
The experimental area of Jaakkoinsuo mire

Peatland forest ecology on a drained mire

Excursion guide



Finnish Forest Research Institute
Vilppula Research Park, Parkano Research Station

Welcome to Jaakkoinsuo mire

We wish you welcome to the oldest forest drainage experimental area in Finland, the Jaakkoinsuo mire. Experiments and research on this field has been started as early as in 1909. At Jaakkoinsuo most aspects in the field of peatland drainage and its effects on peat, vegetation and tree stands have been studied.

The main interest in this experimental area has been the monitoring of stand development after ditching on different site types. Investigations dealing with the hydrology of mires, the effects of mineral nutrition, ash fertilisation and liming and the effect of these on the stand growth, development and productivity have also been done. Other long-term research topics are the treatments of tree stands and the regeneration of peatland forests. More recent subjects are the effects of environmental changes on the mire ecosystem, and hydrological studies.

For decades, the experience and research results obtained from Jaakkoinsuo have been instrumental in guiding forest professionals in practical peatland drainage and stand treatment. At present, Jaakkoinsuo is a looking glass that links the history of peatland forest research with the present. Consequently, Jaakkoinsuo has been a popular excursion and education site for decades.



In this booklet we present the environmental conditions, history and present state of Jaakkoinsuo as well as the main research activities and experiments. Vantaa Research Centre and Parkano Research Station of the Finnish Forest Research Institute can provide with more detailed information.

The excursion route is about 2.5 kilometres long and walking through it takes from one and a half to two hours. Most sites are provided with a permanent field poster presenting the most recent results. Of course, the tour can be made longer or shorter.

We hope that you will spend a rewarding and interesting time at Jaakkoinsuo. We wish you welcome once again.

This booklet is dedicated to Professors Olavi Huikari and Eero Paavilainen, the former chiefs of the Department of Peatland Forest Research at the Finnish Forest Research Institute.

Ahti, E. & Kaunisto, S., Eds:

The Jaakkoinsuo mire experimental area- excursion guide

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Writers:

Seppo Kaunisto and Markku Saarinen (forest regeneration)
Erkki Ahti (peat subsidence, ecological experiments)
Antti Reinikainen (history, site types, ecosystem changes)
Klaus Silfverberg (wood ash experiments)
Heikki Veijalainen (mineral fertilisation experiments, interpretation of peat and
needle analyses)
Mika Nieminen (leaching, liming experiment)
Heikki Takamaa (measurements and maintenance).

Layout: Timo Haikarainen
Photo: Erkki Oksanen
Drawings: Hannu Nousiainen, Raija Linnainmaa and Inkeri Suopanki
Maps: Timo Haikarainen

Info: Finnish Forest Research Institute, Vantaa Research Centre
tel. (09) 857 051, fax (09) 8570 5361;
Finnish Forest Research Institute, Parkano Research Station,
tel. (03) 443 51, fax (03) 443 5200;
Finnish Forest Research Institute, Vilppula Research Area,
tel. (03) 471 6183, fax (03) 471 6496.

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Jaakkoinsuo-from State Park to experimental field

The systematic forest drainage activity was started by the State Board of Forestry in Finland during the first decade of the twentieth century. For a successful realisation of this task the Finnish Senate granted the Board a permission to employ two foresters to specialize in mire drainage in 1908. After getting thoroughly acquainted with the forest drainage program carried out in Sweden, their first task in Finland was to find a suitable mire area for investigating the effects of drainage on tree growth and the relationships between drainage costs and benefits.

A suitable area -Jaakkoinsuo - was found in Central Finland in the forestry district of Orivesi in the State Park of Vuohijoki, near the railway station of Vilppula, railways being the most important means of transport at the time. There was also a highway nearby. The suitability of the area was further emphasised by the great diversity of the mire site types.

Originally, the area of Jaakkoinsuo consisted of 190 hectares of peatlands, and some small patches of uplands. After the second world war parts of the area were conveyed to evacuees from the eastern parts of Finland that were lost to the Soviet Union. The present area of the research forest is about 110

hectares, which includes 1.4 hectares of roads, 6.6 hectares of mineral soil sites and about 103 hectares of peatlands. This area is almost entirely used for different experiments. In 1923 the supervision of the area was ceded to the Finnish Forest Research Institute, which had been established five years earlier. At present, Jaakkoinsuo is part of the Research area of Vilppula and administered by the Parkano Research Station.



Site, situation and quaternary history of Jaakkoinsuo

A primary requirement for the first forest drainage experiments was to find an area that could provide a sufficient variety of mire site types of representative size. In both hydrological and morphological sense, Jaakkoinsuo in Vilppula fulfilled these requirements. When taken into use as an experimental area Jaakkoinsuo was an eccentric raised bog.

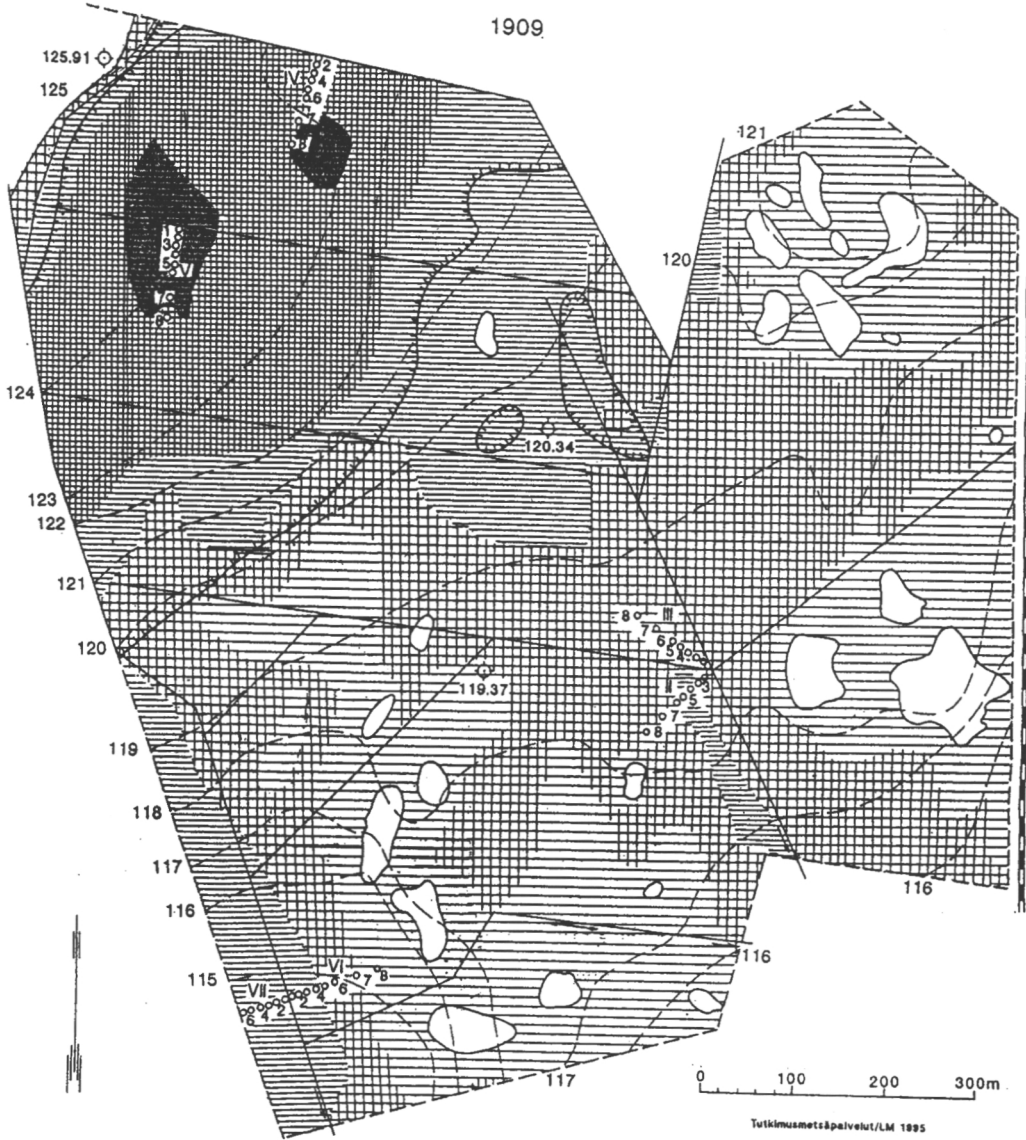
The climate of the Vilppula region is optimal for the development of eccentric bogs (Table 1). These have generated in the part of the boreal conifer zone which has a slight marine influence and relatively warm summers the mean annual temperature being 2...6 °C, mean of the warmest month 15...18 °C and mean annual precipitation 500-1000 mm. The

eccentric raised bogs occur as a narrow belt from Scandinavia to Siberia on both sides along the 60th latitude, between the regions of true raised bogs and aapa mires.


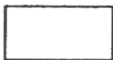


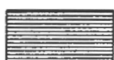





An eccentric raised bog can only develop on a slightly sloping surface. The ombrotrophic bog section, which receives all of its nutrients from precipitation, develops in the upper part of the mire complex. This makes the slope of the mire surface slightly steeper over time. Often, irregularities in the morphology of the mire complex are caused by margin influence in the hydrology such as the occurrence of springs.

JAAKKOINSUO

1909



Tutkimusmetsäpalvelut/LM 1995

	Peat thickness < 0.5 m	26.61 ha	28.8 %		Upland forest
	Peat thickness 0.5-1.0 m	32.85 ha	35.2 %		Height curve
	Peat thickness 1.0-2.0 m	17.85 ha	19.2 %		Area of the mire 5000 BP (26 % of the present)
	Peat thickness 2.0-3.0 m	14.23 ha	15.2 %		Ditches from 1909
	Peat thickness >3.0 m	1.85 ha	2.0 %		Subsidence pole 8 from series II
Tot.		93.39 ha	100.0 %		

In its pristine state, Jaakkoinso was a rather typical eccentric raised bog. The bog development started through forest paludification. The general direction of the slope is from south-east to north-west, the terrain slanting slightly steeper than usual in corresponding mire complexes. The difference in altitude between the highest point, with the thickest (> 3 m) peat layer, and the spruce swamps, with the thinnest peat layer (< 0.5 m), is 9 m over a distance of 1260 m. The oldest part of the mire is the bog section where the peat is 2-3 m thick. There paludification was well on its way over 3000 years BP. In the first survey of 1909 ombrotrophic vegetation had developed on sites where the depth of peat layer was less than one metre. Usually, ombrotrophic site types have a much thicker peat layer.

Table 1. Situation and climatological data

Position	62°04' N, 24°34' E
Altitude above sea level	116–125 m
Mean annual temperature	3.4 °C
– July	16.8 °C
– February	–8.4 °C
Temperature sum of vegetation period (threshold value ≥ 5 °C)	1220.0 °C
Duration of vegetation period	164 d
Annual precipitation	600 mm

Distribution of site types

In its pristine state Jaakkoinso displayed a variety of site types and vegetation which is quite typical of this kind of mire complexes. According to the classification system of Cajander a total of 11 mire site types were determined in 1911. These were:

English name	Finnish abbreviation
Paludified <i>Vaccinium myrtillus</i> spruce forest	KgK
Ordinary spruce swamp	VSK
Herb rich hardwood-spruce swamp	RhK
Tall-sedge hardwood-spruce fen	SK
Paludified pine forest	KgR
Dwarf-shrub pine bog	IR
Dwarf-shrub cottongrass pine bog	ITR
Tall-sedge pine fen	VSR
Herb-rich sedge birch-pine fen	RhSR
Eutrophic pine fen	VLR
Tall-sedge fen	VSN

The present classification system would have separated a few more types, especially among the ordinary spruce swamps and hardwood spruce fens. The tall-sedge hardwood spruce fens included also herb-rich variants. The tall-sedge and herb-rich pine fens were partly very poorly stocked, the plant communities closely resembling those of open fens. Also, the ombrotrophic pine bogs could, in a phytosociological sense, have been distinguished into a few more subtypes.

About half of the present research area comprised of ombrotrophic pine bog site types. They were relatively dry and were dominated by dwarf shrubs and hummock species. *Sphagnum fuscum* hummocks were scarce. Also, wet hollows, typical of the most barren bog site types of large eccentric raised bogs, were not found at Jaakkoinso. The minerotrophic site types are distributed along the eastern and southern edges of the research area. A typical feature for eccentric bog complexes was also found here: the gradient of site types downwards along the slope, e.g. dwarf-shrub pine bog \Rightarrow dwarf-shrub cotton grass pine bog \Rightarrow tall-sedge pine fen \Rightarrow tall-sedge hardwood-spruce fen \Rightarrow *Vaccinium myrtillus* spruce swamp. Mostly, however, the spruce swamps are irregularly scattered among the pine bogs with a thicker peat layer. A small eutrophic pine fen (VLR) in the south-western corner of the area was fed by ground water from an uphill esker. Only 3% of the mire area was classified as treeless fen.

There are no records of the pristine vegetation but the variety of site types and the variations in fertility and moisture suggest a very diverse species composition. Only the species that are typical of very wet open fens and bogs were probably absent. The species composition of the pristine Jaakkoinso ought to have resembled the pristine mire of Lakkasuo in Orivesi with a similar morphology and site type distribution. At Lakkasuo there is a field excursion route administered by the Department of Forest Ecology (Peatland Forestry) of the University of Helsinki that presents 24 mire site types common in south and central Finland. The mire is also described in numerous guides and publications.

Research activities at Jaakkoinsuo

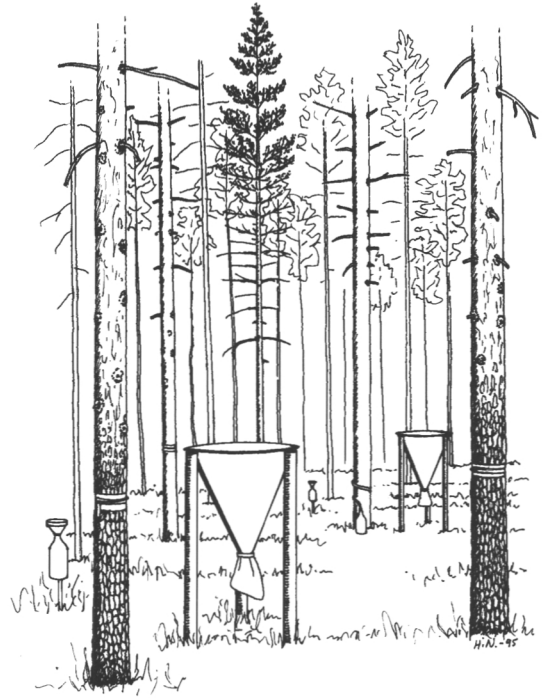
The scientific research at Jaakkoinsuo started in 1909 when the drainage plan of Antti Tantt who had specialised in forest drainage, was completed. The purpose of this initial study was to evaluate the effects of different ditch depths and contours and the effect of different distances between the ditches on tree growth.

The effect of drainage on the subsidence of the peat was another topic of interest in 1909. A total of 54 wooden poles were driven through the peat layer down to the mineral subsoil. The original level of the peat surface was marked on the poles. Today there are still 40 poles left.

More experimental plots for studying the development of tree stands were established in 1915. During the next four decades plots for studying more specific aspects of tree growth and stand yield on peatlands were established. These aspects involved the natural nutrient levels of different site types, distance between the ditches and ditch depth, tree species composition and different stand treatments and silvicultural methods. These experiments were needed for developing classification systems and operational recommendations for peatland forestry.

Investigations concerning site amelioration were started with mineral soil (sand) applications in 1926. Liming experiments were initiated in 1929 and applications of wood ash in 1937. These were followed by NPK-fertilisation experiments in 1946. Some fertilisation experiments were established on the nearby Kaakkosuo mire. Part of the fertilisation experiments have been retreated in the 1980s. The first fertilisation experiments in Jaakkoinsuo including micronutrients were established in 1953.

Forest ecological studies were initiated by professor Olavi Huikari in 1956 and during the 1960s and 1970s especially the effect of the soil water status, soil and air temperature and nutrient status of the substrate on the growth of Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and to some extent also of downy birch (*Betula pubescens*) were studied at different stages of stand development. The central issue in the design of these experiments was the regulation of the ground water level and cooling of the soil. Since 1961 the water level in the ditches surrounding the experimental plots have been kept at the levels of 0, 10, 30, 50 and 70 cm below soil surface. Using a similar design, the effect of flooding at different times of the year on tree growth has been studied.



Another important research topic studied on some sample plots was the relationship between the nutrient status and the microbiological activity of the peat and the tree roots. The translocation of fertilizer nutrients into different biomass compartments, the internal water balance of Scots pine and water uptake from frozen and thawing soils were also studied.

