The Jaakkoinsuo mire experimental area

– The ecology of a drained forested mire

Excursion guide

Finnish Forest Research Institute
Vilppula Research Area, Parkano Research Station

Welcome to the Jaakkoinsuo mire

We welcome you to the oldest peatland forest drainage experimental area in Finland, Jaakkoinsuo mire. Experiments and research were started at Jaakkoinsuo as early as in 1909 and most aspects in the field of peatland drainage and its effects on peat, vegetation and tree stand have been, and are still being studied.

The main interest at Jaakkoinsuo has been the monitoring of stand development after ditching on different site types. Investigations dealing with the hydrology, the effects of mineral nutrition, ash fertilisation and liming on the stand growth, development and productivity have also been done simultaneously. Other traditional research topics are stand management treatments and forest regeneration after harvesting. More recent subjects have included the effects of environmental changes on the mire ecosystem, specific hydrological studies, and the multiple-use of peatland forests.

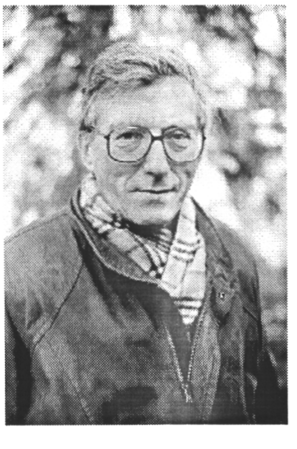
For decades, the experiences and research results obtained from Jaakkoinsuo have been instrumental in guiding practical mire drainage and stand management. Jaakkoinsuo is a looking-glass that links the peatland forest research with practical peatland forestry and has thus continued to be a popular excursion and education site for decades.

In this booklet the environmental conditions, history and present state of Jaakkoinsuo, and the main research activities and experiments are presented. More detailed information can be provided by contacting the Vantaa Research Centre or the Parkano Research Station of the Finnish Forest Research Institute.

The excursion route is about 2.5 kilometres long and walking through it takes from about one and a half to two hours. Most points of interest are marked with a permanent field poster presenting the latest results and information. Of course, the tour can be made as long or as short as you like.

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

The Finnish Forest Research Institute



This booklet is dedicated to Professor *Eero Paavilainen*, Head of Vantaa Research Centre and Professor of the former Department of Peatland Forestry at the Finnish Forest Research Institute.

Heli Mikkelä and Heikki Takamaa (ed.):

The Jaakkoinsuo mire experimental area – excursion guide

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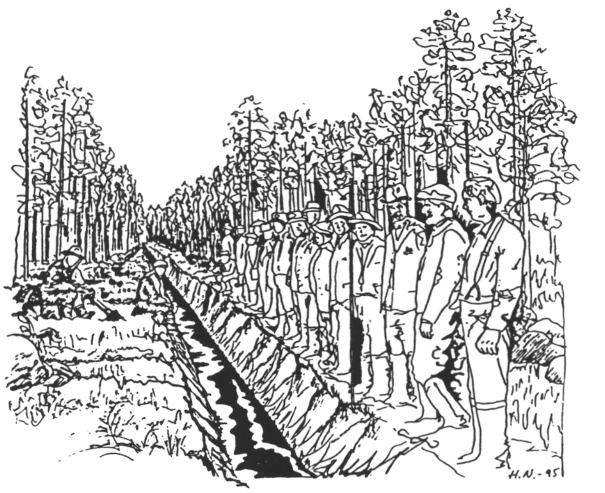
Jaakkoinsuo - from State Park to experimental field

In Finland, the Board of State Forests and Parks started systematic peatland forestry drainage in 1908. In order to successfully realise this program the Finnish Senate granted the Board permission to employ two foresters specialised in peatland drainage. After getting thoroughly acquainted with the peatland forest drainage program of Sweden, the two officers were requested to find an area suitable for investigating the effects of peatland drainage on tree stand growth on peatlands and the costs and benefits of peatland forestry.

The Jaakkoinsuo mire was found to be the most suitable site. Located in the State Park of Vuohijoki near the town of Orivesi in Central Finland, it could be reached by railway (Vilppula station) and highway. The suitability of the area was further emphasised by the great diversity of the mire site types at Jaakkoinsuo. On this rather limited area, mire site types ranging from nutrient-poor ombrotrophic bogs to eutrophic fens and swamps could be found.

Originally, the experimental area at Jaakkoinsuo consisted of 190 hectares of peatlands, and some small patches of uplands. After the loss of Carelia in the second world war refugees were resettled in Jaakkoinsuo. The present area of the research forest is about 100 hectares and is almost entirely in use as sites for different experiments. In 1923 the supervision of the area was turned over to the Finnish Forest Research Institute which had been established five years earlier. At present, Jaakkoinsuo is a part of Vilppula Research Area and administered from Parkano Research Station.



