snipe	*(Gallinago gallinago)*	2,2	100	140
Whimbrel	*(Numenius phaeopus)*	0,5	23	32
Curlew	*(Numenius arquata)*	0,2	8	11
Greenshank	*(Tringa nebularia)*	1,1	50	70
Wood Sandpiper	*(Tringa glareola)*	4,8	230	340
Meadow Pipit	*(Anthus pratensis)*	6,8	320	480
Yellow Wagtail	*(Motacilla flava)*	6,6	310	490
Wagtail	*(Motacilla alba)*	3,0	140	220
Whinchat	*(Saxicola rubetra)*	0,8	39	60
Wheatear	*(Oenanthe oenanthe)*	0,1	7	11
Sedge Warbler	*(Acrocephalus schoenobaenus)*	0,4	18	29
Red-backed Shrike	*(Lanius collurio)*	0,1	5	9
Great Grey Shrike	*(Lanius excubitor)*	0,2	9	14
Reed Bunting	*(Emberiza schoeniclus)*	2,4	110	170
Total		32,6	1500	2300
LEVANEVA				
Kestrel	*(Falco tinnunculus)*	0,2	6	9
Willow Grouse	*(Lagopus lagopus)*	0,8	21	38
Crane	*(Grus grus)*	0,4	10	14
Golden Plover	*(Pluvialis apricaria)*	3,9	110	160
Lapwing	*(Vanellus vanellus)*	0,5	15	21
Ruff	*(Philomachus pugnax)*	0,9	26	40
Jack Snipe	*(Lymnocryptes minimus)*	0,1	2	5
Snipe	*(Gallinago gallinago)*	0,5	14	20
Whimbrel	*(Numenius phaeopus)*	1,9	55	75
Curlew	*(Numenius arquata)*	0,4	12	17
Spotted Redshank	*(Tringa erythropus)*	0,3	10	13
Redshank	*(Tringa totanus)*	0,4	11	16
Wood Sandpiper	*(Tringa glareola)*	5,9	170	250
Red-necked Phalarope	*(Phalaropus lobatus)*	0,4	12	19
Meadow Pipit	*(Anthus pratensis)*	25,9	750	1100
Yellow Wagtail	*(Motacilla flava)*	2,6	75	120
Total		45,2	1300	3800
LAUHANVUORI				
Willow Grouse	*(Lagopus lagopus)*	0,8	12	21
Crane	*(Grus grus)*	0,5	7	10
Golden Plover	*(Pluvialis apricaria)*	1,3	18	26
Lapwing	*(Vanellus vanellus)*	0,6	8	11

		D	Min	Max
Ruff	*(Philomachus pugnax)*	0,3	5	7
Snipe	*(Gallinago gallinago)*	0,8	12	16
Greenshank	*(Tringa nebularia)*	0,1	1	2
Wood Sandpiper	*(Tringa glareola)*	4,5	65	95
Meadow Pipit	*(Anthus pratensis)*	16,2	230	350
Yellow Wagtail	*(Motacilla flava)*	12,5	180	290
Wagtail	*(Motacilla alba)*	2,0	29	46
Great Grey Shrike	*(Lanius excubitor)*	0,3	4	6
Reed Bunting	*(Emberiza schoeniclus)*	0,4	5	8
Total		40,2	600	900
KAUHANEVA				
Willow Grouse	*(Lagopus lagopus)*	1,2	50	95
Crane	*(Grus grus)*	0,3	13	19
Golden Plover	*(Pluvialis apricaria)*	3,6	150	210
Lapwing	*(Vanellus vanellus)*	1,1	48	65
Ruff	*(Philomachus pugnax)*	1,3	55	85
Snipe	*(Gallinago gallinago)*	0,7	32	45
Black-tailed Godwit	*(Limosa limosa)*	0,1	3	4
Whimbrel	*(Numenius phaeopus)*	1,4	60	85
Curlew	*(Numenius arquata)*	0,8	35	49
Redshank	*(Tringa totanus)*	0,3	13	20
Greenshank	*(Tringa nebularia)*	0,3	15	20
Wood Sandpiper	*(Tringa glareola)*	8,0	340	500
Marsh Owl	*(Asio flammeus)*	0,1	5	7
Meadow Pipit	*(Anthus pratensis)*	34,5	1500	2200
Yellow Wagtail	*(Motacilla flava)*	7,8	340	550
Wagtail	*(Motacilla alba)*	0,7	32	50
Whinchat	*(Saxicola rubetra)*	1,4	60	90
Red-backed Shrike	*(Lanius collurio)*	0,8	35	55
Ortolan Bunting	*(Emberiza hortulana)*	0,2	10	15
Reed Bunting	*(Emberiza schoeniclus)*	0,4	16	24
Total		65,1	2800	4200
SEITSEMINEN				
Willow Grouse	*(Lagopus lagopus)*	0,2	3	6
Crane	*(Grus grus)*	0,3	5	7
Golden Plover	*(Pluvialis apricaria)*	0,7	10	14
Lapwing	*(Vanellus vanellus)*	0,0	0	1
Snipe	*(Gallinago gallinago)*	0,5	7	10
Curlew	*(Numenius arquata)*	0,1	1	2
Greenshank	*(Tringa nebularia)*	0,1	1	2
Wood Sandpiper	*(Tringa glareola)*	2,2	33	49
Meadow Pipit	*(Anthus pratensis)*	1,7	25	38
Yellow Wagtail	*(Motacilla flava)*	2,8	42	65
Wagtail	*(Motacilla alba)*	3,0	45	70
Whinchat	*(Saxicola rubetra)*	1,3	19	29