Prior to the drainage in 1909, the mire was very sparsely stocked with the exception of some spruce swamps. However, no active afforestation measures were needed even in the treeless fen as seeding from the adjacent stands soon provided satisfactory seedling stands. Before the 1970s, some sparsely stocked areas had been regenerated in 1916, and before 1951, the mature stands had been regenerated in 15 experiments or single plots. Not before the 1970s the first forest regeneration studies were started. Depending on site type and tree stand, various regeneration methods were included in the experiments.

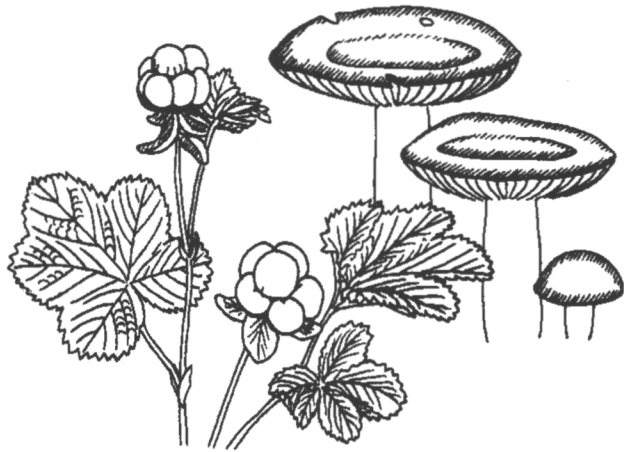
In the middle of the 1970s experiments with forest regeneration were resumed by establishing so

called 'H cultures' planned by professor Olavi Huikari (see site J15). This method aimed at maximum tree production and highly rationalised stand treatment practices during the second tree generation.

In the middle of the 1980s some experiments were established for the comparison of natural and artificial regeneration. These include the natural regeneration of Norway spruce after seed tree cutting, regeneration of small clear-cut areas from bordering stands and comparisons between natural regeneration and planting of downy and silver birch. Also the effect of soil preparation in the connection of both natural and artificial (by planting and sowing) regeneration of Scots pine was investigated.

Fairly recent research topics are the effect of air pollutants on soil acidification in the late 1980s and the effect of clear cutting on the concentration of phosphorus and nitrogen in the runoff waters in the 1990s.

One important purpose of the Jaakkoinso experimental area was to provide empirical long-term data concerning the effects of different silvicultural treatments of peatland forests on their post-drainage development. The monitoring of the experiments and the careful documentation of stand treatments have provided useful information for operational peatland forestry. Jaakkoinso has also provided excellent possibilities for analysing the yield and nutritional demands of the second tree generation in peatland forests.



The effects of drainage on the mire ecosystem

During the 90 years after drainage Jaakkoinso mire has changed from a sparsely stocked mire to a well stocked peatland forest. By now the drainage network consists of 23 000 m of ditches of which 19 900 m are open ditches. There are, on average, 250 m of ditches per hectare.

Stand growth and yield

The effect of drainage on stand volume and growth at Jaakkoinso has been considerable. On the pine bog sites of Jaakkoinso the tree stand before drainage consisted of old, stagnant pine stands with volumes between 30...50 m³ ha⁻¹. On the more fertile sites with a thinner peat layer the stand volumes were only 3...10 m³ ha⁻¹. The yields by main site types after drainage are presented in Fig.1.

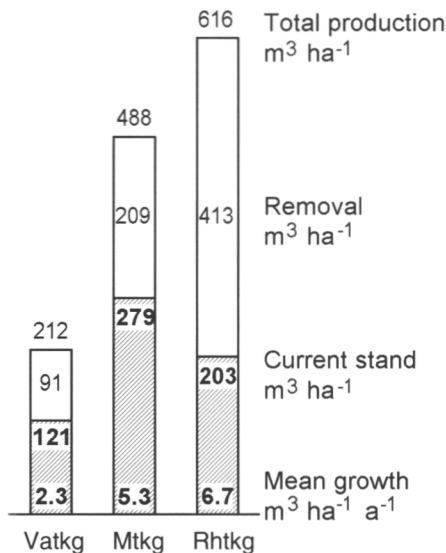


Fig 1. Total production, removal, stock and mean growth by site type in 1909-2000. Vatkg = dwarf-shrub peatland forest, Mtkg = *Vaccinium myrtillus* peatland forest, Rhtkg = herb-rich peatland forest.

The total removal during the period 1909...1995 obtained by thinnings and final cuttings and from road and ditch lines was 14 375 m³ (Table 2). There are numerous sites at Jaakkoinso already, where the second post-drainage generation of Scots pine or Norway spruce grow at different stages of their development. The age of oldest stands of the second generation already exceeds 50 years.

On the pine mires (in all 10 plots measured) the mean total yield after drainage by 1994 was 236 m³ ha⁻¹, the maximum yield being 380 m³ ha⁻¹. The mean annual yield in the pine-dominated stands was 2.8 m³ ha⁻¹ a⁻¹ during the first 85 years after drainage. In the spruce dominated stands the corresponding figures were: mean total yield 491 m³ ha⁻¹, maximum yield 670 m³ ha⁻¹, and mean annual yield 5.8 m³ ha⁻¹ a⁻¹. The mean post-drainage roundwood production has so far been 1.5 m³ ha⁻¹ a⁻¹.

Changes in site types and vegetation

The succession at Jaakkoinso, after the initial drop of the water table caused by the drainage, has resulted in the typical sequence of changes on all site types via transforming types to 'climax' types resembling upland site types (Table 3). The original site types with different mire vegetation and ecology have now transformed into 4-6 drained peatland forest site types (the exact number depends on the

Table 2. Cutting yield in 1909-1995

1909-27	about	300	m ³
1928-47		3 430	m ³
1948-64		1 620	m ³
1965-81		520	m ³
1982-84		4 650	m ³
1985-86		1 930	m ³
1992-95		1 925	m ³
1909-94	tot.	14 375	m³
average		167	m ³ ha ⁻¹

classification method). The nutrient-poor pine bogs with a thick peat layer have transformed into dwarf-shrub peatland forests (presently 38% of the mire area), the pine mires with thinner peat layers and the tall sedge pine fens into *Vaccinium vitis-idaea* peatland forests (14%), the herb-rich pine fens, tall-sedge hardwood-spruce fens and *Vaccinium myrtillus* spruce swamps into *Vaccinium myrtillus* peatland forests (34%), and the herb-rich sedge hardwood-spruce fens and herb-rich spruce swamps into herb-rich peatland forests (7%). The remaining part of the peatland area at Jaakkoinso (7%) was still classified into transforming peatland phases in the early 1990s.

The vegetation of drained peatland forests differs from both mire and upland forest vegetation, and is compositionally closer to the vegetation of the upland forests. The magnitude of the changes in vegetation after drainage depends on the original site type (Fig. 3). On a poor pine bog (dwarf-shrub pine bog) the change in the number of species and in species assortment has been small, but the species abundancies have changed. On the other hand, the changes on a more fertile and wetter site type (tall-sedge pine fen) have been quite fundamental. Out of the original 23 species only 3 remained 85 years after drainage. The herb-rich hardwood spruce swamp is an example of the succession of a forested mire site type. More than 60% of its species have changed; the species that have increased in abundance are typically original upland forest species. The number of species has decreased due to the

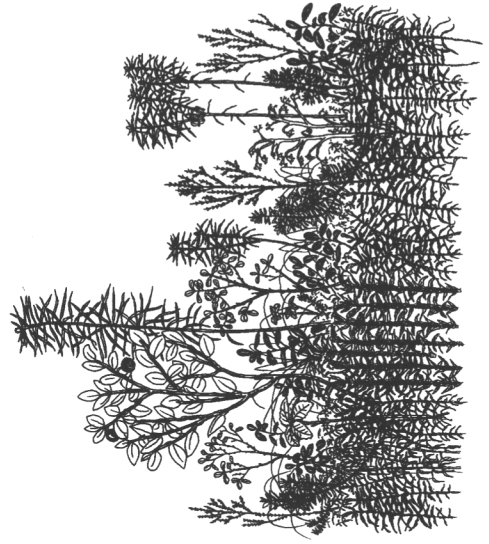
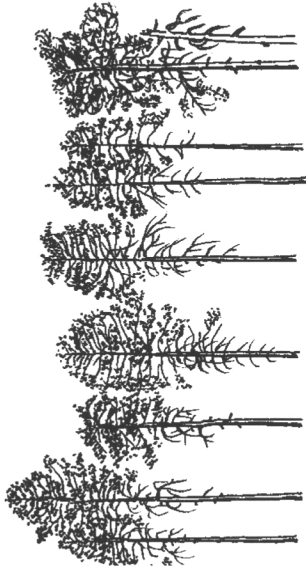
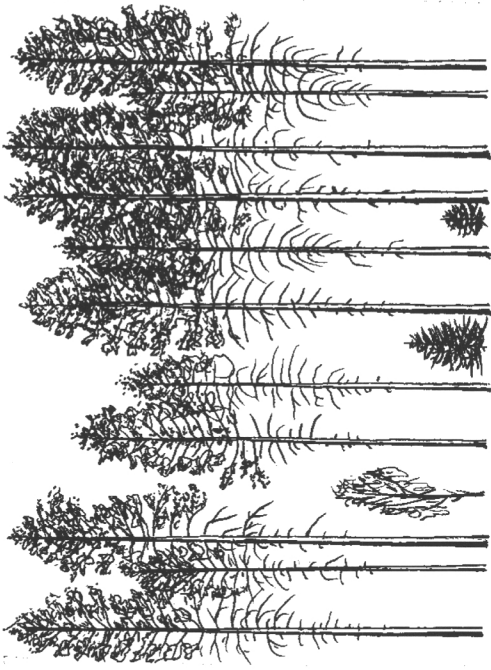
closing of the spruce canopy. However, the number may increase again after cuttings

The changes in the vegetation of the whole mire complex were estimated by comparing the drained Jaakkoinso and the pristine part of Lakkasuo (see p.5). Equal sample areas representing site types originally common to both mires were inventoried in 1994, i.e. 85 years after the first ditching of Jaakkoinso area. On twenty sample plots in both mires totally 140 species was observed out of which 65 (46.4%) occurred both in drained and pristine sites, 54 (38.6%) only in pristine sites and 21 (15.0%) only in drained sites. The species that have disappeared from Jaakkoinso were mire and wetland species indicating mesotrophy, eutrophy, spring influence, seepage water influence and flooding influence. The new species are mostly upland forest species. The forest species dominate in the present vegetation. The remaining mire species are mostly drought tolerant ombrotrophic and hummock species that are adapted to living on sites with a deep groundwater level. The proportion of original mire species is the greater the poorer the original mire site type has been.

Drainage has decreased the species diversity at Jaakkoinso. On the other hand, the species number on the site, or alpha diversity, has remained roughly the same. The replacement of the original mire site types by peatland forest types has diminished the total diversity or beta diversity because the ecological gradients have shortened. The change from different mire sites to forests that resemble upland types has caused a closer resemblance with the sur-

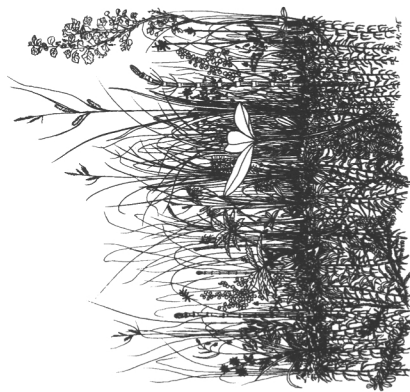
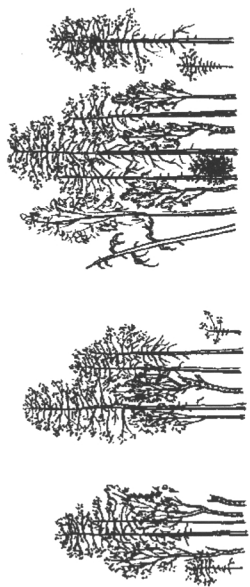
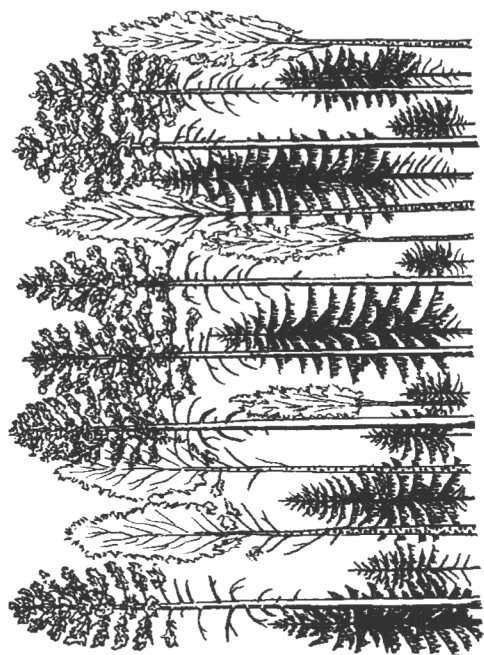
Table 3. Changes in site types on Jaakkoinso (93 ha) between 1911 and 1994. The paludified spruce and pine forests (6.7 ha in 1911) are now partly drained peatland forests and partly upland forests or paludified upland forests (in all 4.6 ha in 1994).

Site type	1911	1934	1949	1964	1994
	portion of mire area, %				
<u>Pristine or recently drained</u>					
Spruce swamps	33.4	22.3	13.0	-	-
Pine mires	62.9	46.4	27.0	-	-
Open mires	3.1	-	-	-	-
<u>Transforming stages</u>					
Spruce swamps	0.6	20.7	13.1	16.5	2.2
Pine mires	-	9.9	28.8	24.1	4.9
Peatland for. site types	-	0.7	18.1	59.4	92.9



a) Dwarf-shrub cottongrass pine bog (ITR)

b) Dwarf-shrub peatland forest (Vatkg)



c) Herb-rich sedge pine fen (RhSR)

d) *Vaccinium myrtillus* peatland forest (Mtkg)

Fig. 2. From pristine mire to drained peatland forest. The drawings show the changes in the species and structure of the plant communities of a poor and fertile mire site type.

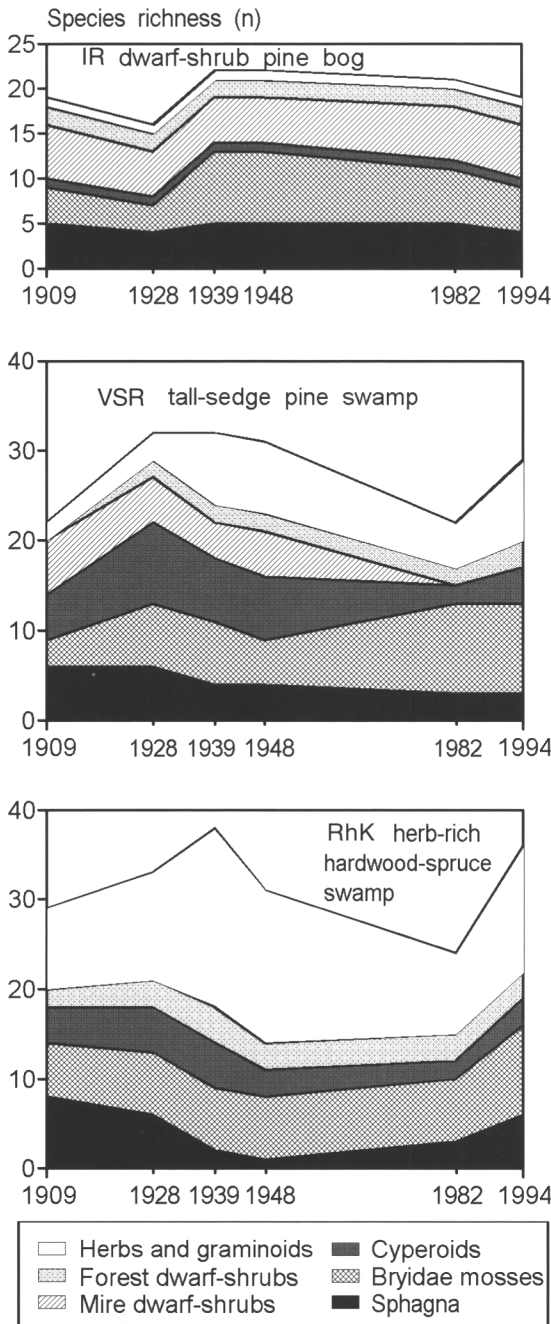


Fig. 3. Changes in the composition of vegetation on three ecologically different sample plots on Jaakkoinsoo during 1909-1994 (Dwarf-shrub pine bog, Plot 4, object J1; Tall-sedge pine fen, Plot 8b, object J15 and herb-rich spruce swamp, Plot 2, object J11). The data for the pristine state of 1909 is collected from plots of corresponding site type from the Lakkasuo mire in Orivesi.

rounding forest nature and consequently decreased the gamma diversity both at vegetation community and landscape levels (Fig. 2) In addition to drainage, the activities included in peatland forestry such as cuttings, fertilisation, soil preparation and road building have increased the number of species by introducing especially pioneer plants, weeds and ditch spoil species. The decrease in the diversity along the post-drainage succession displays the importance of the hydrology in sustaining pristine mire complexes and site types. The peatland forests of Jaakkoinsoo give a general impression of how drained peatlands in the south-western part of Finland can be expected to develop during the next 40 to 50 years.