Site, situation and Quaternary history of Jaakkoinsuo

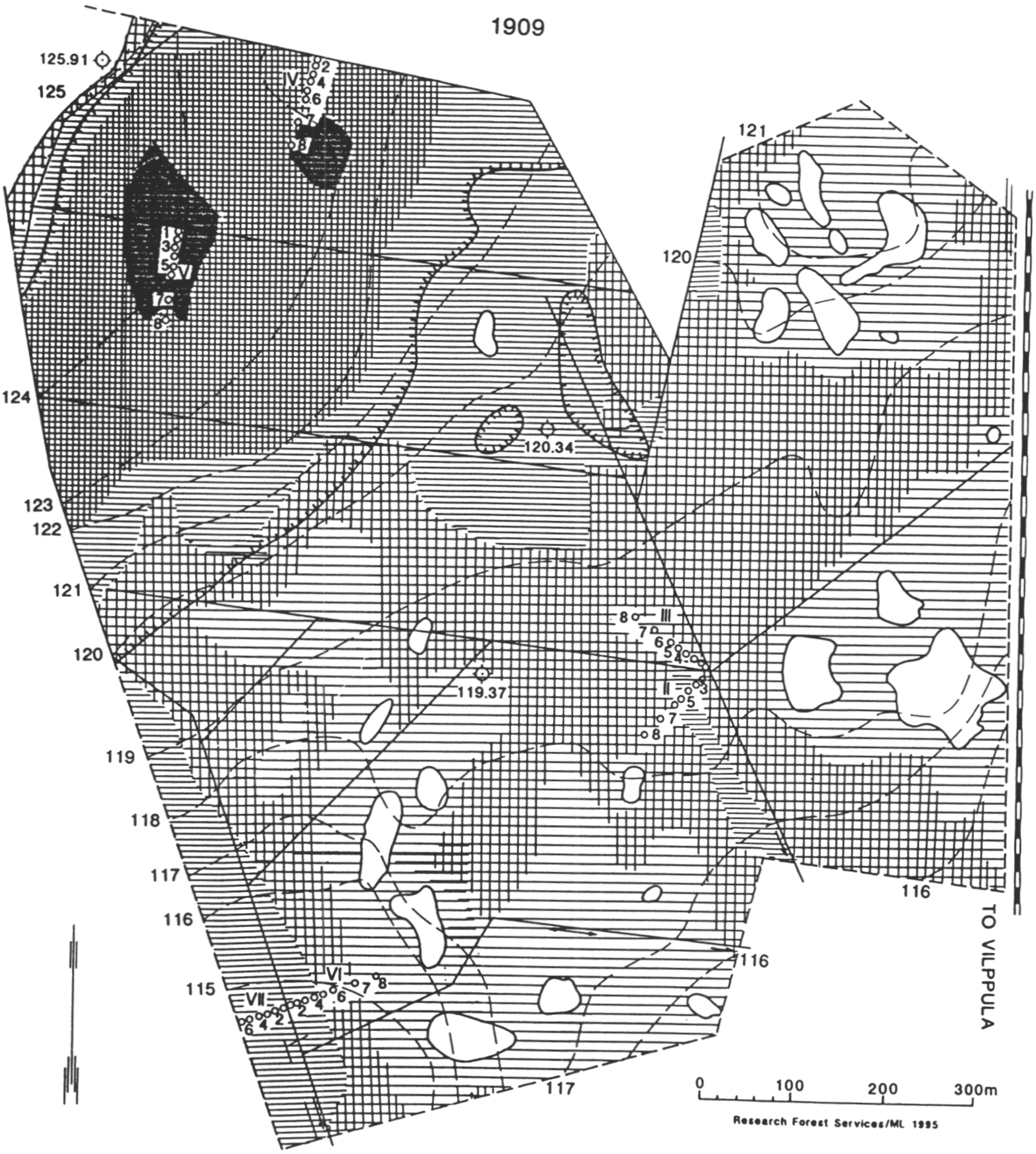
It was important that Jaakkoinsuo contained a variety of mire site types in a relatively small area. In both a hydrological and morphological sense, Jakkoinsuo fulfilled these requirements. When taken into use as an experimental area, Jaakkoinsuo was an eccentric raised bog of considerable size.

The climate in the Vilppula region (Table1) is optimal for the development of eccentric bogs – boreal, with a slight marine influence and relatively warm summers. Eccentric bogs are confined to areas where the mean annual temperature is 2 to 6 °C, mean temperature of the warmest month 15 to 18 °C and an annual precipitation of 500 to 1000 mm. Accordingly, eccentric raised bogs occur in a narrow belt along the 60^{th} parallel from Scandinavia to Siberia, between the region of true raised bogs and aapa mires.

An eccentric raised bog starts to develop e.g. through forest paludification and can only develop on a slightly sloping surface. The ombrotrophic bog section, which receives all of its nutrients from the precipitation, develops at the upper end of the mire complex. Thus, the slope of the mire surface slightly steepens over time. Irregularities in the mire complex morphology often occur, caused by the influence of the mire margin on

JAAKKOINSUO

1909



Peat thickness	< 0,5 m	26.61 ha	28.4 %
Peat thickness	0.5 – 1.0 m	32.85 ha	35.2 %
Peat thickness	1.0 – 2.0 m	17.85 m	19.2 %
Peat thickness	2.0 – 3.0 m	14.23 m	15.2 %
Peat thickness	>3.0 m	1.85 m	2.0 %
Tot.		93.39 ha	100.0 %

Upland forest

height curve

area of the mire 5000 BP (26 % of the present)

ditches from 1909

II o 8 subsidence pole 8 from series II

the hydrology, e.g., occurrence of springs.

On Jaakkoinsuo, the general direction of the slope goes from south-east to north-west, the plane is even and slightly steeper than on the average eccentric bog. The difference in devation between the highest point with the thickest (> 3 m) peat layer and the spruce swamps with the thinnest peat (< 0.5 m) is 9 m and takes place over a distance of 1260 m. The oldest part of the mire is the bog section with 2-3 m thick peat layers; here paludification was well under way over 5000 years ago. Evidently, ombrotrophication started early in the development of the bog as ombrotrophic site types with less than 1 m thick peat were recorded in the first survey made in 1909. Ombrotrophic site types usually have a much thicker peat layer.

Table 1. Location and climatological data

Location	62°04' N, 24°34' E
Elevation	116–125 m
Mean annual temperature	3,4 °C
– July	16,8 °C
– February	–8,4 °C
Temperature sum of vegetation period (treshold value ≥ 5 °C	1220,0 °C
Duration of vegetation period	164 vrk
Annual precipitation	600 mm

Distribution of site types

At its pristine state, Jaakkoinsuo 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 abbrevation
Paludified *Vaccinium myrtillus* spruce forest	KgK
Vaccinium myrtillus spruce swamp	VK
Herb rich hardwood-spruce swamp	RhK
Tall-sedge hardwood-spruce fen	SK
Spruce-pine swamp	KR
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	LR
Tall-sedge fen	SN

The present classification system would have separated a few more types, especially among the *Vaccinium myrtillus* spruce swamps and hardwood-spruce fens. The tall-sedge and herb-rich pine fens were partly very poorly stocked, clearly resembling the plant communities of open fens. Also, the ombrotrophic pine bogs could have been distinguished into a few more subtypes.