		D	Min	Max
Sedge Warbler	*(Acrocephalus schoenobaenus)*	0,2	3	6
Red-backed Shrike	*(Lanius collurio)*	0,1	2	4
Reed Bunting	*(Emberiza schoeniclus)*	0,5	7	10
Total		13,6	200	310
PUURIJÄRVI - ISOSUO				
Bittern	*(Botaurus stellaris)*	0,0	1	2
Marsh Harrier	*(Circus aeruginosus)*	0,0	1	2
Water Rail	*(Rallus aquaticus)*	0,1	2	3
Spotted Crake	*(Porzana porzana)*	0,3	8	11
Crane	*(Grus grus)*	0,3	9	13
Golden Plover	*(Pluvialis apricaria)*	4,0	120	170
Lapwing	*(Vanellus vanellus)*	1,3	39	55
Ruff	*(Philomachus pugnax)*	0,5	14	21
Snipe	*(Gallinago gallinago)*	1,2	34	47
Curlew	*(Numenius arquata)*	0,9	26	37
Redshank	*(Tringa totanus)*	0,6	17	26
Greenshank	*(Tringa nebularia)*	0,0	1	2
Wood Sandpiper	*(Tringa glareola)*	2,6	75	120
Skylark	*(Alauda arvensis)*	2,0	60	85
Meadow Pipit	*(Anthus pratensis)*	17,6	500	750
Yellow Wagtail	*(Motacilla flava)*	17,4	500	800
Wagtail	*(Motacilla alba)*	1,2	34	55
Whinchat	*(Saxicola rubetra)*	3,8	110	170
Sedge Warbler	*(Acrocephalus schoenobaenus)*	13,9	410	650
Reed Warbler	*(Acrocephalus scirpaceus)*	0,6	18	27
Red-backed Shrike	*(Lanius collurio)*	0,3	8	12
Ortolan Bunting	*(Emberiza hortulana)*	0,1	3	5
Reed Bunting	*(Emberiza schoeniclus)*	7,9	230	350
Total		76,7	2200	3400
PUNASSUO				
Crane	*(Grus grus)*	0,2	0	1
Lapwing	*(Vanellus vanellus)*	3,4	7	9
Curlew	*(Numenius arquata)*	1,0	2	3
Greenshank	*(Tringa nebularia)*	0,3	1	2
Wood Sandpiper	*(Tringa glareola)*	1,8	4	5
Skylark	*(Alauda arvensis)*	2,8	5	8
Meadow Pipit	*(Anthus pratensis)*	10,5	21	31
Yellow Wagtail	*(Motacilla flava)*	7,4	15	23
Wagtail	*(Motacilla alba)*	11,9	24	38
Total		39,3	80	120