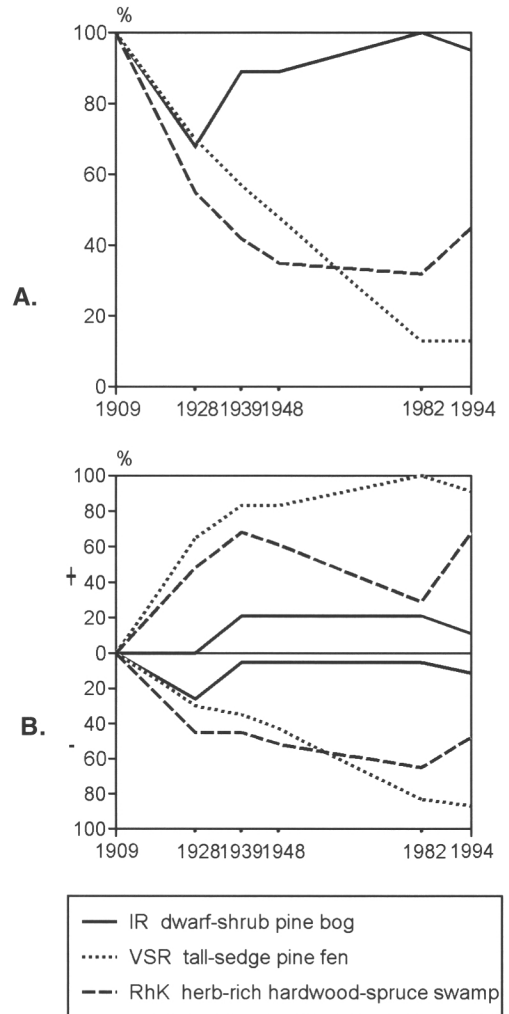


Fig 4. A. Changes in the composition of vegetation calculated as percent of the original pristine plant species on the three sample plots of Fig. 3. **B.** Disappeared and appeared species on the three sample plots as percent of the original vegetation. Other explanations as in Fig. 3.

The excursion route of the Jaakkoinsuo mire

On the following pages the sites along the excursion route of Jaakkoinsuo are presented. At the gate of Jaakkoinsuo there is an information board providing general information about the area and maps of the experiments and the ditch network. Most sites have also their own information boards.

The excursion path starts at the most nutrient-poor part of the mire and, as a general rule the fertility of the sites increases along it. The total length of the path is 2.5 km and the time required to stroll through it is 1.5...2.5 hours. You can also take a shortcut from site 10 straight to site 17 and further by sites 21 and 22 along the forest road and the paths back to the starting point. The path ends up on a road at the southern edge of the mire. You can return to the starting point along a path, which starts at site 24 and follows the western edge of the mire.

Abbreviations used

V	Stand volume, m ³
I _v	Annual stand volume increment, m ³ ha ⁻¹ a ⁻¹
G	Basal area, m ² ha ⁻¹
H	Mean stand height, m
H _{dom}	Dominant stand height, m
D _{1.3}	Mean diameter at breast height, cm
S _n	Stem number, stems ha ⁻¹
N _{0-10 cm}	Peat nitrogen concentration, % (0–10 cm layer)
Total prod.	Total stem volume production since 1909 (unless otherwise mentioned), m ³ ha ⁻¹ .

J1. Pine stand preserved in pristine state

Plot 4

Established in 1928

Plot area: 0.25 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 2.5 m

$N_{0-10\text{ cm}}$ (1994): 1.26%

Mineral subsoil: sand

The site was drained in 1909 and 1915. At the time of drainage the pine stand growing on the plot was about 117 years old. Its volume was $47\text{ m}^3\text{ ha}^{-1}$ and annual volume increment $1.0\text{ m}^3\text{ ha}^{-1}$ which at that time was the highest annual stand growth at Jaakkoinso.

The purpose of this experiment is to study the growth and yield of the old pine stand which - except for the drainage in 1909 - has been left totally undisturbed.

Table J1. Stand data of Plot 4 in 1998.

Age, years	206
Total yield, $\text{m}^3\text{ ha}^{-1}$ in 1909–98	173
– of which natural removal, $\text{m}^3\text{ ha}^{-1}$	33
Stand volume, $\text{m}^3\text{ ha}^{-1}$	187
Increment, $\text{m}^3\text{ ha}^{-1}\text{ a}^{-1}$ in 1992–98	2.7
Dominant height, m	17.1
Basal area, $\text{m}^2\text{ ha}^{-1}$	22.3
Mean diameter, cm	22.4

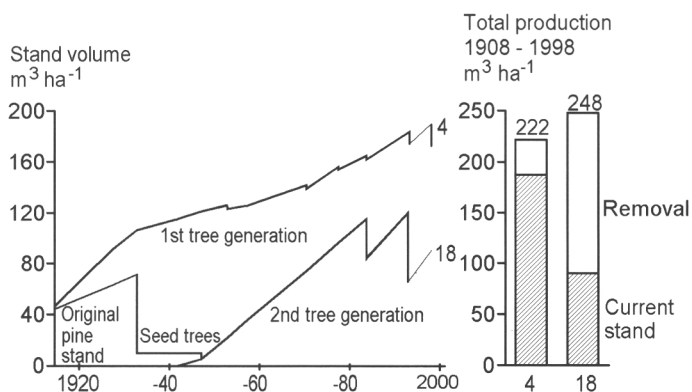


Fig. J1. Production of treated and pristine pine bog stand. Plot 4 = growing of original pine bog stand, Plot 18 (see p.24) = stand regenerated with seed trees.

J2. Regeneration of peatland forests, development of young stands and fertilisation

Experiment 17

Plots 1-8

Established in 1952

Plot area: 0.0525 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 2.5 m

$N_{0-10\text{ cm}}$ (1995):

Plot 2 1.24%

Plot 3 1.37%

Plot 4 1.28%

Mineral subsoil: sand

The site was drained in 1909 and the drainage was completed with subsurface drains in 1949-50.

The purpose of this experiment is to investigate forest regeneration, the early development of the second tree generation, and the effect of fertilisation on the stand productivity during the second stand generation. In 1935, most of the trees in the 125 year-old stand were removed (953 stems ha^{-1} , $50\text{ m}^3\text{ ha}^{-1}$), and 90 stems ($13\text{ m}^3\text{ ha}^{-1}$) were left for seed trees. At that time there were about 1500 pine seedlings per hectare, which all were less than 50 cm high. The seed trees were removed in 1947. By then the seedling number per hectare had increased to about 21 000. The young stand was slightly thinned in 1955. The first actual thinning was done in 1983, and the second in 1993.

In 1952 the stand was divided into eight plots in order to investigate the effect of different nitrogen, phosphorus and potassium fertilisations on tree growth. Additionally, 2000 kg ha^{-1} of milled limestone was applied to all plots. In May 1962 nitrogen was added to part of the plots and in 1984 the whole experiment was refertilised similarly to the first fertilisation. According

to needle analyses there was a slight deficiency of N, P and K on the control plots in 1994. Increased growth was observed after the first application of phosphorus and potassium. After refertilisation in 1984, only the application of potassium seemed to increase tree growth. Surprisingly, the nitrogen applications seemed to have no positive effect on tree growth on this ombrotrophic site, which had been ditched 53 and 75 years earlier.

Table J2/a. Fertilisers used in Experiment 17, kg ha⁻¹

Plot	In 1952				In 1962		In 1984		
	Amm.nitr. with lime	Phosh- phate	Potass. chloride	Milled limestone	Amm.nitr. with lime	Amm.nitr. with lime	Rock phosph.	Potass. chloride	
	15,5% N	9,8% P	33% K	37% Ca	15,5% N	27,5% N	15% P	50% K	
1	100	-	300	2 000	400	400	-	200	
2	-	300	300	2 000	-	-	300	200	
3	-	-	-	2 000	-	-	-	-	
4	100	300	300	2 000	400	400	300	200	
5	100	300	-	2 000	400	400	300	-	
6	-	-	300	2 000	-	-	-	200	
7	100	-	-	2 000	400	400	-	-	
8	-	300	-	2 000	-	-	300	-	

Table J2/b. Remaining tree stand in Experiment 17 in 1992.

Plot	S _n stems ha ⁻¹	V m ³ ha ⁻¹	I _{v(1983-92)} m ³ ha ⁻¹ a ⁻¹	G m ² ha ⁻¹	D _{1,3} cm	H m
1	800	94.1	4.5	13.77	15.5	13.3
2	762	106.6	6.9	15.35	16.5	13.4
3	857	81.3	5.2	13.16	14.7	11.9
4	819	92.2	7.2	14.03	15.4	12.8
5	629	75.8	4.6	11.10	15.9	13.5
6	781	103.3	7.6	14.77	16.1	13.8
7	705	76.7	6.8	11.76	15.4	12.8
8	724	106.7	6.6	14.30	16.8	14.8

Table J2/c. Effects of fertilisation in Experiment 17.

Treatment 1952 and 1984	1952–1982		1983–1992
	m ³ ha ⁻¹	m ³ ha ⁻¹ a ⁻¹	m ³ ha ⁻¹ a ⁻¹
Control	84	2.7	5.2
N	72	2.3	6.8
P	138	4.5	6.6
NP	131	4.3	4.6
K	120	3.9	7.6
NK	109	3.5	4.5
PK	127	4.1	6.9
NPK	92	3.0	7.2
Average	109.1	3.54	6.40
Effect of N	-16.2	-0.52	-0.30
Effect of P	+ 25.8	+ 0.88	-0.15
Effect of K	+ 5.8	+ 0.17	+ 1.25

Total production of 2nd tree generation in 1952-92

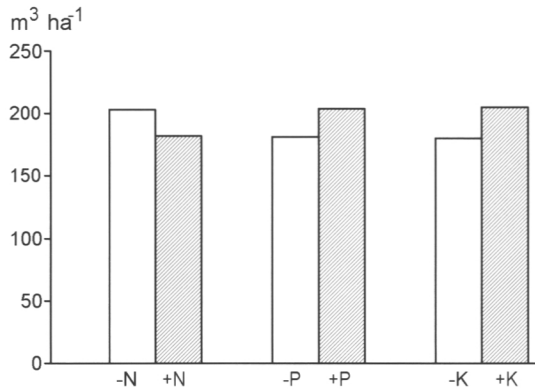


Fig. J2. Effect of fertiliser application on the total production of Scots pine. On an old drained pine bog fertilisation with P and K is sufficient.

J3. Peat subsidence after drainage

In 1909 54 wooden poles were driven through the peat layer into the mineral subsoil. At each pole, the level of the mire surface was determined by levelling and marked on the pole. The levelling was repeated in 1935, 1960, and 1995. Today, 40 poles are still left.

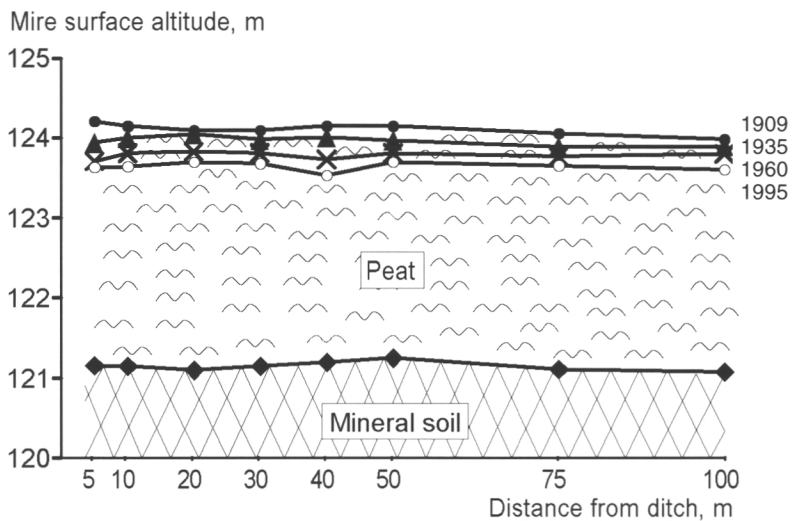


Fig. J3. Subsidence of peat layer along the pole line V between 1909 and 1995.

J4. Liming and growth of tree stands

Experiment I

Plots 1-10

Established in 1929

Plot area: 0.04 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 2.5 m

$N_{0-10\text{ cm}}$ (1995): 1.26%

Mineral subsoil: sand

The site was drained in 1909. The experiment was established in 1929 in order to study the effect of liming on tree stand and soil properties.

The pine stand of this experiment has been thinned in 1983 and again in 1992 (at the age of 73 years). There were no significant differences in stand growth between the limed and the control plots.

Table J4. Stand characteristics of Experiment 1 in 1992.

Plot	Lime in 1929 kg ha ⁻¹	Remaining tree stand in 1992					
		S_n stems ha ⁻¹	V m ³ ha ⁻¹	$I_{V1983-1992}$ m ³ ha ⁻¹ a ⁻¹	G m ² ha ⁻¹	$D_{1.3}$ cm	H m
1	2 000	800	91.9	3.2	13.05	14.7	13.8
2	4 000	700	86.5	3.6	12.61	15.8	13.5
3	-	650	89.9	4.5	12.07	16.0	14.8
4	6 000	650	97.4	3.7	12.92	16.8	15.1
5	8 000	550	82.4	2.8	11.46	17.7	14.4
6	8 000	500	77.5	3.2	11.14	17.4	13.8
7	6 000	650	74.7	4.4	11.20	15.3	13.2
8	-	650	65.9	3.2	10.11	14.6	12.7
9	4 000	650	69.0	2.3	10.90	15.2	12.5
10	2 000	600	74.3	4.7	11.14	16.1	13.1

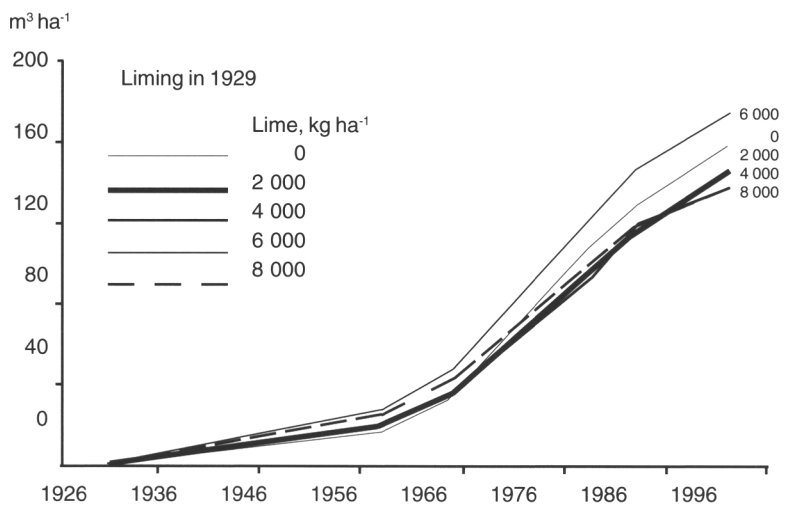


Fig. J4. Stand development after different lime applications.

J5. Drainage and wood ash fertilisation in a pine stand on a bog

Experiment XII Plots 1 and 2

Established in 1937

Plot area: 0.065 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 2.2 m

$N_{0-10\text{ cm}}$ (1994):
Plot 1 = 1.34%
Plot 2 = 1.59%

Mineral subsoil: clay

This site was drained in 1909, 1915 and 1923; in 1916 it was sown with Scots pine seeds. Wood ash (5000 kg ha^{-1}) was applied in 1937. The tree stand has been thinned several times between 1953 and 1992. There are only small differences in the ground vegetation between the control and the ash-fertilised plot. Wood ash has almost doubled the total production compared to the control.

Table J5. Stand characteristics of Experiment XII in 2001.