About half of the present research area was covered by ombrotrophic pine bog site types. They were relatively dry and dominated by dwarf shrubs and hummock species, although *Sphagnum fuscum* hummocks were scarce. Neither, wet hollows - typical of the most barren bog site types of large eccentric raised bogs - were found on Jaakkoinsuo. Minerotrophic site types are located along the eastern and southern edges of the research area. A characteristic feature of eccentric bog complexes, is also found at Jaakkoinsuo: a fertility gradient of site types according to the steepness of the slope. Moving down slope, the gradient consists of: dwarf-shrub pine bog - dwarf-shrub-cottongrass pine bog - tall-sedge pine fen - tall-sedge hardwood-spruce fen - *Vaccinium myrtillus* spruce swamp. Most of the spruce swamps are irregularly scattered among the pine bogs with a thicker peat layer. In the west-south-western corner of the area there was a spring fen which was fed from ground water that emanated from the esker uphill from the mire. Only 3% of the mire area was classified as treeless fens.

There are no records of the original vegetation prior to drainage 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 absent. The species composition of the pristine Jaakkoinsuo ought to have very much resembled the still pristine mire Lakkasuo in Orivesi. These mires resemble highly each other as regards morphology and site type distribution. In fact, Lakkasuo is a good comparison to the drained Jaakkoinsuo. At Lakkasuo there are about 90 vascular plant species and 25 moss species and 20 *Sphagnum* moss species. There is a field excursion route through Lakkasuo administered by the Department of Forest Ecology (Peatland Forestry) of the University of Helsinki. Along the route 24 mire site types common in south and central Finland are indicated. Lakkasuo has also been described in numerous guides and publications.

Research activities at Jaakkoinsuo

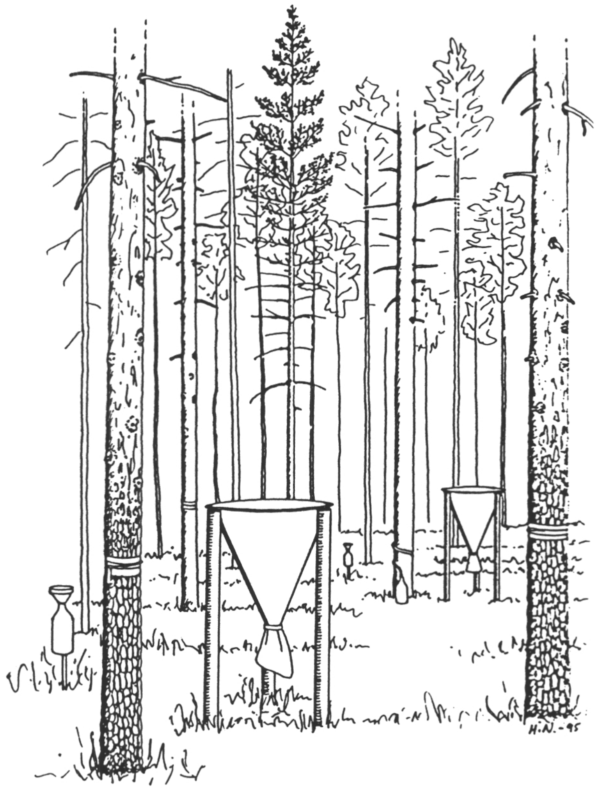
The history of scientific research at Jaakkoinsuo started in 1909 when the drainage plan of forester Antti Tanttu was completed. The purpose of this initial study was to evaluate the effects of different ditch depths, contours and spacing (distance between ditches) on forest productivity.

The effect of drainage on the peat subsidence was another topic of interest in 1909. A total of 54 wooden poles were driven through the peat layer down into the mineral subsoil. The original level of the peat layer was marked on the pole. In 1995 still 41 poles were found.

The first experimental plots for studying the development of tree stands were established in 1915. During the next four years, plots for studying more specific aspects of growth and productivity of the peatland forests were established. These studies included the effects of nutrient status, ditch spacing, ditch depth, tree species distribution and different stand treatments and silvicultural methods. The results of these experiments were needed in developing classification systems for the silvicultural use of peatlands and in preparing operational recommendations for forest drainage.

In the 1920s and 1930s it was a common belief that drained mires which had a scarse forest cover could be better stocked through the use of soil improving measurs such as adding mineral soil to the peat. Investigations concerning the improvement of the substrate were started in 1926. These included the application of mineral soil ("sanding"). In 1929, experiments with liming were initiated and in 1937, the application of wood ash. These were followed in 1946 by experiments with nitrogen, phosphorus and potassium. By then, there was no more available space at Jaakkoinsuo for more extensive experiments. Therefore new experiments were located at Kaakkosuo mire near Jaakkoinsuo. In the 1980s some of the experiments have been retreated. In 1953, trials with micronutrients were initiated and in the 1970s the use of direct injection of micronutrients into the tree trunk was also studied.

Forest ecology research at Jaakkoinsuo was initiated by professor Olavi Huikari in 1956. As a rapid increase in practical forest improvements such as ditching and fertilisation were expected to take place in the 1960s, experiments were designed accordingly. During the 1960s and 1970s the effects of soil water status, soil temperature and nutrient requirements of Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and to some extent also downy birch (*Betula pubescens*) at different stages of stand development was studied in particular. A common feature in the design of the experiments



was the regulation of the groundwater level. Since 1961 the water level in the ditches surrounding the experimental plots have been kept at the levels 0, 10, 30, 50 and 70 cm. Using a similar design, the ecophysiolocical effect of flooding at different times of the year on tree growth has been studied. A model describing the growth of Norway spruce based on the results from Jaakkoinsuo has also been developed.

Another important research topic studied on some sample plots was the relationship between nutrient status and microbiological activity in peat and tree roots. In nutrient experiments, the effect of fertilisation on the biomass production and nutrient cycling in drained peatlands as well as the internal water balance of the trees and the aspects of water uptake from freezing and thawing soils have been studied.

Prior to drainage in 1909 the mire was very sparsely stocked with the exception of some spruce swamps with dense stands. However, no active afforestation measures were needed after drainage as seeding from the adjacent upland forests soon provided seedling stands, even on the originally treeless parts of the mire. Only in the 1970s the first forest regeneration studies were started. Before then only some sparsely stocked areas were regenerated (in 1916) and those plots whose tree stands had reached maturity before 1951 (15 sample plots) were regenerated.