		D	Min	Max
LIESJÄRVI				
Crane	*(Grus grus)*	0,1	0	1
Golden Plover	*(Pluvialis apricaria)*	1,1	3	5
Lapwing	*(Vanellus vanellus)*	0,2	1	2
Snipe	*(Gallinago gallinago)*	1,7	6	8
Curlew	*(Numenius arquata)*	0,1	0	1
Wood Sandpiper	*(Tringa glareola)*	0,5	2	3
Meadow Pipit	*(Anthus pratensis)*	7,0	23	34
Yellow Wagtail	*(Motacilla flava)*	1,1	3	6
Wagtail	*(Motacilla alba)*	6,9	23	36
Whinchat	*(Saxicola rubetra)*	2,1	7	11
Sedge Warbler	*(Acrocephalus schoenobaenus)*	2,0	7	10
Ortolan Bunting	*(Emberiza hortulana)*	0,3	1	2
Reed Bunting	*(Emberiza schoeniclus)*	0,9	3	4
Total		23,8	80	120
TORRONSUO				
Marsh Harrier	*(Circus aeruginosus)*	0,0	1	2
Water Rail	*(Rallus aquaticus)*	0,0	1	2
Spotted Crake	*(Porzana porzana)*	0,2	6	8
Crane	*(Grus grus)*	0,4	10	14
Golden Plover	*(Pluvialis apricaria)*	4,1	110	160
Lapwing	*(Vanellus vanellus)*	1,5	41	55
Ruff	*(Philomachus pugnax)*	0,4	10	15
Snipe	*(Gallinago gallinago)*	1,0	27	38
Black-tailed Godwit	*(Limosa limosa)*	0,0	1	2
Curlew	*(Numenius arquata)*	0,7	19	27
Spotted Redshank	*(Tringa erythropus)*	0,0	1	2
Redshank	*(Tringa totanus)*	0,5	12	19
Greenshank	*(Tringa nebularia)*	0,0	1	2
Wood Sandpiper	*(Tringa glareola)*	3,8	100	160
Marsh Owl	*(Asio flammeus)*	0,1	2	3
Skylark	*(Alauda arvensis)*	1,5	42	60
Meadow Pipit	*(Anthus pratensis)*	16,9	460	700
Yellow Wagtail	*(Motacilla flava)*	11,4	310	500
Wagtail	*(Motacilla alba)*	1,5	41	65
Whinchat	*(Saxicola rubetra)*	3,2	85	130
Sedge Warbler	*(Acrocephalus schoenobaenus)*	5,4	150	230
Red-backed Shrike	*(Lanius collurio)*	0,6	16	26
Ortolan Bunting	*(Emberiza hortulana)*	0,1	4	5
Reed Bunting	*(Emberiza schoeniclus)*	1,7	48	70
Total		55,1	1500	2300

DOCUMENTATION PAGE

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Abstract	This book presents a transect of Finnish mire nature from Forest Lapland in the north to the hemiboreal mires on the southern coast of Finland. It has been compiled in connection with the International Mire Conservation Group field symposium in Finland in July 2006, and it gives an overview of the biodiversity of Finnish mires on mire system, massif, site and species levels as well as about the ecology, utilization, conservation and restoration of Finnish mires. A special topic is the primary succession of mires on the land uplift coast of the Bothnian Bay, which is a globally unique phenomenon in the boreal zone. Most of the mires presented here are protected as national parks or mire reserves. Thus this book gives a positive view over Finnish mires. We must remember, however, that about 75 % of Finnish mires have been destroyed by forestry drainage, agriculture, peat mining or reservoir building. The aim of this book is to emphasize the great diversity and high conservation value of Finnish mires. During the compiling of this book it was revealed that despite a long mire research tradition and intensive inventories conducted in nature reserves recently, we know surprisingly little about our mires. This emphasizes the importance of mire research in Finland – land of mires.
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Julkaisun teema	Luonto			
Julkaisun osat/ muut saman projektin tuottamat julkaisut				
Tiivistelmä	Tämä kirja esittelee poikkileikkauksen suomalaisesta suoluonnosta Metsä-Lapista etelärannikon hemiboreaalisille soille. Se on koottu Suomessa heinäkuussa 2006 järjestetyn kansainvälisen soidensuojelusymposion yhteydessä, ja se tarjoaa yleiskatsauksen Suomen soihin suosysteemien, yhdistymien, biotooppien ja lajien tasolla. Lisäksi käsitellään soiden ekologiaa, käyttöä, suojelua ja ennallistamista. Erityisaihepiiri on maailmanlaajuisesti boreaalisessa vyöhykkeessä ainutlaatuinen maankohoamisrannikon soiden kehitys Perämeren rannalla. Kirjassa esitellään enimmäkseen kansallispuistoina ja soidensuojelualueina suojeltuja soita. Siten kirja antaa positiivisen käsityksen suoluonnosta. On kuitenkin muistettava, että 75 % Suomen soista on tuhottu metsäojituksella, maataloudella, turpeennostolla ja tekoaltaiden rakentamisella. Kirjan tavoite on korostaa Suomen soiden suurta monimuotoisuutta ja suojeluarvoa. Kirjan kokoamisen aikana kävi ilmi, että pitkästä suotutkimusperinteestä ja nykyisin suojelualueilla tehtävistä intensiivisistä inventoinneista huolimatta soistamme tiedetään yllättävän vähän. Tämä korostaa suotutkimuksen tärkeyttä Suomessa.			
Asiasanat	Monimuotoisuus, suojelu, kehityssarja, suojelualue, suotutkimus			
Rahoittaja/ toimeksiantaja	Ympäristöministeriö			
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Julkaisun myynti/ jakaja	Edita Publishing Ltd. PL 800, 00043 EDITA puh. +358 20 450 05, fax +358 20 450 2380			
Julkaisun kustantaja	Suomen ympäristökeskus			
Painopaikka ja -aika	Kurikka 2006			