Plot	Wood ash in 1937 kg ha^{-1}	V $\text{m}^3 \text{ha}^{-1}$	$I_{V1994-2001}$ $\text{m}^3 \text{ha}^{-1} \text{a}^{-1}$	Total prod. $\text{m}^3 \text{ha}^{-1}$	G $\text{m}^2 \text{ha}^{-1}$	$D_{1.3}$ cm
1	0	116	3.0	231	14.0	20.4
2	5 000	240	7.7	446	23.9	23.6

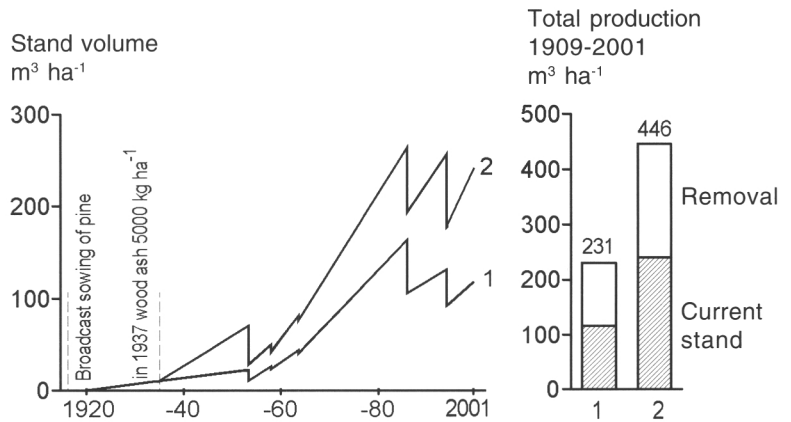


Fig. J5. Development of the tree stand in Experiment XII. There is a strong effect of the wood ash fertilisation on tree growth. 1 = control, 2 = wood ash fertilisation $5\ 000\text{ kg ha}^{-1}$.

J6. Nutrition of Scots pine

Experiment XXII

Plots 1–12

Established in 1963

Plot area: 0.096 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 1.4 m

The site has been drained in 1909, 1915, 1923, and 1988. In 1963 a spot fertilisation experiment with a NPK fertiliser (10-5.2-5.0) and with two spot sizes and different fertiliser dosages was established on the naturally born young seedling stand. About 2500 seedlings ha⁻¹ were fertilised. The spot sizes involved were 0.25 and 1.0 m² and the amounts of the NPK fertiliser 0, 25, 50, and 100 g per 0.25 m² spot and 0, 100, 200 and 400 g per 1.0 m² spot. In 1987 the young stand was thinned and broadcast fertilised with N, PK or NPK.

The effect of fertilisation on the small spots ended in 4-6 years while the effect on the larger spots is still apparent. Refertilisation with all nutrient combinations had a strong effect on stand growth. Partly, the growth increase may be due to improved drainage conditions.

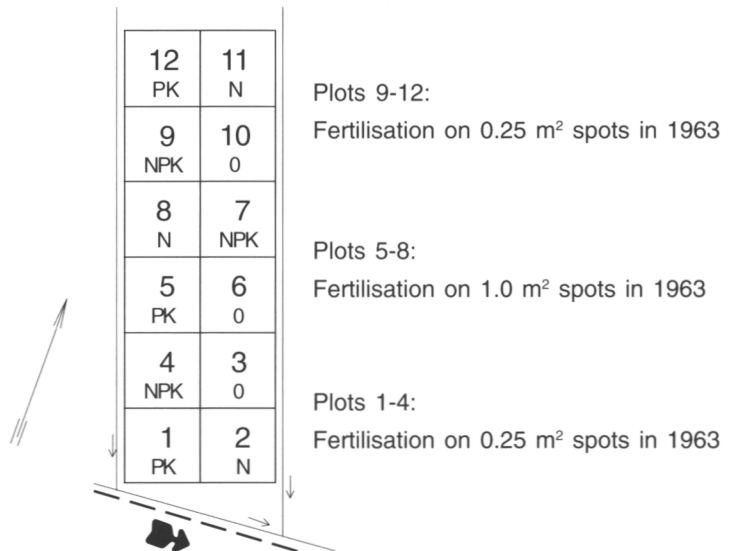


Fig. J6. Location of the plots of Experiment XXII and the broadcast fertilisations in 1987.

0 = Unfertilised control

N = Ammonium nitrate with lime 400 kg ha⁻¹ (N 27.5%, Mg 2.2%)

PK = PK fertiliser for peatland forests 500 kg ha⁻¹ (P 9%, K 17%, B 0.2%)

---> Excursion path, direction of route

J7. Drainage and fertilisation of a pine bog stand

Experiment XX

Established in 1943

Area: Plot a 0.10 ha
 Plot b 0.10 ha
 Plot c 0.07 ha
 Plot d 0.13 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 1.5 m

N_{0-10 cm} (1995):
 Plot a 1.28%
 Plot b 1.37%
 Plot c 1.27%
 Plot d 1.40%

Mineral subsoil: sand

The site was drained in 1909, 1915 and 1953. The purpose of the experiment was to study the effect of drainage and fertilisation on the growth of an old pine stand.

In 1992, at the age of 116 years the stand was slightly thinned on Plots a, b and c.

In 1960 a 0.1...4.5 m high stand of young pine grew on Plot d. When thinned in 1987 and 1992 altogether 74 m³ ha⁻¹ was removed from this plot.

Table J7/a. Fertiliser applications in Experiment XX, kg ha⁻¹.

Plot	14.9.1949		12.5.1970	22.5.1984		1948
	Rock phosph. 14% P	Potassium chloride 33% K	Urea 46% N	PK-fertilizer for peatl.for. 9% P, 17% K, 0.2% B	Amm.nitrate with lime 27.5% N, 2.2% Mg	Wood ash kg ha ⁻¹
a	-	300	216	-	-	-
b	400	-	216	500	-	-
c	200	150	216	500	400	-
d	-	-	-	-	-	8000

Table J7/b. Stand characteristics of Experiment XX in 1992.

Plot	V m ³ ha ⁻¹	I _{V(1983-92)} m ³ ha ⁻¹ a ⁻¹	Total prod. m ³ ha ⁻¹	G m ² ha ⁻¹	D _{1,3} cm	H m	Age a
a	93	2.0	143	12.5	18.4	15.0	116
b	94	1.6	143	12.8	20.2	14.7	116
c	88	2.8	142	12.1	14.2	14.6	116
d	69	4.9	143	10.9	15.0	12.3	44

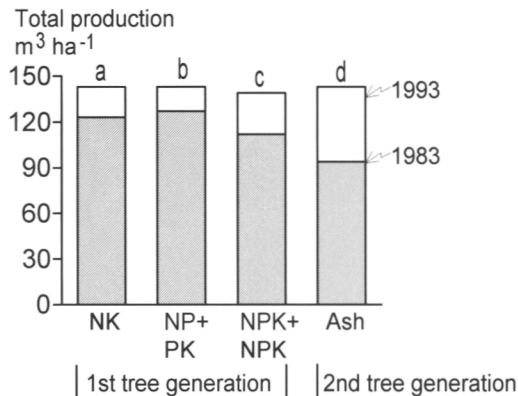


Fig J7. On the ombrotrophic pine bogs at Jaakkoinsoo, the reaction of tree growth to fertilisation was small, which is typical of old pine stands on peat.

J8. A mature pine stand: drainage and wood ash fertilisation

Experiment XIII

Plots 0, 1 and 2

Established in 1937

Plot area: 0.09 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 1.2 m

$N_{0-10\text{ cm}}$ (1995): 1.45%

Mineral subsoil: sand

Drainage of this site was carried out in 1909, 1923 and 1935. The main purpose of the experiment is to study the effect of drainage and wood ash fertilisation on the stand growth. The stand was thinned in 1984. The latest measurements were made in 1993, when the 117 year old stand was thinned. Wood ash application has almost doubled the total yield compared with the control.

Table J8. Stand data of Experiment XIII in 1992.

Plot	Wood ash kg ha ⁻¹	V m ³ ha ⁻¹	I_V m ³ ha ⁻¹ a ⁻¹	Total prod. m ³ ha ⁻¹	G m ² ha ⁻¹	D _{1,3} cm
0	-	120	2.2	189	14.6	21.7
1	5 000	246	3.9	368	23.1	27.3
2	10 000	213	5.1	380	18.9	30.6

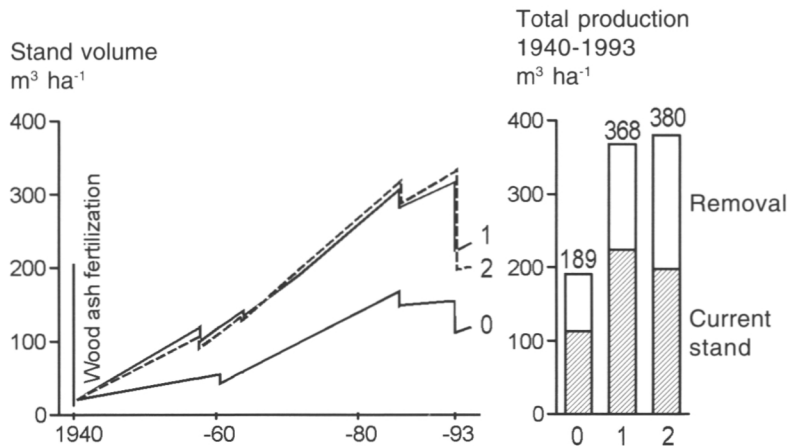


Fig. J8. The effect of wood ash fertilisation on wood production on Experiment XIII. 0 = control, 1 = wood ash 5000 kg ha⁻¹, 2 = wood ash 10 000 kg ha⁻¹.

J9. The ecological experiment fields

Experiments 66 , 67

Established in 1961-62

Plot area: 0.06 ha

Original site type: dwarf-shrub pine bog

Peat thickness: 1.5 m

$N_{0-10\text{ cm}}$:
(straw covered plots)
water table

-10 cm	1.32%
-30 cm	1.27%
-50 cm	1.35%
-70 cm	1.41%

Mineral subsoil: fine silt

In the 1950s when the forest improvement activities increased rapidly in Finland, more knowledge was needed of the combined effect of drainage intensity and climate on tree growth. Two ecological experiments, where soil drainage and tree nutrition were regulated, were established on Jaakkoinsuo in 1961-1962. 52 years after the initial drainage, monitoring of the tree stand growth was started on the sample plots (15 x 40 m) which had the water level in the surrounding ditches regulated at five fixed levels: 0 cm (1 plot), 10 cm, 30 cm, 50 cm and 70 cm (3 plots each) below soil surface. Five plots were repeatedly fertilised. Soil temperature during the growing season was lowered by retarding the soil thawing with a straw cover during three years (1962-64). The straw cover has decomposed long ago, but its effect is still visible in tree growth.

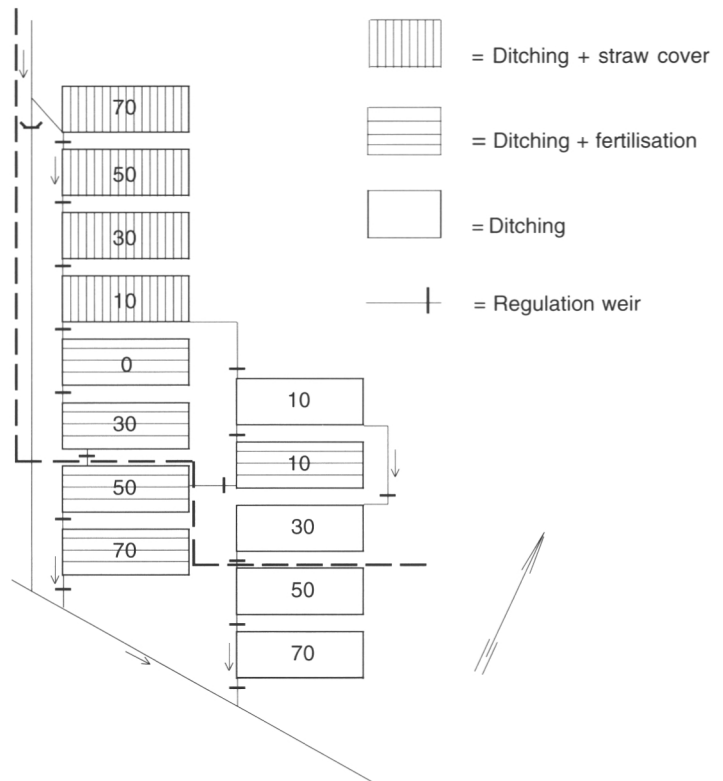


Fig. J9. Layout of the experiment. The figures within the plots indicate the regulated water depth in the ditches surrounding the sample plots.

On each plot, stand growth, ground water level (9 points) and soil temperature (3 points, each at 4 depths) has been regularly monitored.

Scots pines reacted to the treatments in an interesting manner. Without fertilisation, stand growth was the better, the deeper the regulated water table was during the first decades of the experiment. On the fertilised plots, on the other hand, tree growth was equal for the regulation depths of 30, 50 and 70 cm, whereas it was clearly smaller for the 10 and 0 cm depths. The conclusions from this are that drainage affects stand growth also indirectly

by nutrient mobilization: as the water level is lower, more nutrients are mobilized in the decomposition of the peat and taken up by the trees. On the fertilised plots, the water level is not essential from the point of view of tree nutrition, and drainage is needed only for a sufficient oxygen input in the vicinity of roots. On the dwarf-shrub pine bog part of Jaakkoinsoo, there seems to be enough oxygen for tree roots with the water level at a depth of 30 cm. Now, as 40 years have passed since the experiment was started, the effect of fertilisation is not as apparent as it was at the initial stage (Table J9). The straw cover, which was used for regulating soil temperature, has clearly increased stand growth. This is probably a consequence of decreased competition by the ground vegetation.

Table J9. Tree stand data in 1993. S_n = stem number per hectare; V = stand volume, $m^3 ha^{-1}$; I_v = annual growth, $m^3 ha^{-1} a^{-1}$.

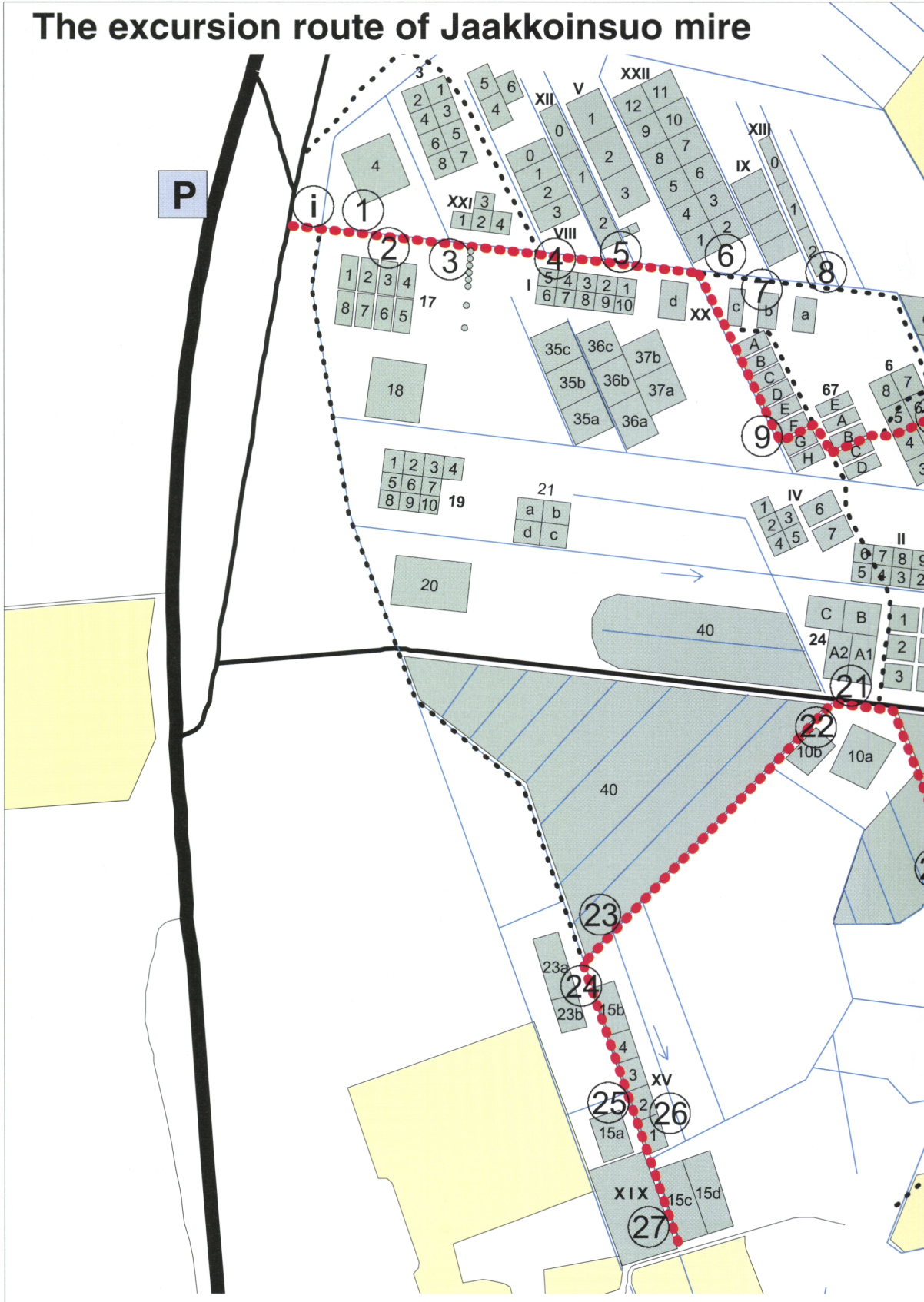
Regulated water level cm	Ditching			Ditching+straw cover			Ditching+fertilisation		
	S_n	V	I_v	S_n	V	I_v	S_n	V	I_v
0	-	-	-	-	-	-	1050 ¹⁾	20	0.5
10	517	48	1.0	617	82	2.4	716	75	1.5
30	576	66	1.7	816	148	4.6	733	97	2.5
50	635	91	2.8	733	165	5.2	700	111	3.1
70	600	129	3.9	750	172	5.6	550	111	3.2