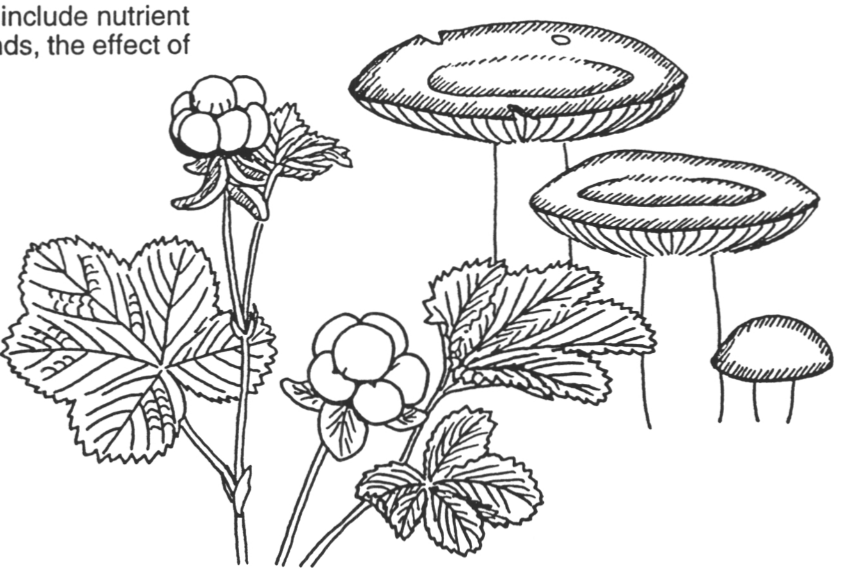
Numerous regeneration methods were used depending on the site type and existing tree stand. Methods included select compartment thinning, broadcast and patch sowing, and methods resembling seed tree cutting and shelterwood cutting.

In the mid 1970s experiments in forest regeneration were resumed by establishing the 'H cultures' planned by Professor Olavi Huikari (see site 15). This regeneration method aimed at a highly rationalised silviculture through planning both the regeneration, seedling stand treatment and harvesting.

In the mid 1980s some experiments comparing natural and artificial regeneration were established. These experiments included the natural regeneration of Norway spruce after seed tree cutting and regeneration of clear-cut areas from border stands. The effect of soil preparation was also studied. The regeneration of Scots pine, by natural or artificial means (by planting or sowing), was investigated.

More recent research topics include nutrient cycling in drained pine mire stands, the effect of ground water level during the growing season regulation on the growth of Scots pine and Norway spruce, and the effect of air pollution on peat acidification.The effect of excess trampling on the mire surface, yields of cranberry (*Vaccinium oxycoccos*) and cloudberry (*Rubus chamaemorus*), and the yield, species distribution and ecology of mushrooms have also been studied. Also, the number of breeding birds has been inventoried. In the 1990s investigations concerning the effect of clearcutting on runoff water quality, particularly nitrogen, was of special interest.

A particular objective in establishing the Jaakkoinsuo experimental area was to provide information about the needs of stand treatment of the drained mire forests and their effects on the post-drainage yield. Careful monitoring and documentation of both the experiments and of the stand treatments have provided useful information that can be applied to peatland forestry on an operational scale. The experimental area has also provided excellent possibilities to analyse the yield and nutritional requirements of the second generation post-drainage stands.



Drainage and its effect on the mire ecosystem

Over the 90 years since drainage, the Jaakkoinsuo mire has changed from a sparsely stocked, partly almost treeless, mire to a well stocked forest drainage area. The present drainage network consists of 23 000 m of ditches of which 19 900 m are open drains. There are on an average 250 m of ditch per hectare.

Stand growth and yield and cuttings

Compared with the situation before draining, the post drainage stand growth on Jaakkoinsuo has been considerable. On the poor pine mire part of Jaakkoinsuo, for instance, the tree stands before drainage consisted of old, stagnant pine trees with volumes between 30 and 50 m³/ha. On the more fertile sites, with a thinner peat layer, the stand volumes were only 3 to 10 m³/ha. The post-drainage yields by the main site types are pesented in Figure 1.

At its best, the total stand yield had reached 670 m³/ha (on site J18) by 1992.

The total wood removal between 1909 and 1995 obtained by thinnings and final cuttings and from road and ditch lines was 14 375 m³ (Table 2). On Jaakkoinsuo there are numerous sites where the second post-drainage Scots pine and Norway spruce is growing. The oldest second generation stands are already more than 50 years old.

The mean annual post drainage cuttings has only been 1.94 m³/ha/a. This low increment is is due to either too sparse ditch spacings or research measures which have hampered normal tree growth. Some sample plots have been left uncut to form old-growth stands while others have received exceptional cutting methods, both lowering the mean annual increment.

The mean post-drainage total yield of 10 pine sample plots in 1994 was 236 m³/ha, the maximum yield being 380 m³/ha. The mean annual yield during the first 85 years after drainage was therefore 2.8 m³/ha/a. In the spruce dominated stands, the corresponding values were: mean total yield 491 m³/ha, maximum yield 670 m³/ha, and mean annual yield 5.8 m³/ha/a.

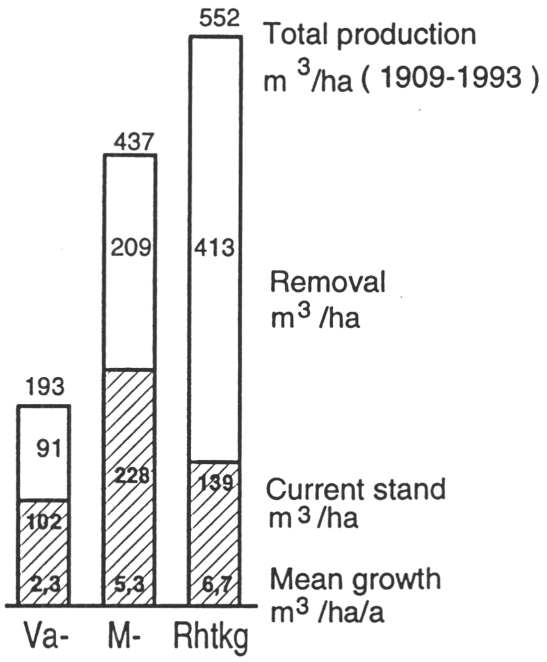


Fig. 1. Total production, removal, present growing, stock and mean growth by site type. Vatkg = dwarf-shrub peatland forest, Mtkg = *Vaccinium myrtillus* peatland forest, Rhtkg = herb-rich peatland forest.