PRESENTATIONSBLAD

Utgivare	*Datum 7 / 2006* Finlands miljöcentral
Författare	Raimo Heikkilä, Tapio Lindholm och Teemu Tahvanainen (eds.)
Publikations titel	**Mires of Finland – Daughters of the Baltic Sea**
Publikationsserie och nummer	The Finnish Environment 28 / 2006
Publikationens tema	Natur
Publikationens delar/ andra publikationer inom samma projekt	
Sammandrag	Den här boken presenterar ett transekt över finsk myrnatur från Skogs-Lappland till de hemiboreala myrarna på sydkusten. Den har sammansatts vid den internationella myrskyddskonferensen i Finland i Juli 2006, och den bjuder en översikt över Finlands myrar på nivåer av myrsystem, myrkomplex, biotoper och arter. Därtill behandlas myrarnas ekologi, utnyttjande, skydd och restorering. En speciell tema är den i boreala zonen globalt unika utvecklingsserien av myrarna på landhöjningskusten vid Bottenhavet. I boken presenteras myrarna mestadels skydda i nationalparker och myrskyddsområden. Därmed ger boken en positiv omfattning av myrnaturen. Vi måste ändå komma ihåg, att 75 % av finska myrarna har förstörts vid myrdikning, jordbruk, torvtäkten och konstruktionen av vattenreservoirer. Målet av boken är att betona den stora mångfalden och skyddsvärdet av Finlands myrar. Vid kompletteringen av boken blev det klart, att trots den långa myrforskningstraditionen och de intensiva inventeringarna pågående i skyddsområdena man vet överraskande litet om de finska myrarna. Det här accentuerar viktigheten av myrundersökning i Finland.
Nyckelord	Mångfald, naturskydd, utvecklingsserie, skyddsområde, myrundersökning
Finansiär/ uppdragsgivare	Miljöministeriet
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Förläggare	Finlands miljöcentral
Tryckeri/tryckningsort och -år	Kurikka 2006

This book presents a transect of Finnish mire nature from Forest Lapland in the north to the hemiboreal mires on the southern coast of Finland. It has been compiled in connection with the International Mire Conservation Group field symposium in Finland in July 2006, and it gives an overview of the biodiversity of Finnish mires on mire system, massif, site and species levels as well as about the ecology, utilization, conservation and restoration of Finnish mires. A special topic is the primary succession of mires on the land uplift coast of the Bothnian Bay, which is a globally unique phenomenon in the boreal zone. Most of the mires presented here are protected as national parks or mire reserves. Thus this book gives a positive view over Finnish mires. We must remember, however, that about 75 % of Finnish mires have been destroyed by forestry drainage, agriculture, peat mining or reservoir building.

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