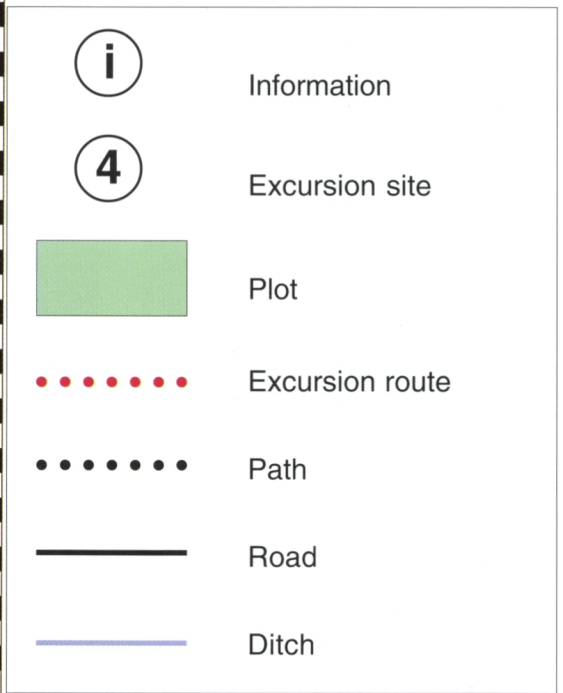
1) the original tree stand died after raising of the water

The regulation of the ditch water level had an effect on both the ground vegetation and mire surface level. The plot with 0 cm water level is now much wetter than originally and has transformed from a dwarf-shrub pine bog transition site type to a cottongrass low-sedge bog. Some small pine plants that have developed after the experiment started are growing on the plot; the old stand died after the raising of the water level. During 30 years (1962-1992) the peat layer has grown 8 cm thicker. On the other plots the ground vegetation has undergone smaller changes. Peat thickness has changed most on the plots with 70 cm water level: there it has decreased with 10 cm.

Changes in carbon store were determined by two methods: 1) by using levelling data from 1962 and 1992, the 80 cm depth for the year 1962 was reconstructed, and the carbon store above that depth was determined, 2) synchronous layers in the bulk density of peat was used to identify comparable peat layers to be used in the estimation of the carbon store. There was no clear relationship between water regulation depth and carbon store. However, irrespective of fertilisation treatment and basis of estimation, the carbon store was lower for the 0 cm regulation depth than for the other treatments. This would indicate that over a period of ca 30 years, ditching had increased the carbon store of the peat layer.

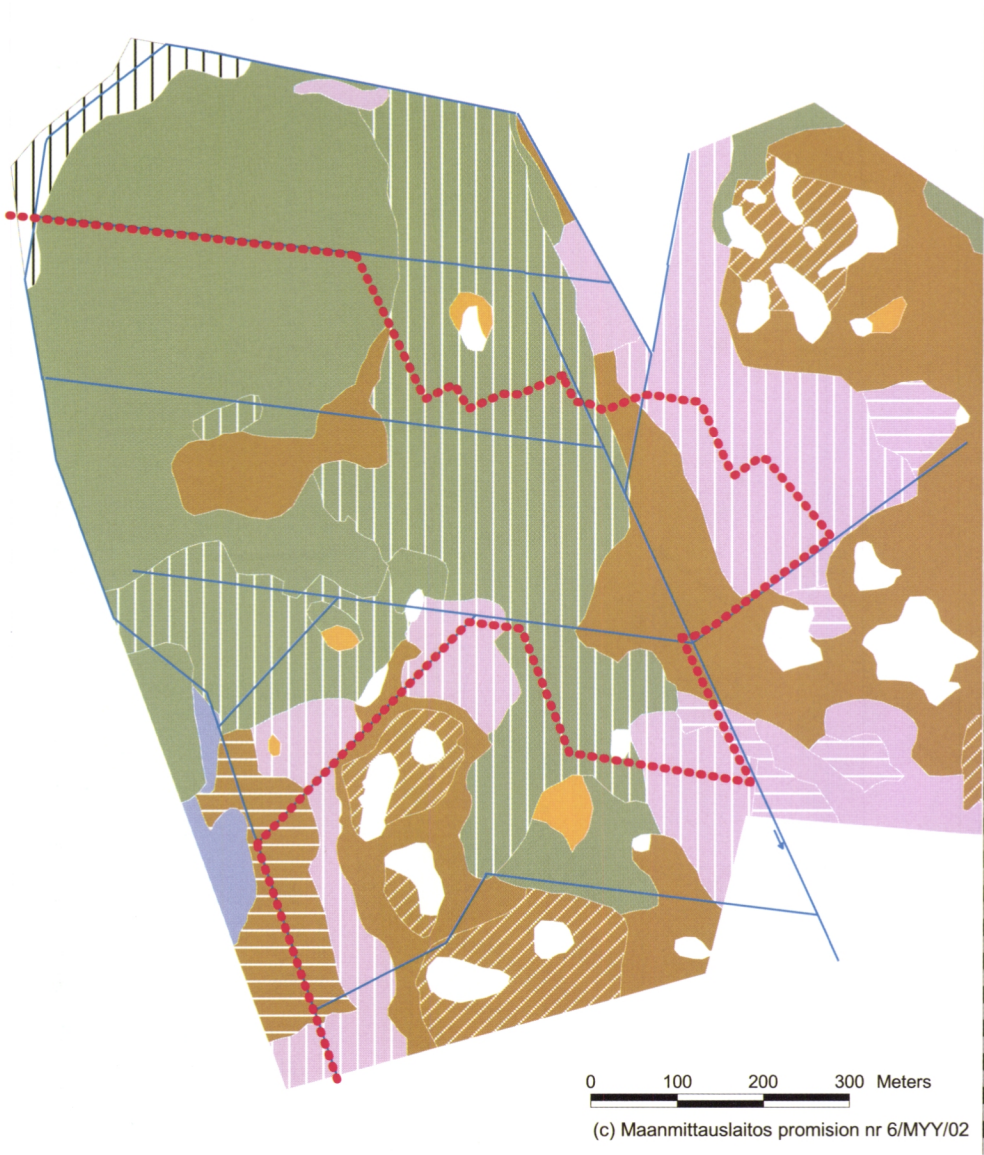
The excursion route of Jaakkoinsuo mire

















(c) Maanmittauslaitos promision nr 6/MYY/02

Original mire site types of Jaakkoinsuo in 1911



- | | | | | | |
|---|----------------------------------|---|---|---|---------------------------------|
|  | Mineral soil forest |  | Paludified pine forest |  | Herb-rich hardwood spruce swamp |
|  | Paludified forest |  | Ordinary spruce swamps |  | Herb-rich sedge birch-pine fen |
|  | Dwarf-shrub pine bog |  | Tall-sedge fen/ tall-sedge pine fen |  | Hardwood spruce fens |
|  | Dwarf-shrub cottongrass pine bog |  | Paludified <i>Vaccinium myrtillus</i> spruce forest |  | Eutrophic pine fen |

Distribution of site types in 2000



- | | | |
|--|--|---|
|  Herb-rich peatland forest |  <i>Vaccinium vitis-idaea</i> peatland forest |  Mineral soil forest |
|  <i>Vaccinium myrtillus</i> peatland forest |  Dwarf-shrub peatland forest | |

J10. Cycling of nutrients and their distribution in a Scots pine stand

Experiment 6

Plots 1-6

Established in 1928

Area: Plots 1-4 0.06 ha
Plots 5-6 0.07 ha

Original site type: dwarf-shrub cottongrass pine bog

Peat thickness: 1.1 m

$N_{0-20\text{ cm}}$: 1620 kg ha⁻¹
(1997)

Mineral subsoil: fine silt

The experiment consists of six plots (Table J10). Both basic and refertilisation treatments were involved (Paavilainen 1980). The nutrient allocation (N, P, K, Ca, Mg, Mn, B, Cu and Zn) and cycling in a poor, drained peatland forest were studied during 1974-1978.

Both the tree stand, the field layer of the ground vegetation and the soil were included in the study.

Fertilisation increased phosphorus concentrations in the needles, branches, bark and roots as well as potassium concentrations in the stemwood. There was on average 20 kg ha⁻¹ of phosphorus and 64 kg ha⁻¹ of potassium allocated in the above-ground parts of the stand biomass (stem volume 135 m³ ha⁻¹). In the below-ground parts and stumps the corresponding amounts were 5 kg ha⁻¹ of P and 15 kg ha⁻¹ of K. The nutrient amounts in the field layer of the ground vegetation were 5 kg ha⁻¹ of P and 10 kg ha⁻¹ of K. The amounts in the surface peat layer (0-20 cm) were 220 kg ha⁻¹ of P and 80 kg ha⁻¹ of K.

The effects of the first fertilisation were barely noticeable. Refertilisation with NPK increased the annual biomass production and the amount of litter. The macronutrient content of the tree crop and the field layer vegetation increased while the copper and boron content decreased after refertilisation. NPK fertilisation also increased the amount of nutrients in the litter and accelerated the decomposition of cellulose slips and needle litter.

Table J10/a. Fertilisers used in Experiment 6.

Plot	Fertilisation in 1965		Fertilisation in 1974	
	PK fertil. for peatland for. (7.2% P, 13.7% K)	Y fertiliser for peatland forests (14% N, 7.8% P, 8.3% K)	Amm.nitr. with lime (26% N)	PK fertiliser for peatland forests (10.5% P, 12.5% K)
1	-	-	-	-
2	-	-	400	500
3	-	500	-	-
4	-	500	400	500
5	600	-	-	-
6	600	-	400	500

Table J10/b. Stand data of Experiment 6 in 1993.

Plot	S_n stems ha ⁻¹	G m ² ha ⁻¹	$D_{1.3}$ cm	H m	$V_{(1974)}$ m ³ ha ⁻¹	$V_{(1993)}$ m ³ ha ⁻¹	Growth 1974-93 m ³ ha ⁻¹ a ⁻¹
1	592	21.8	22.6	18.8	116	179	3.75
2	400	16.7	23.8	18.7	99	146	2.35
3	608	19.5	22.0	18.6	79	163	2.45
4	544	19.2	22.4	17.7	92	154	2.95
5	643	20.0	20.8	16.1	115	155	3.80
6	571	20.2	22.4	18.6	95	164	3.60

J11. Growth of a spruce swamp forest

Plot 2

Established in 1928

Plot area: 0.12 ha

Original site type: herb-rich hardwood spruce swamp

Peat thickness: 0.5 m

$N_{0-10\text{ cm}}$: 1.96%

Mineral subsoil: fine silt

The site was drained in 1909. The distance between the ditches is 90 m. The spruce stand growing on the plot has - at least partly - developed after a broadcast sowing in 1916. The purpose of this experiment is to study the growth of Norway spruce. In 1957 the old dominant birches and pines were removed. In 1983, when the mean age of the spruce stand was 67 years, the first thinning was performed and in 1993 the second.

According to the needle analyses in 1993 the stand suffered from severe phosphorus and potassium deficiency. The zinc concentrations were also low.

Table J11. Stand data of Plot 2 in 1999.

	V $\text{m}^3 \text{ha}^{-1}$	$I_{V(1994-99)}$ $\text{m}^3 \text{ha}^{-1} \text{a}^{-1}$	Total prod. $\text{m}^3 \text{ha}^{-1}$	G $\text{m}^2 \text{ha}^{-1}$	$D_{1.3}$ cm	H m
Birch	-	-	199	-	-	-
Pine	-	-	28	-	-	-
Spruce	214	8.7	344	23.5	19.9	18.5
Total	214	8.7	565	23.5	19.9	18.5

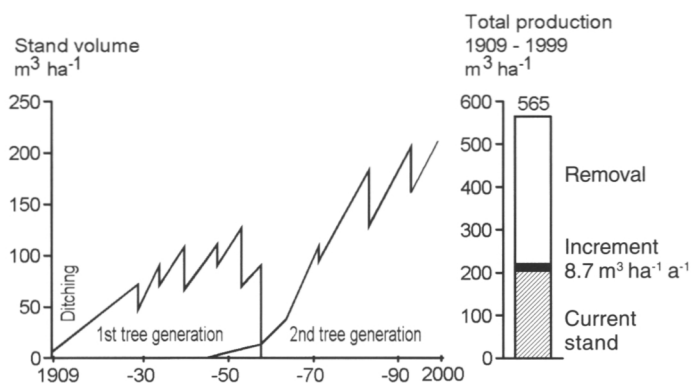


Fig. J11. Development of the tree stand on Plot 2.

J12. Comparison between a pristine and a treated spruce stand

Experiment 5

Plots 5a and 5b

Established in 1928

Area: Plot 5a 0.15 ha
Plot 5b 0.20 ha

Original site type: herb-rich tall sedge pine fen

Peat thickness: 0.5 m

$N_{0-10\text{ cm}}$ (1994): 2.01%

Mineral subsoil: fine silt

This site was drained in 1909. The distance between the ditches was then 90 m. At the time of drainage there was a mixed, 37 year old pine-spruce stand ($5 \text{ m}^3 \text{ha}^{-1}$) on the site. The stand has remained untreated on Plot 5a, while 5b has been treated more intensively. In 1963 the shelterwood was removed on Plot 5b leaving the naturally developing spruce stand. On Plot 5a the share of birch is still 59%.

The plots were measured in 1994 and 1999. The stand age in 1999 was 128 years on Plot 5a and 62 years on Plot 5b. The stem volume and the mean diameter are much higher in the untreated Plot 5a. The volume growth, however, was almost equal in the two plots. Thinning was carried out on Plot 5b in 2000.

According to needle analysis in 2001 there was a severe deficiency of phosphorus and potassium, particularly on Plot 5b.

Since spring 2000 a monitoring study of the spruce stand including nutrient analyses and measurements of environmental variables is going on here.

Table J12. Tree stand data of Plots 5a and 5b in 1999.

	S_n stems ha^{-1}	V $m^3 ha^{-1}$	$I_{V(1995-99)}$ $m^3 ha^{-1} a^{-1}$	Total prod. $m^3 ha^{-1}$	G $m^2 ha^{-1}$	$D_{1.3}$ cm	H m
Plot 5a (pristine)							
Pine	27	8	0.1	11	0.9	2.6	19.8
Spruce	2113	115	2.5	159	14.1	18.8	16.5
Birch	453	177	3.9	236	17.7	24.0	21.2
Total	2 593	300	6.5	406	32.7	24.0	19.1
Plot 5b (treated with cuttings)							
Pine	10	2	0.1	58	0.3	18.4	16.9
Spruce	1220	160	8.7	249	20.6	15.6	15.1
Birch	-	-	-	166	-	-	-
Total	1230	162	8.8	473	20.9	15.7	15.1

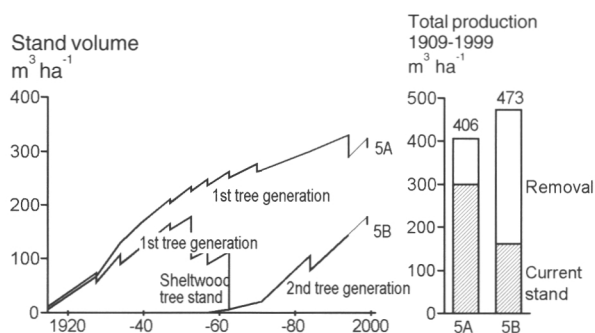


Fig. J12. Development of tree stand on Plots 5a and 5b.