Table 2. Cutting yield 1909-1995

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

Changes in site types and vegetation

On Jaakkoinsuo, the succession initiated by the water level drawdown after drainage has resulted in the typical sequence of changes on almost all site types : from recently drained sites via transforming types to 'climax' types resembling upland soil site types, drained peatland forests (Table 3). The original site types have now transformed into 4 to 6 drained peatland forest site types (the exact number depends on the 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%).

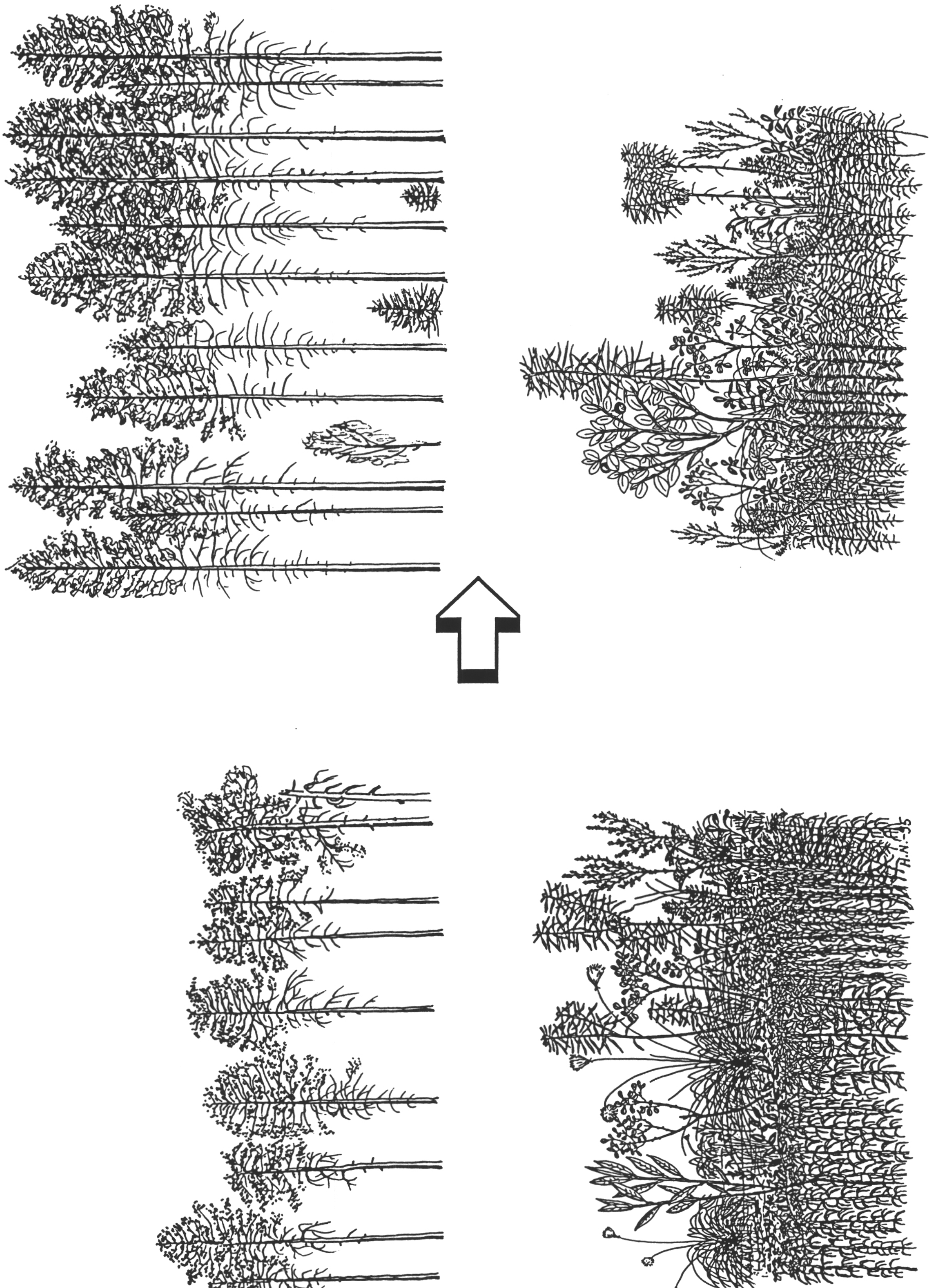
The vegetation in the drained peatland forests differs from both pristine peatland and upland forest vegetation; the differences to mires being greater. The magnitude of the changes in vegetation after drainage depends on the original site type (Fig. 3). On a poor pine bog (dwarf-shrub pine bog) the changes in species present, was small, but the species distribution changed. The species changes on a more fertile and wetter site type (tall-sedge pine fen) were quite fundamental. Of the original 23 species only 3 remain 85 years after drainage. A herb-rich spruce swamp demonstates the succession on an originally forested mire site type, more than 60% of its species change and those species that become more abundant are typically upland forest species. The number of species has decreased as a consequence of canopy closure and less light reaching the forest floor. However, species diversity may increase again after cuttings.

Regarding the changes in the vegetation of the entire mire complex in 1994 when 33 drained peatland forest compartments were investigated a total of 112 plant species were found (including trees, shrubs and the species groups presented in Fig. 3 and 4). For corresponding site types on the pristine Lakkasuo mire, the total species number was 135. There were 87 species (68 %) left of the estimated original pristine species of Jaakkoinsuo (42 (32 %) species from the pristine state had disappeared) and 22 new species had appeared, which account for 20 % of the present species number. The species that have disappeared were mire and wetland species indicating mesotrophy, eutrophy, spring influence, seepage water influence, and flooding influence. The new species are mostly upland forest species. In the present vegetational landscape the forest species form a very characteristic feature. The remaining mire species are mostly drought tolerant ombrotrophic species and species that are adapted to living on sites with a deep groundwater level. The proportion of mire species is the greater the poorer the original mire site type has been.