J13. Regeneration of a birch stand

Experiment 60

Established in 1985

Plot area: 0.0725 ha

Original site type: tall-sedge pine fen

Peat thickness: 0.4 m

The site was drained in 1909, 1915 and 1985. The distance between the ditches is 30 m.

In 1985, an experiment was established to study the effect of fertilisation on 1) the natural regeneration of downy birch and 2) the development of planted downy birch (*Betula pubescens*) and silver birch (*Betula pendula*) seedlings. The sample plots were fertilised in the spring of 1985. In the winter of 1987 the shelterwood stand was removed and in the spring of 1988 the downy birch and silver birch seedlings were planted as presented on the map in Fig. J13.

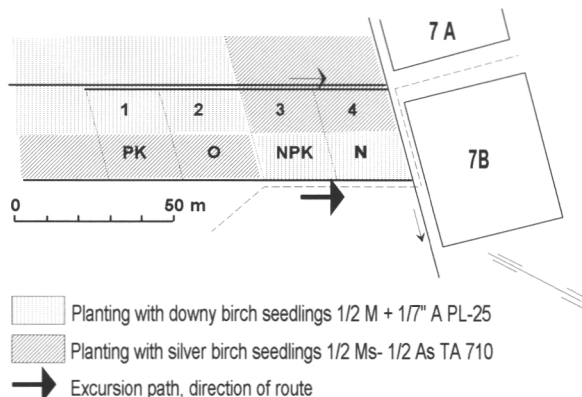


Fig. J13. Treatments on the plots of Experiment 60.

PK = PK fertiliser for peatland forests 500 kg ha^{-1} (P 9%, K 17%)
 N = Ammonium nitrate with lime 450 kg ha^{-1} (N 27.5%, Mg 2.2%)

J14. Effect of cuttings on the productivity of a mixed forest

Experiment 7 Plots a and b

Established in 1928

Plot area: 0.20 ha

Original site type: tall-sedge pine fen

Peat thickness: 0.4 m

$N_{0-10\text{ cm}}$ (1995): 2.32%

Mineral subsoil: fine silt

The site was drained in 1909, 1915 and 1986. Presently, the distance between the ditches is 45 m. The purpose of this experiment is to study the effect of drainage and thinning on the growth and development of tree stands. The stand on the Plot 7a has been thinned six times (in 1928, 1934, 1939, 1945, 1953 and 1957). In the thinnings, Scots pine was not favoured with respect to downy birch as in Experiment 8. In 1984 the remaining dominant birches were removed from over the new spruce stand which had developed naturally. The stand on Plot 7b has not been treated by any cuttings, and there the only removal has been through natural competition.

According to needle analyses (1992) the spruce stand on Plot 7b suffered from a slight nitrogen and phosphorus deficiency, while the stand on Plot 7a suffered from a slight potassium deficiency.

Table J14. Tree stand data of Experiment 7 in 1999.

		S_n stems ha^{-1}	V $m^3 ha^{-1}$	$I_{V(1995-99)}$ $m^3 ha^{-1} a^{-1}$	Total prod. $m^3 ha^{-1}$	G $m^2 ha^{-1}$	$D_{1,3}$ cm	H m
Plot 7a	Pine	-	-	-	133	-	-	-
	Spruce	945	135	8.7	194	18.3	17.1	14.7
	Birch	-	-	-	159	-	-	-
	Total	945	135	8.7	486	18.3	17.1	14.7
Plot 7b	Pine	265	165	4.6	236	14.6	27.3	24.8
	Spruce	1 705	61	1.5	64	10.7	14.5	11.1
	Birch	410	133	4.0	195	13.9	23.2	21.9
	Total	2 380	359	10.1	495	39.2	22.2	20.3

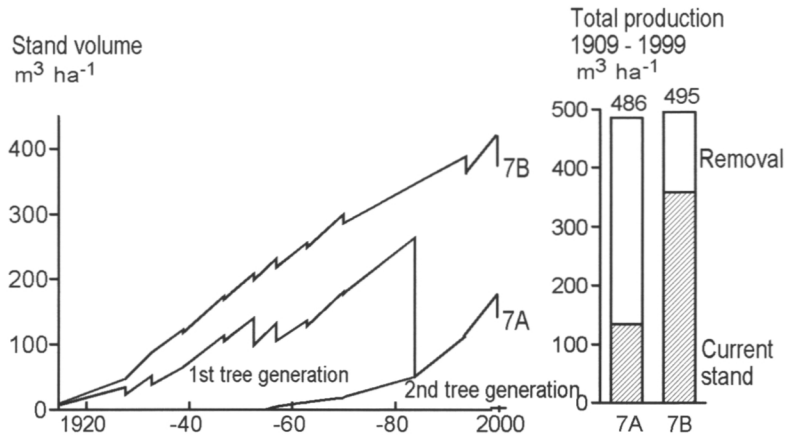


Fig. J14. Tree stand development of Plots 7a and 7b.

J15. Comparison between a pristine and a thinned mixed forest

Experiment 8

Plots a and b

Established in 1928

Plot area: 0.20 ha

Original site type: tall-sedge pine fen

Peat thickness: 0.4 m

$N_{0-10\text{ cm}}$ (1995): 2.29%

Mineral subsoil: fine silt

The site was drained in 1909, 1915, 1936 and 1986. The distance between the ditches is 45 m. The purpose of this experiment is to study the effect of drainage and thinning on the tree stand. Plot 8 has been thinned six times (in 1928, 1934, 1939, 1947, 1953 and 1957). In the thinnings, Scots pine was favoured with respect to birch. In 1985 the last trees of the first tree generation were removed. The stand on Plot 8b has not been treated by any cuttings, and there the only removal has been through natural competition.

Experiment 8 is a replicate of Experiment 7 (J14). However, the plots of Experiment 8 are situated in the middle between two ditches while the Plots 7a and b are alongside a ditch, dug in 1915. The initial distance between the ditches was 125 m.

According to the needle analysis, spruces on Plot 8a do not suffer from nutrient deficiencies.

Table J15. Tree stand data of Experiment 8 in 1999.

		S_n	V	$I_{V(1995-99)}$	Total prod.	G	$D_{1.3}$	H
		stems ha^{-1}	$m^3 ha^{-1}$	$m^3 ha^{-1} a^{-1}$	$m^3 ha^{-1} m^2 ha^{-1}$		cm	m
Plot 8a	Pine	-	-	-	297	-	-	-
	Spruce	756	103	8.2	115	15.2	17.8	13.8
	thinned Birch	63	0.36	0.1	83	0.1	6.7	6.6
	Total	819	103	8.3	495	15.3	17.8	13.8
Plot 8b	Pine	400	247	3.4	310	21.9	27.7	25.6
	Spruce	1 255	95	3.4	101	12.7	17.6	15.1
	pristine Birch	330	88	3.2	113	8.4	22.2	22.4
	Total	1 985	430	9.8	524	43.0	23.6	21.9

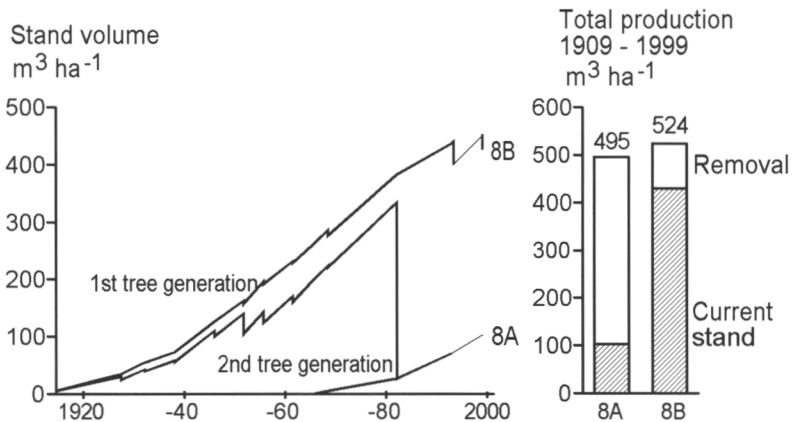


Fig. J15. Tree stand production on Plots 8a and 8b.

J16. 'H culture'

Experiment 42

Blocks I and II

Established in 1974

Area: 3.5 ha

Original site type: dwarf-shrub cottongrass pine bog

Peat thickness: 0.5–1 m

$N_{0-10\text{ cm}}$ (1984): 1.80%

Mineral subsoil: fine silt

Blocks III and IV

Established in 1974

Area: 1.1 ha

Original site type: *Vaccinium myrtillus* spruce swamp

Peat thickness: 0.5–1 m

$N_{0-10\text{ cm}}$ (1984): 2.34%

Mineral subsoil: fine silt

Block V

Established in 1974

Area: 0.8 ha

Original site type: *Vaccinium myrtillus* spruce swamp

Peat thickness:
0.2–0.4 m

$N_{0-10\text{ cm}}$ (1984): 1.91%

Mineral subsoil: fine silt

In the mid-1970s forest regeneration studies were continued at Jaakkoin-suo. The method described here, called H-culture, aims at a highly productive and rationalised forest regeneration including preplanning of both regeneration, future thinnings and other silvicultural measures. The method aims at growing tree crops in the hydrologically and nutritionally most favourable part of the drained area e.g. along the ditches while the middle part of the strips is used for transports and other forms of logistics.

At Jaakkoin-suo, the H-culture experiment was established in 1973-74 on three sites. In the winter of 1973 the old tree stand was felled. Besides the stems, also the stumps and snags were removed from the area. The distance between the ditches was as low as 10 m and the ditch spoil was spread between the ditches. In the spring of 1974 two-year-old Scots pine seedlings were planted in rows alongside the ditches, leaving a track in the middle for silvicultural measures. Simultaneously with the planting, the seedlings were fertilised along 0.5 m broad strips and on 1 m² patches with a phosphorus and potassium fertiliser designed for peatland forests (Su-PK) with an amount corresponding to 1000 kg ha⁻¹.

In the spring of 1984 the experiment was inventoried. The initial development of the planted seedlings had been very rapid and it clearly exceeded the corresponding initial height increment for the fertility classes 3 and 4 for the first ten years on upland forests in South Finland.

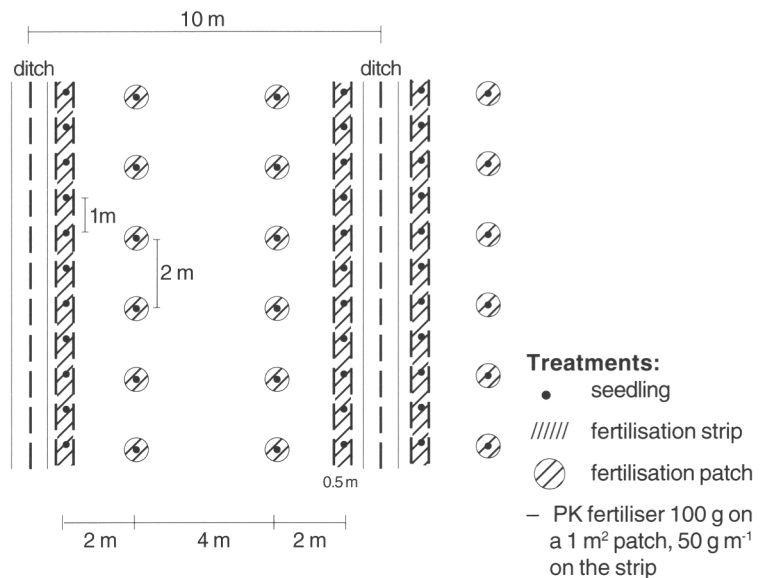


Fig. J16a. The 'H culture' experiment.

An application of micronutrients did not affect the growth or survival rate of the trees. The occurrence of growth disturbances were rather frequent within the experiment. Twisted stems were frequent especially in blocks III and IV with the highest amounts of nitrogen in peat. The growth disturbance symptoms disappeared after fertilisation with micronutrients.

In 1994, the H-culture experiment was subject to a fertilisation trial. The treatments were control, P, K, PK and NPK fertilisation (N 100 kg ha⁻¹, K 80 kg ha⁻¹ and P 45 kg ha⁻¹). All treatments received the same amount of boron (B). The control plots were divided into two subplots of which one was fertilised with boron.

There are several mire site types that do not require afforestation after drainage. Also on these sites there would apparently have developed a natural spruce stand because, according to an inventory, there were 11 000 natural spruce seedlings per hectare in the area.

Table J16. Fertiliser treatments of the 'H culture'

Fertiliser treatment	kg ha ⁻¹	Blocks/Plots					
		I	II	III	IV	V	
1. Control	0	-	3	6	4	8	3
2. Boron *1	(B)	214	3a	6a	4a	8a	3a
3. Apatite *2	(P)	281	5	9	2	10	1
Boron	(B)	214					
4. K fertiliser with B and Zn *3	(K)	267	4	7	1	9	4
5. Apatite	(P)	281	2	8	5	7	5
K fertiliser with B and Zn	(K)	267					
6. Amm. nitrate with lime *4	(N)	364	1	10	3	6	2
Apatite	(P)	281					
K fertiliser with B and Zn	(K)	267					

Fertilisers used:

*1 Boron fertiliser (B 0.5%, Ca 19%, S 18%, Mg 2%)

*2 Apatite (P 16%, Ca 36.5%)

*3 K fertiliser with B and Zn (K 30%, Ca 1.5%, S 6%, Mg 7%, B 0.4%, Zn 0.4%)

*4 Ammonium nitrate with lime (N 27.5%, Mg 1%)

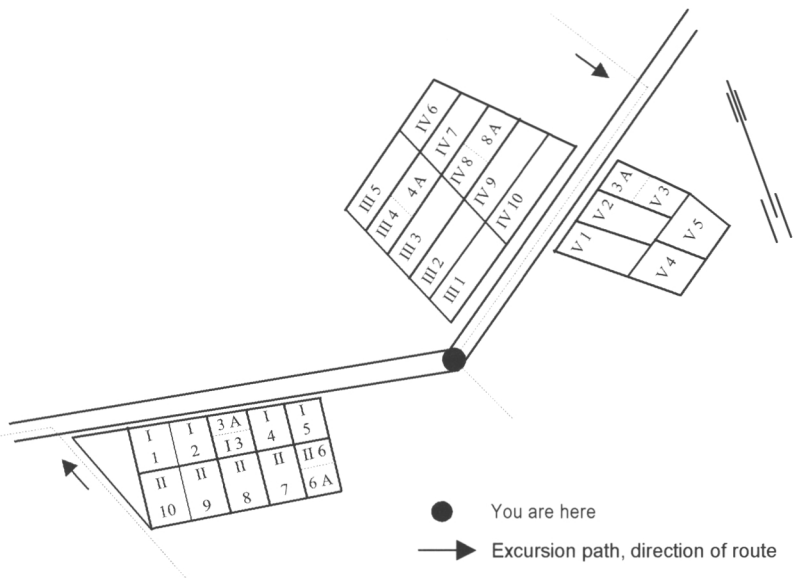


Fig. J16b. Blocks of the experiment.

J17. Effect of fertilisation on the natural regeneration of spruce

Experiment 61

Established in 1985

Area: Plot 1-3 0.08 ha
Plot 4 0.07 ha

Original site type: herb-rich hardwood-spruce swamp

Peat thickness: 0.35 m

$N_{0-10\text{ cm}}$: 2.19%
(Plot 1 in 1995)

Mineral subsoil: fine silt

The site was drained in 1909 and 1938. The distance between the ditches is 90 m.

A shelterwood cutting aiming at natural regeneration of spruce was done in 1982. About 200 stems per ha of spruce ($V = 150\text{ m}^3\text{ ha}^{-1}$) was left on the plot. To enhance regeneration a fertilisation trial was established in the area in 1985. Regeneration of spruce was not successful. The tree stand was clear-cut in the winter of 1995-96.

The area was ditched and the ditch spoils mounded on the strips, and planted with silver birch in 1996.

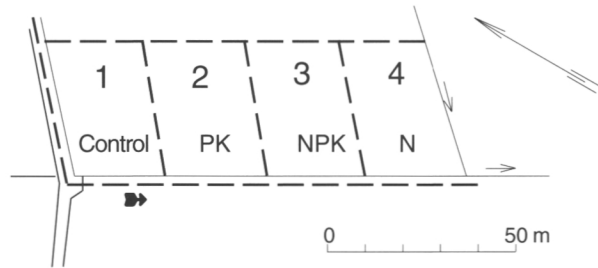


Fig. J17. Fertiliser treatments of Experiment 61 in 1985.
PK = PK fertiliser for peatland forests 555 kg ha^{-1} (P 9%, K 17%)
N = Ammonium nitrate with lime 436 kg ha^{-1} (N 27.5%, Mg 2.2%)

- - - ➔ excursion path, direction of excursion route

J18. A spruce stand growing on a thin peat layer

Experiment 26

Established in 1935

Area: 0.25 ha

Original site type: tall-sedge hardwood-spruce fen

Peat thickness: 0.3 m

$N_{10-20\text{ cm}}$: 1.97% (1940)
 N_{org} : 2.56%

Mineral subsoil: fine silt

The site was drained in 1909. The distance between the ditches is about 120 m. At the time of drainage the forest consisted of a sparse, uneven downy birch stand. The purpose of this experiment is to study the effects of drainage and cuttings on changes in the site type and also on the growth and regeneration of the stand. When established, the stand was a sparse (heavily thinned) downy birch forest with a spruce undergrowth. The total stand volume was $112\text{ m}^3\text{ ha}^{-1}$.