Drainage has decreased the species diversity on Jaakkoinsuo. 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 with peatland forest types has diminished the total diversity or beta diversity and thus the ecological gradients have shortened. The change from mire vegetation to forests that resemble upland types has resulted in closer resemblance with the surrounding upland forest and consequently decreased the gamma diversity on both the vegetation community and landscape levels (Fig. 2). The activities involved in drained peatland forestry

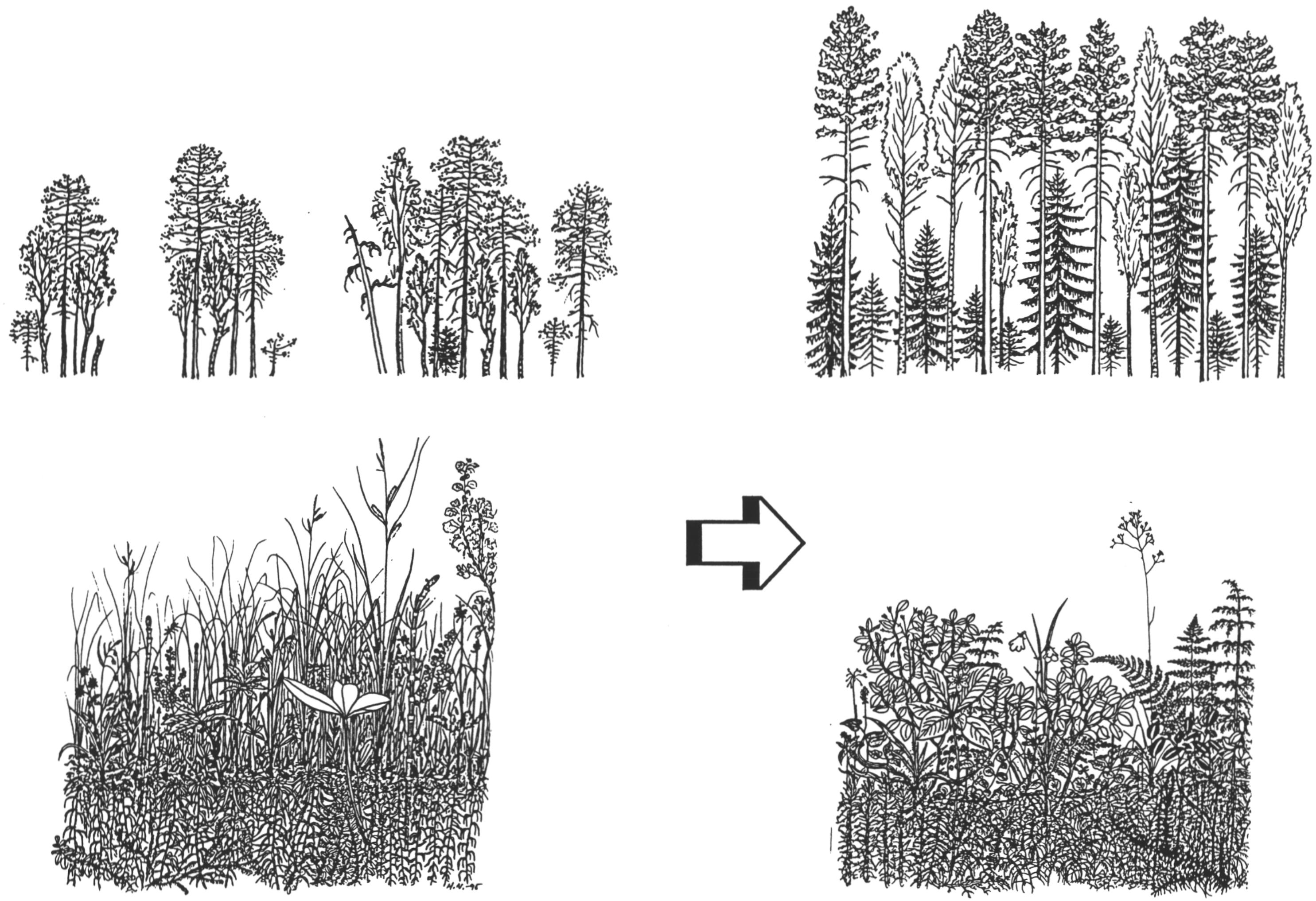
Table 3. Changes in site types on Jaakkoinsuo (93 ha) between 1911 and 1994. Part of the paludified spruce forests and paludified pine forests (6.7 ha in 1911) are now partly drained peatland forests and partly upland forests or paludified upland forests (in all 4.6 ha in 1994).

Site type	1911	1934	1949	1964	1994
	portion of mire area, %				
Pristine or recently drained					
Spruce swamps	33,4	22,3	13,0	-	-
Pine mires	62,9	46,4	27,0	-	-
Open fens	3,1	-	-	-	-
Transforming stages					
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 species and structure of the plant communities of a poor and fertile mire site type.

such as cuttings, fertilisation, soil improvement, soil preparation, making paths and road building have increased the number of species. These activities have introduced species that typically appear after disturbance: pioneer plants, weeds and ditch spoil species that increase the species number but not necessarily the scenic values of the site.

The decrease in diversity during the post-drainage succession is a good indicator of the importance of the hydrology in conserving pristine mire complexes and site types.

The tree stands of Jaakkoinsuo have been treated more intensively than normal operational-scale forests. However, Jaakkoinsuo indicates how the drained peatlands in the south-western part of Finland can be expected to develop during the next 40 to 50 years.

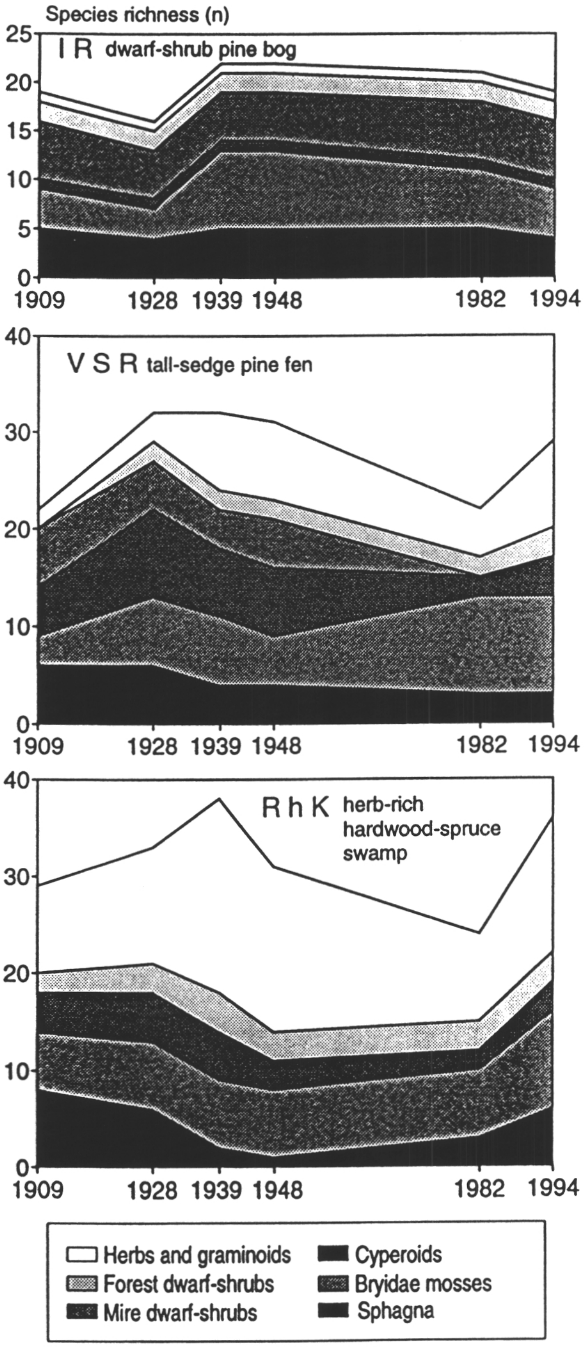


Fig. 3. Changes in plant species structure on three ecologically different sample plots on Jaakkoinsuo during 1909...1994 (Dwarf-shrub pine bog, sample plot 4, object JI; Tall-sedge pine fen, sample plot 8b, object J15 and Herb rich spruce swamp, sample plot 2, object J11). The data for the pristine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

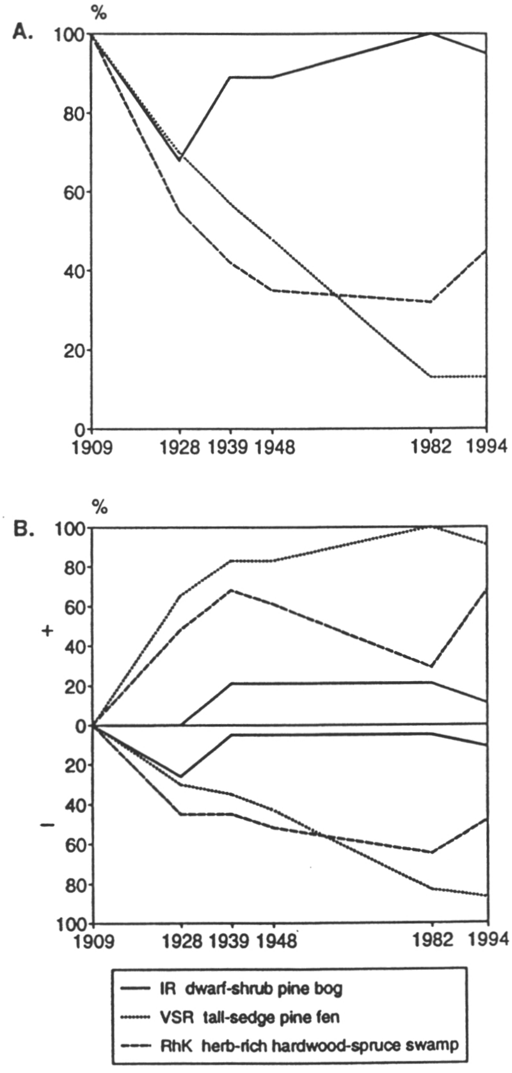


Fig. 4.
A. Changes in composition of the vegetation calculated as percent of the original pristine plant species on the tree sample plots of Fig. 3.
B. Disappeared and appeared species on the tree sample plots as percent of the original vegetation. Other expleanations as in Fig. 3.

The excursion route of the Jaakkoinsuo mire

In the following pages the sites along the excursion route of Jaakkoinsuo are described. At the enterance gate to Jaakkoinsuo there is an information board providing general information about the area and maps of the experiments and the ditch network. There is a map also at the resting place, the so-called 'Anttila hotel', next to site 17, where you can take a break and enjoy your snack . Most sites have also their own information boards.

The path starts at the most nutrient-poor part of the mire and, as a general rule, the fertility of the sites increase along it. The total length of the path is 2.5 km and the time required to stroll through it is 1 1/2 to 2 1/2 hours. You can also take a shortcut from site 10 straight to site 17 or from sites 21 and 22 by the forest road back to the starting point. The path ends at the road on the southern edge of the mire and from there you can return to the starting point along a path which starts at site 24 and leads along the western edge of the mire.

Abbreviations used

V	Stand volume
Iv	Annual stand volume increment (m3/ha/a)
G	Basal area (m2/ha)
H	Mean stand height, m
Hdom	Dominant stand height
D1.3	Mean diameter at breast height, cm
Sn	Stem number, stems/ha
N^{0-10}	Peat nitrogen concentration, % (0-10 cm layer)
Prod	Total stem volume production since 1909 (unless otherwise mentioned)

J1. Pine stand preserved in pristine state

Sample plot 4
- Established: 1928
- Area: 0.025 ha
- Site type: Dwarf-shrub pine bog/Dwarf-shrub peatland forest

Peat thickness: 2.5 m
N0-10 cm 1.26 % (1994)
Mineral subsoil: sand

Drainage at this site was carried out 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 m³/ha and the annual volume increment 1.0 m³/ha which at that time, was the largest annual stand growth on Jaakkoinsuo.

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 statistics for sample plot 4 in 1992

Age, years	200
Total yield 1909–92, m³/ha	156
– of which natural removal, m³/ha	29
Increment, m³/ha/a (1984–92)	2,6
Dominant height, m	18,7
Basal area, m²/ha	21,8
Mean diameter, cm	21,9

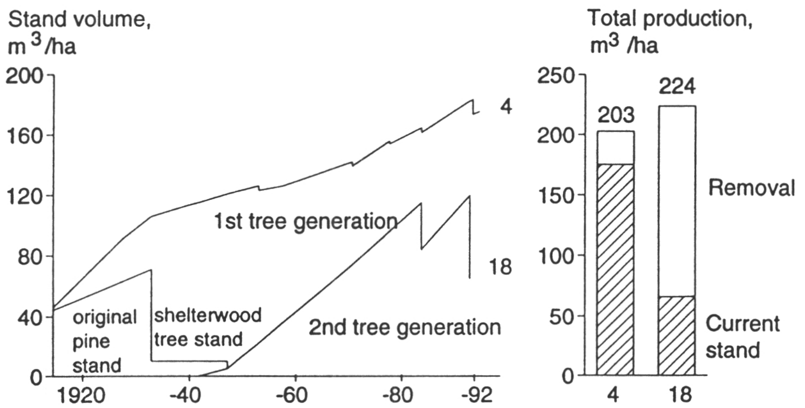


Fig. J1. Production of treated and pristine pine bog stand. Plot 4 = growing of original pine bog stand, plot 18 = stand regenerated with seed trees.