The stand has been thinned in 1916 and 1934, and after establishing the experiment, in 1935, 1940, 1947, 1953, 1958 and 1982. The last birches were removed in 1958. The spruce stand was measured in 1999 at the mean age of 97 years. This stand has the highest productivity on Jaakkoinsoo mire.

Table J18. Tree stand data of Plot 26 in 1999.

	S_n Stems ha^{-1}	V $\text{m}^3\text{ ha}^{-1}$	$I_{V(1994-99)}$ $\text{m}^3\text{ ha}^{-1}\text{ a}^{-1}$	Total prod. $\text{m}^3\text{ ha}^{-1}$	G $\text{m}^2\text{ ha}^{-1}$	$D_{1.3}$ cm	H m
Birch	-	-	-	199	-	-	-
Spruce	504	373	12.9	547	30.5	29.0	26.1
Total	504	373	12.9	746	30.5	29.0	26.1

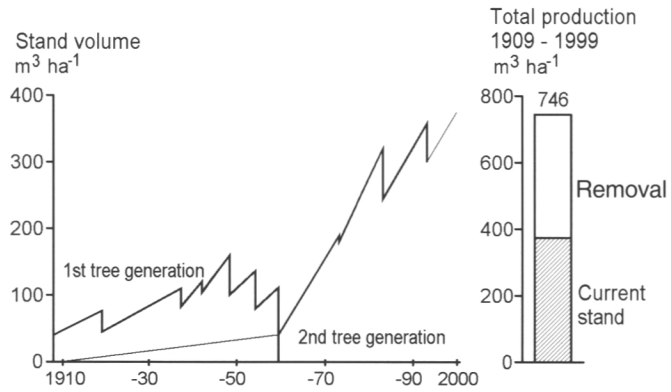


Fig. J18. Stand development on Plot 26.

J19. Recovery of spruce stands after shelterwood removal

Experiment 27 Plots a and b

Established in 1935

Plot area : 0.10 ha

Original site type: tall-
sedge pine fen

Peat thickness:
0.4–0.8 m

$N_{0-10\text{ cm}}(1995)$: 2.11%

The site was drained in 1909, 1929, 1938, and 1983. The first thinning of the tree stand was done in 1909, the next time at the time of establishing the experiment in 1935 and after that five more times (in 1940, 1947, 1953, 1957, and 1963). Plot 27b was fertilised with a mixture of phosphorus and potassium in 1965.

The purpose of this experiment is to study the effects of drainage, thinning, natural regeneration and fertilisation on tree growth. In 1982 the shelterwood over the undergrowth was removed in the following way: on Plot 27a half of the shelterwood trees and on Plot 27b all the shelterwood trees. Presently the reactions of the undergrowth stands are followed up.

According to the needle analysis (1993) the spruce stand under the shelterwood (27a) suffered from a severe phosphorus deficiency and from slight nitrogen and potassium deficiencies. The unsheltered stand (27b) had no nitrogen deficiency, and only a marginal phosphorus and potassium deficiency. The magnesium concentration was low, especially under the shelterwood.

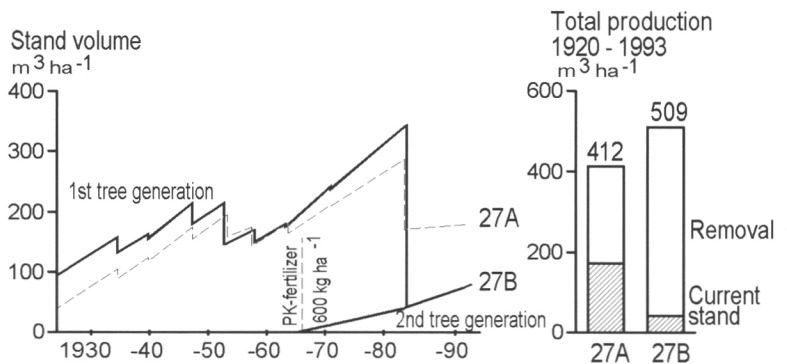


Fig. J19. Stand development on Plots 27a and 27b. The fertiliser treatment has increased the stand growth with about $3.2\text{ m}^3\text{ ha}^{-1}\text{ a}^{-1}$.

J20. Regeneration on a pine bog

Experiment 41

Established in 1983

Area: 2.5 ha

Original site type: *Carex globularis* pine swamp

Peat thickness: 0.2-1 m

Mineral subsoil: fine silt

The site was drained in 1909 and 1928. The distance between the ditches was 40 m. Complementary drainage was done in 1982. The purpose of this experiment is to study different regeneration methods: natural regeneration, sowing, planting and the effect of soil preparation.

The old tree stand was cut into a seed tree position on some parts of the area (leaving 40-50 seed trees per ha) while the other parts were clear-cut in the winter of 1983. Soil preparation was done with a cultivator with 4-5 m intervals which forms a 50-60 cm wide ridge and about a 20-25 cm deep and 20-30 cm wide furrow. The clear-cut areas were afforested with Scots pine in the spring of 1984. Part of the area was sown and part of it planted with 1A+1A plants. The seed trees were removed in the winter of 1992-93.

The planted and sown parts of the experiment were inventoried in 1994. The mean survival rate of the planted seedlings was 89% (2380 plants per hectare were alive). The survival rate for the sown seedlings was 70% (1690). There was a statistically significant difference in the survival rates between the planted and sown areas. Cultivation, distance from ditch and peat thickness had no effect on the survival rate or plant height growth.

The number of natural seedlings was ca 1600 per hectare. There were more seedlings in the thick-peat than in the thin-peat areas. The most common faults recorded on the planted and sown seedlings were stem crookedness and leader change. These features were more common in the planted seedlings. Leader changes were more common in the sown than in the naturally seeded seedlings. Leader dieback was most common on the cultivated strips.

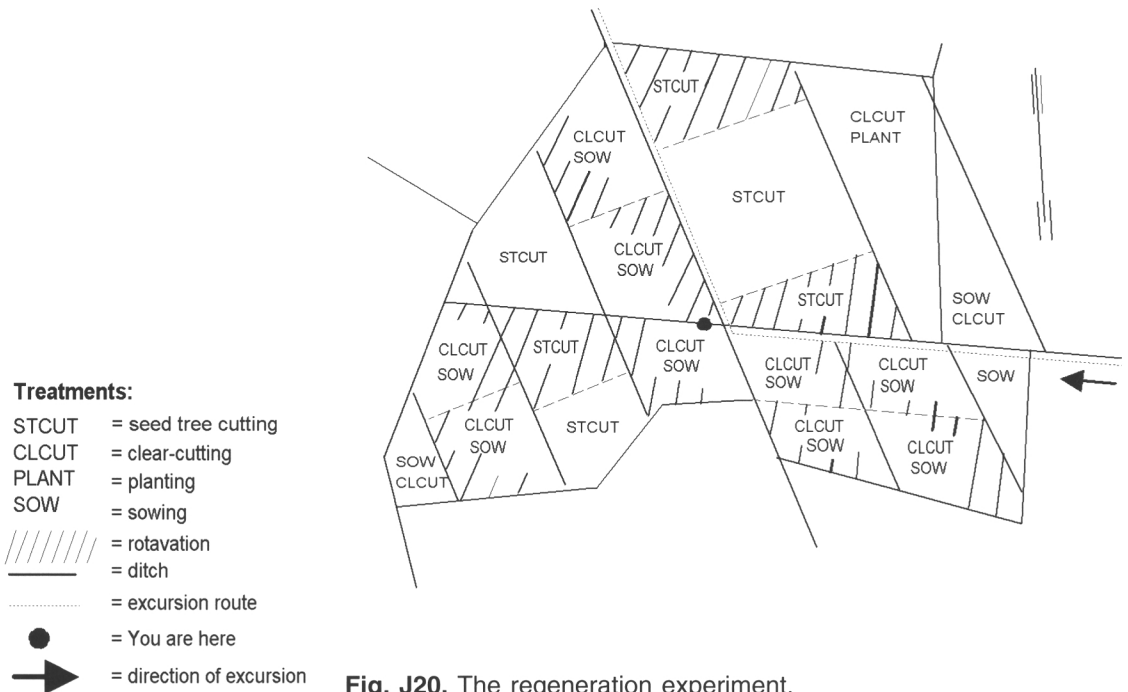


Fig. J20. The regeneration experiment.

Before the excursion path reaches the forest road there are some sample plots that belong to the experiment J16 (H-culture) on the right hand side of the path.

J21. Drainage and prescribed burning

Experiment 24 Plots A1 and A2

Established in 1935

Plot area: 0.125 ha

Original site type: dwarf-shrub cottongrass pine bog

Peat thickness: 0.5 m

$N_{0-10\text{ cm}}$ (1995): 2.08%

Mineral subsoil: fine silt

The site was drained in 1909 and 1925. At the time of drainage the tree stand consisted of sparse, slowly growing pines.

The purpose of this experiment is to study the effect of drainage and prescribed burning on regeneration and subsequent stand development. In 1956 the stand ($V=76\text{ m}^3\text{ ha}^{-1}$; $I_v=1.8\text{ m}^3\text{ ha}^{-1}\text{ a}^{-1}$) was clear-cut and two years later the area was burned.

First thinning of the stand was performed in 1978. On Plot A1 a mixed pine-birch stand was left growing while only pines were left on Plot A2. The stands were measured in 1996 at the age of 37 years and thinned lightly in the winter of 1995. Even on a relatively poor site like this the competition by birch was too severe for Scots pine.

In the mixed birch-pine stand the nitrogen concentrations of the pine needles were lower and the phosphorus and potassium concentrations higher than in the pure pine stand which had a mild potassium deficiency. The birch mixture also seemed to increase needle weight, Ca and Zn concentrations but decrease Mg, Cu and Mn concentrations (1993).

Table J21. Tree stand data of Plots 24 A1 and A2 in 1996.

		S_n stems ha^{-1}	V $\text{m}^3\text{ ha}^{-1}$	$I_{V(1995-96)}$ $\text{m}^3\text{ ha}^{-1}\text{ a}^{-1}$	G $\text{m}^2\text{ ha}^{-1}$	$D_{1.3}$ cm	H m
24 A1	Pine	488	32	1.5	5.7	12.8	10.9
	Birch	408	24	1.6	4.2	12.1	12.0
	Total	896	56	3.1	9.8	12.5	11.3
24 A2	Pine	800	70	2.8	11.9	14.5	11.3

From here you can return to the forest plough. The path goes between the Experiments 24 and 72.

J22. Comparison of a pristine and a thinned tree stand

Experiment 10

Established in 1928

Area: Plot 10a 0.20 ha
Plot 10b 0.10 ha

Original site type: tall-
sedge pine fen

Peat thickness: 0.3 m

$N_{0-10\text{ cm}}$ (1995): 2.31%

Mineral subsoil: fine silt

The site has been drained in 1909 and 1938. Prior to the first drainage the tree stand consisted of a mixed forest with a volume of about $8\text{ m}^3\text{ ha}^{-1}$. An experiment for studying the development of a pristine and regularly thinned pine stand was established.

The stand on the Plot 10a has been treated several times. During the last cutting in 1982 the shelterwood covering the spruce undergrowth was removed and monitoring of the 2nd stand generation started. The stand on Plot 10b has been left to develop naturally.

According to needle analysis the spruce stand on Plot 10b suffers from severe nitrogen and moderate phosphorus and potassium deficiencies. The magnesium concentrations are also low.

Table J22. Tree stand data of Plots 10a and 10b in 1999.

		S_n	V	$I_{V(1995-99)}$	Total prod.	G	$D_{1,3}$	H
		stems ha^{-1}	$\text{m}^3\text{ ha}^{-1}$	$\text{m}^3\text{ ha}^{-1}\text{ a}^{-1}$	$\text{m}^3\text{ ha}^{-1}\text{ m}^2\text{ ha}^{-1}$	$\text{m}^2\text{ ha}^{-1}$	cm	m
10 a thinned	Pine	-	-	-	308	-	-	-
	Spruce	925	83	6.0	103	12.3	15.0	13.5
	Birch	140	0.26	-	88	0.1	3.9	4.5
	Total	1065	83	6.0	499	12.4	14.9	13.5
10b pristine	Pine	480	277	4.7	403	23.9	26.1	24.0
	Spruce	2730	86	3.1	86	12.8	13.9	13.1
	Birch	600	113	3.7	124	12.0	20.4	19.8
	Total	3810	476	11.5	613	48.7	21.5	20.1

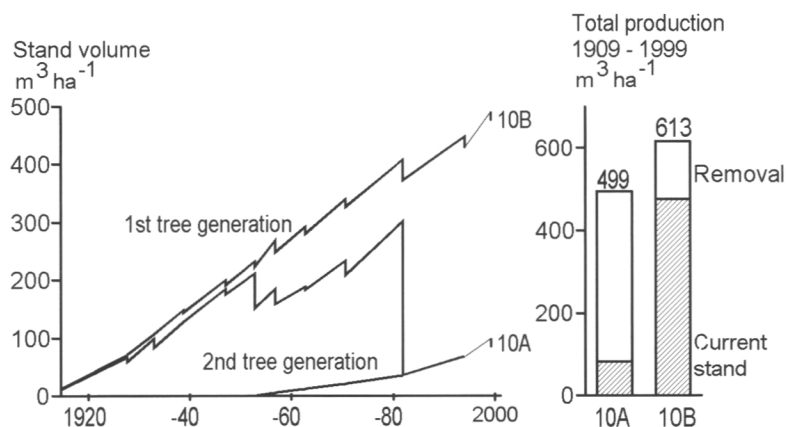


Fig. J22. Tree stand development on Plots 10a and 10b.

J23. Leaching of nutrients and suspended solids

Experiment 40

Established in 1993

Area: 7 ha

Original site type: dwarf-shrub cottongrass pine bog

Peat thickness: 0.4-1 m

N_{0-10 cm} (1984): 0.9-1.7%

Mineral subsoil: clay - fine silt

The purpose of this experiment is to study the effect of clear-cutting and soil preparation on the leaching of nutrients and suspended solids from a nutrient-poor pine bog.

In May 1993 five small catchment areas were designed by building overfall weirs in the middle ditch of each catchment (Fig. J23a). Since then, the quality of the runoff waters has been monitored by sampling the overflow of the runoff water at the weirs.

In the early winter of 1995, four catchment areas south of the road were clear-cut while the single catchment north of the road was left as a control. During the summer of the same year, one of the clear-cut areas was ditched so that the ditches reached down to the mineral subsoil (clay) and small mounds for planting were created from the soil removed from the ditches. Another catchment was treated in the same way except that the ditch bottoms remained in the peat layer. A third clear-cut catchment was mounded without ditches and the fourth was left untreated.

High leaching rates of suspended solids were detected from the ditch-mounding area, where the ditches reached down into the mineral subsoil (Fig. J23b). In contrast to the clear-cutting + mounding (without ditches) and clear-cutting alone, cutting and ditch-mounding also increased the leaching of ammonium and nitrate. Phosphorus concentrations in runoff following clear-cutting and soil preparation increased from the areas where the contents of phosphorus sorbing minerals (Al and Fe) in peat were very low. The study has demonstrated that clear-cutting and soil preparation can significantly impair water quality from nutrient poor bogs.

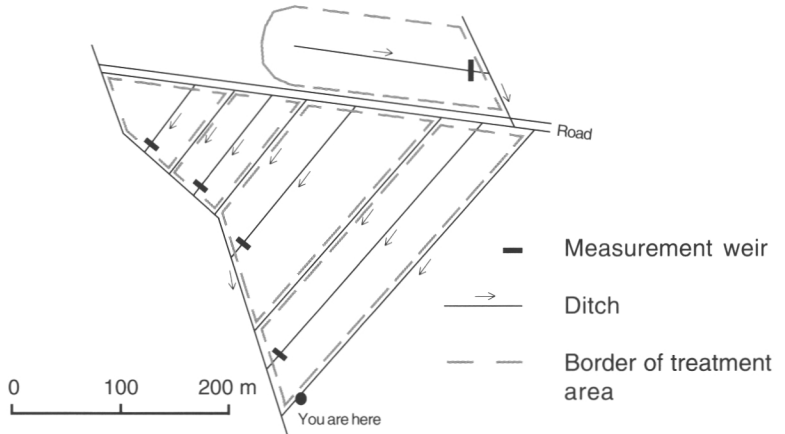


Fig. J23a. Layout of the experiment

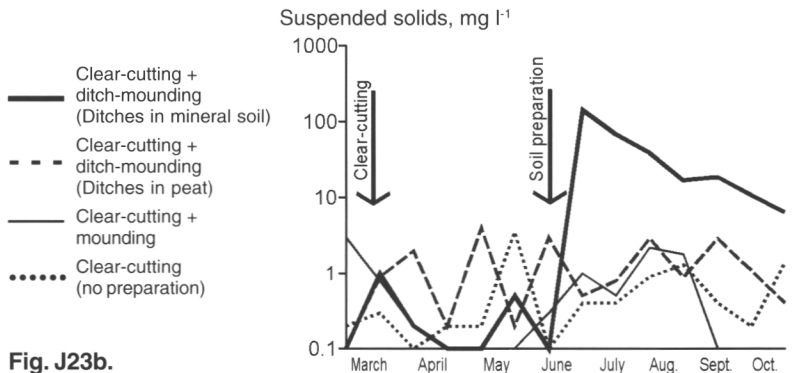


Fig. J23b.

J24. Productivity and natural regeneration of a herb-rich peatland forest

Experiment 23

Established in 1934

Area: Plot 23a 0.125 ha
Plot 23b 0.100 ha

Original site type:
Eutrophic pine fen

Peat thickness: 0.8–1m

$N_{0-10\text{ cm}}$ (1995): 2.40%

Mineral subsoil: fine silt

The site has been drained in 1909, 1915 and 1935. An experiment for studying wood production was established in 1934. The tree stand has been thinned several times; the heavy thinning in 1982 aimed at natural regeneration. Plot 23b was fertilised in 1965 (phosphorus and potassium fertiliser, 600 kg ha⁻¹). The stands were cut into seed tree position in 1994 and the remaining stands and undergrowths were measured.

Table J24. Tree stand data of Plots 23a and 23b in 1994.

Plot		S_n stems ha ⁻¹	V m ³ ha ⁻¹	I_V m ³ ha ⁻¹ a ⁻¹	Total		$D_{1.3}$ cm	H m
					prod. m ³ ha ⁻¹	G m ² ha ⁻¹		
23 a	Pine	40	41	3.0	359	3.8	35.3	24.5
	Spruce	-	-	0.5	64	-	-	-
	Birch	24	17	2.0	181	1.7	30.2	23.5
	Total	64	58	5.5	604	5.5	33.7	24.1
23b (PK fertiliser 600 kg ha ⁻¹ in 1965)	Pine	40	38	4.5	294	3.5	33.8	23.8
	Spruce	-	-	0.3	28	-	-	-
	Birch	10	9	1.2	199	0.9	33.6	23.8
	Total	50	47	6.0	521	4.4	33.7	23.8

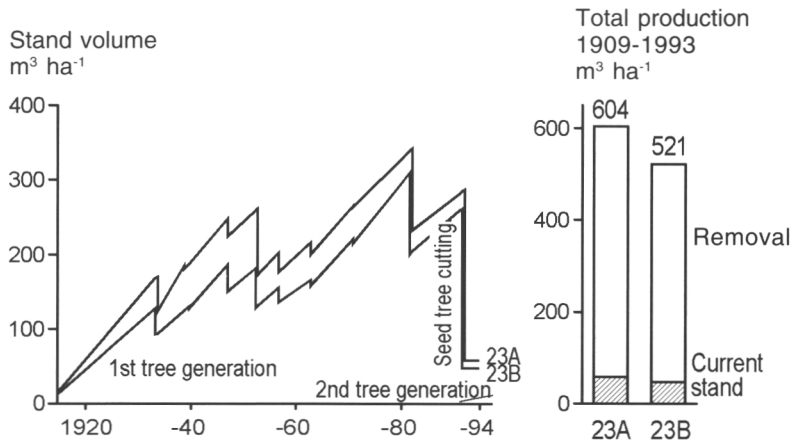


Fig. J24. Tree stand development on Plots 23a and 23b.

J25. Thinning of a peatland forest stand

Experiment 15 Plots 15a and 15b

Established in 1928

Area: Plot 15a 0.125 ha
Plot 15b 0.120 ha

Original site type: tall-sedge fen

Peat thickness: 0.75 m

$N_{0-10\text{ cm}}$ (1985):
Plot 15a 2.31%
Plot 15b 2.65%

Mineral subsoil: fine silt-clay

The site has been drained in 1909, 1935 and 1951. The distance between the ditches is 25 m.

At the time of the first drainage the site was occupied by a sparse mixed pine-birch stand with a mean age of 20 years.

The purpose of this experiment is to study the productivity and development of tree stands. The stands have been thinned several times. The heavy thinning in 1982 aimed at natural regeneration. On Plot 15b all the dominant trees were removed and the second tree generation came in focus.

Table J25. Tree stand data of Experiment 15 in 1982.

Plot	Remaining stand $\text{m}^3 \text{ha}^{-1}$	Removed in thinnings $\text{m}^3 \text{ha}^{-1}$	Total prod. $\text{m}^3 \text{ha}^{-1}$
15a	142	136	278
15b	38	270	308

J26. Planting and fertilisation of spruce

Experiment XV Plots 1–4

Established in 1964

Plot area: 0.05 ha

Original site type: tall-sedge fen

Peat thickness: 0.1–0.2 m

Mineral subsoil: fine silt

The site has been drained in 1909 and 1953. The area was planted with 2+2 year old spruce seedlings in 1939. In 1964 the experiment was divided into four parts and fertilised with different levels of a NPK fertiliser. The tree stands were measured and the first thinning was done in 1992.

The needle analyses from adjacent sites outside the experiment reveal that the stands in this area have slight deficiencies of nitrogen and potassium.

Table J26. Tree stand data in 1992

Plot	Y-fertiliser kg ha^{-1}	S_n stems ha^{-1}	V $\text{m}^3 \text{ha}^{-1}$	Total prod. $\text{m}^3 \text{ha}^{-1}$	G $\text{m}^2 \text{ha}^{-1}$	$D_{1.3}$ cm	H m
1	1 500	920	204	306	23.8	20.1	17.3
2	1 000	980	140	187	18.4	17.1	15.2
3	0	880	190	287	21.8	19.3	17.6
4	500	780	142	216	18.0	18.3	15.8

Fertiliser: Y- fertiliser for peatlands (N 14%, P 7.8% , K 8.3%)

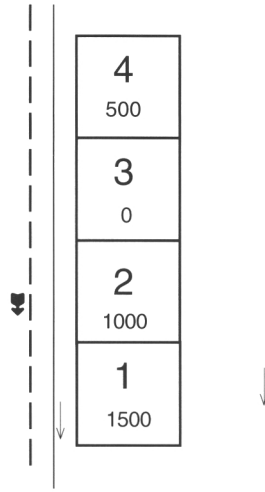


Fig. J26. Layout of Experiment XV.
 - - - ➔ excursion path, direction of excursion route

J27. A grafted birch stand

Experiment XIX

Established in 1949

Area: 0,5 ha

Original site type: tall-sedge pine fen

Peat thickness: 0.1–0.2 m

Mineral subsoil: fine silt

The site has been drained in 1909 and 1935. The mixed stand was clear-cut in 1949 and the harvest residues piled and burned.

The site was afforested by planting downy and silver birch seedlings. Downy birch succeeded much better than silver birch. This resulted in openings in the centre of the site. In the mid-1950s 'mixed' birch seedlings were planted in the openings. These were vegetatively reproduced seedlings: silver birch scions that had been grafted to downy birch stocks (in all 30) and downy birch scions that had been grafted to silver birch stocks (in all 22). In addition one curly birch scion was grafted to a silver birch stock.

The tree stand was thinned in 1994.

The grafted birch stand is the last site of the excursion path on the Jaakkoinsuo mire. Hopefully you have enjoyed your tour. We hope you will visit the mire again.

List of subjects

	Site number (J1 - J27)
– Downy birch (<i>Betula pubescens</i>)	13, 27
– dwarf-shrub peatland forest	1-8, 10, 20, 21
– fertilisation	2, 6, 7, 9, 10, 13, 14, 16, 17, 19
– flooding experiment	9
– herb-rich peatland forest	17, 18, 24
– hydrology	9, 23
– leaching	23
– liming	2, 4
– mixed tree stands	12, 14, 15, 21, 22, 24, 25
– natural regeneration	13, 17, 20, 24, 25
– Norway spruce (<i>Picea abies</i>)	11, 12, 17, 18, 19, 22, 25, 26
– nutrient cycle, nutrient budget	10
– prescribed burning	21
– Scots pine (<i>Pinus sylvestris</i>)	1, 2, 4-9, 10, 20, 21, 23
– seedling stands	13, 17, 20, 22
– Silver birch (<i>Betula pendula</i>)	13, 17, 27
– soil preparation	17, 20, 23
– sowing or planting	13, 16, 17, 20, 26
– subsidence of peat	3
– stand growth and production	practically all
– untreated tree stands	1, 12, 14, 15, 22
– <i>Vaccinium myrtillus</i> peatland forest	11, 12, 14, 15, 19, 26, 27
– <i>Vaccinium vitis-idaea</i> peatland forest	13, 20, 22, 25
– vegetation succession, monitoring of vegetation	15
– wood ash fertilisation	5, 8

List of sites

	Experiment number
J1. Pine stand preserved in the pristine state	4
J2. Regeneration of peatland forests, development of young stands and fertilisation	17
J3. Peat subsidence after drainage	
J4. Liming and growth of tree stands	I
J5. Drainage and wood ash fertilisation in a pine stand on a bog	XII/1 and XII/2
J6. Nutrition of Scots pine	XXII/1–12
J7. Drainage and fertilisation of a pine bog stand	XX /a–d
J8. A mature pine stand: drainage and wood ash fertilisation	XIII /0, 1 and 2
J9. The ecological experiment fields	66
J10. Cycling of nutrients and their distribution in a Scots pine stand	6
J11. Growth of a spruce swamp forest	2
J12. Comparison between a pristine and a treated spruce stand	5a and 5b
J13. Regeneration of a birch stand	60
J14. Effect of cuttings on the productivity of a mixed forest	7a and 7b
J15. Comparison between a pristine and a thinned mixed forest	8a and 8b
J16. 'H culture'	42
J17. Effect of fertilisation on the natural regeneration of spruce	61
J18. A spruce stand growing on a thin peat layer	26
J19. Recovery of spruce stands after shelterwood removal	27a and 27b
J20. Regeneration on a pine bog	41
J21. Drainage and prescribed burning	24A1 and 24A2
J22. Comparison of a pristine and a thinned tree stand	10a and 10b
J23. Leaching of nutrients and suspended solids	40
J24. Productivity and natural regeneration of a herb-rich peatland forest	23a and 23b
J25. Thinning of a peatland forest stand	15a and 15b
J26. Planting and fertilisation of spruce	XV/1–4
J27. A grafted birch stand	XIX

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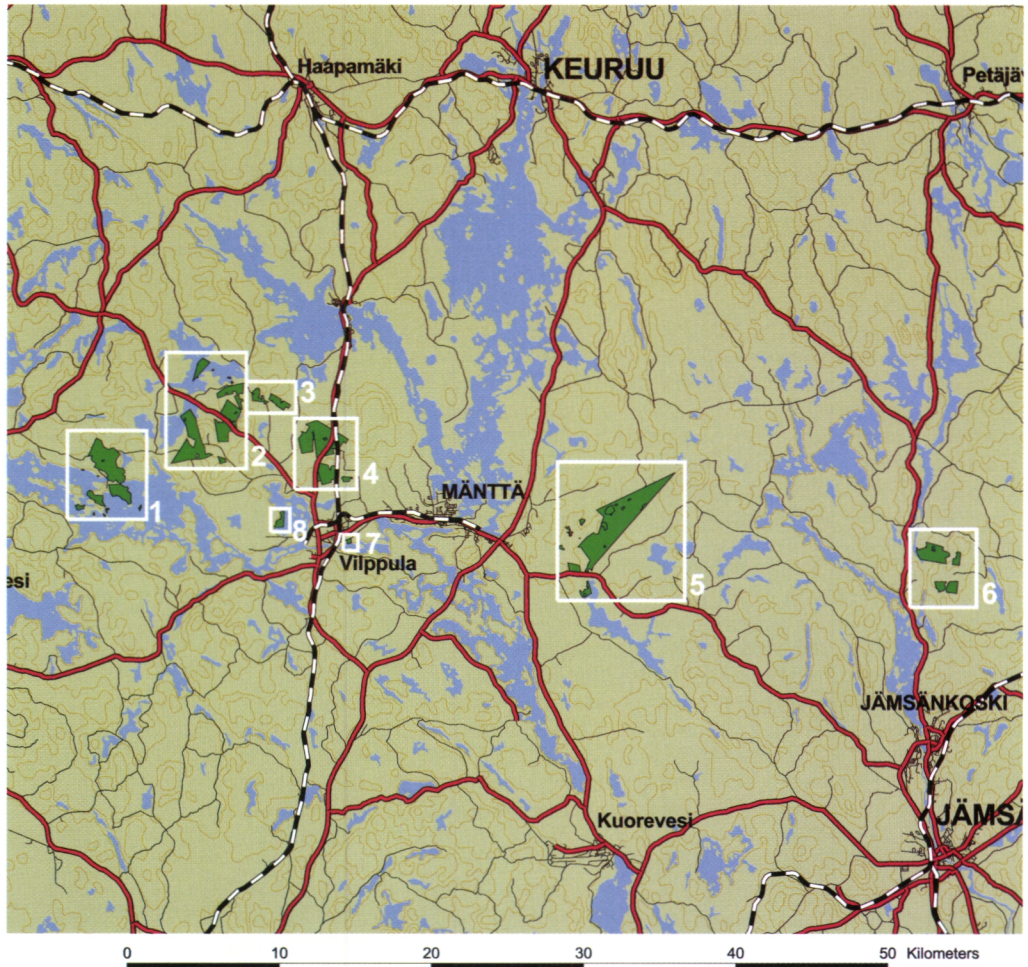
Vilppula Research Area

The research area of Vilppula was established in 1922. It is the oldest research area of the Finnish Forest Research Institute. Its total area is 2547 ha of land and 275 ha of waters and these are distributed in four communes: Ruovesi, Vilppula, Kuorevesi and Jämsänkoski. The land area consists mainly of upland forests and peatlands. 70 % of the upland forests are of the *Vaccinium myrtillus* or more fertile site types. The peatlands cover 24 % of the land area. The distribution of the forest and peatland site types is a good basis for a diversified research activity in the area.

The silviculture of the area aims mainly at serv-

ing the research needs. There are 245 ha of protected areas. Ten percent of the research area consists of experiments or sample plots and these have their own specially designed forest planning. The rest of the research area is divided into sections with delayed, normal or intensified silviculture with the aim of providing suitable areas for future experiments.

At present, the growing stock of the research area is 381 000 m³. The mean volume is 156 m³ ha⁻¹ and the mean annual increment about 7 m³ ha⁻¹. The annual cuttings from the experiments and normal forests is about 9 000 m³.



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Finnish Forest Research Institute (METLA)

Founded in 1917, the Finnish Forest Research Institute (METLA) is Finland's leading forest research organisation. Metla is an impartial state research institute which, in accordance with its remit, solves forest-related problems through scientific research. Research work at Metla is carried out at ten units: at the Helsinki and Vantaa research centres and at eight regional research stations. Metla's area of activity covers research, research forests, customer-funded research and support services. Metla has a staff of 800 people, over 200 of these being researchers.

Research work at Metla has been organised into problem-centred projects. A number of projects have been combined to form multidisciplinary research programmes to address specific contemporary problems. Research activities also include laboratory services, field trials, library and information services, publication activities, information systems serving research, and international activities.

Metla's own research forests enable a versatile, long-term execution of field trials. There are altogether 150 000 hectares of such forests, of which 69 000 hectares are conservation areas. 5000 hectares are used by forestry schools for instruction. Cur-

rently, Metla has stewardship over three national parks: Koli, Pallas-Ounas and Pyhä-Luosto as well as five strict nature reserves. These and numerous smaller conservation areas, e.g. herb-rich forests, old-growth forests, peatland reserves, serve the needs of conservation, research and public recreation.

In addition to the research work Metla's official remit demands, that it conducts the national forest inventories, monitors forest health, inspects plant protection products, provides an information service for forest taxation, clarifies the bases of forest taxation, fulfils duties connected to the timber measurement act and maintains a forest genetic register.