J2. Regeneration of peatland forest, development of plant stand and fertilization

Experiment no 17
- Established: 1952
- Area: 0.6 ha

Site type: Dwarf-shrub pine bog/Dwarf-shrub peatland forest
Peat thickness: 2.5 m
N0-10 cm (1995)
- sample plot 17:2 1.24 %
- sample plot 17:3 1.37 %
- sample plot 17:4 1.28 %

Mineral subsoil: sand

This site was drained in 1909 and complimented with subsurface drains in 1949-50.

The purpose of this experiment is to investigate forest regeneration, the development of the young stand, and the effect of fertilisation on the productivity of the second generation stand. In 1935 the 125 year-old stand was cut by removing 953 stems/ha (50 m³/ha) which left 90 seed trees/ha (13 m³/ha) still growing. At that time there were about 1500 pines/ha which were all less than 50 cm tall. The seed trees were removed in 1947. By then the stem number/ ha had increased to about 21 000 plants/ha. The young stand was very lightly thinned in 1955. In 1983 the stand was thinned proper and again in 1993.

In 1952 the stand compartment was divided into eight plots which were treated with phosphorus, potassium and nitrogen fertilisers. In addition each plot received 2000 kg/ha of milled limestone. In May 1962 nitrogen fertilizer was added to a part of each plot and retreated in 1984. According to needle chemical analyses there was a slight deficiency of N, P and K on the control plots. During the period after the first nutrient applications growth increased above control plot levels with PK-fertilisation and after the second plain K addition would have been sufficient. Surprisingly, the addition of N did not seem to have any positive effect on this poor site ditched 53 years earlier.

Table J2/a. Fertilizers used in experiment 17, kg/ha.

Sample-plot	v. 1952 Amm. nitr. with lime 15,5 % N	Phosh-phate 9,8 % P	Potass. chloride 33 % K	Milled limestone 37 % Ca	Amm. nitr. with lime 15,5 % N	v. 1962 Amm. nitr. with lime 27,5 % N	v. 1984 Rock phosph. 15 % P	Potass. chloride 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 1992, exp. 17.

Sample plot	Sn stems/ha	V m³/ha	$Iv_{(1983-92)}$ m³/ha/a	G m²/ha	D1.3 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

Measurement in 1992

Table J2/c. Effects of fertilization on exp. 17.

Treatment (1952–62) and 1984	1952–1982 m³/ha	m³/ha/a	1983–1992 m³/ha/a
Mean	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

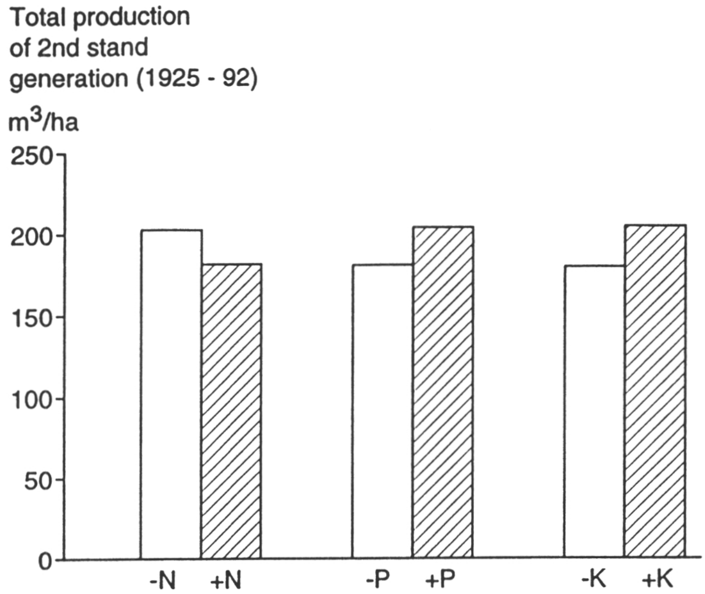


Fig. J2. Effect of fertiliser application on the total production of Scots pine. On an old drained pine bog fertilisation with P and K is sufficient.

J3. Subsidence pole study

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. Part of the poles have been destroyed through forest road construction and because part of the area changed ownership. Today, 40 poles remain.

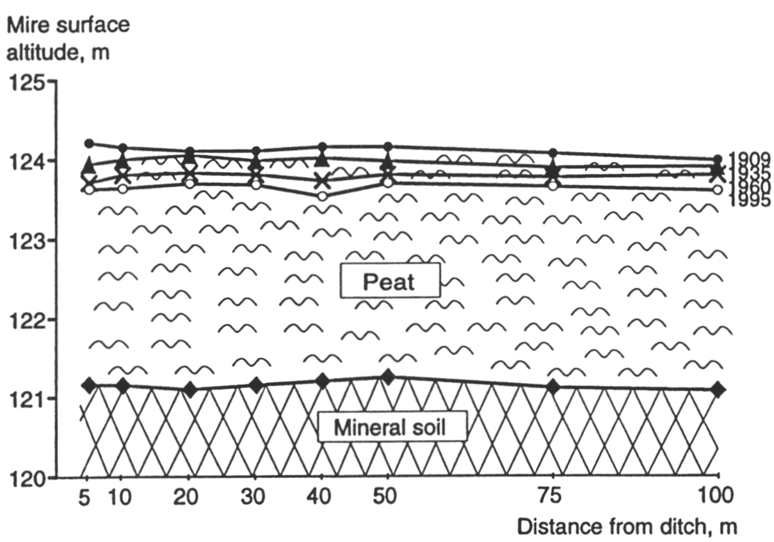


Fig. J3. Subsidence of peat layer along pole line V between 1909 and 1995.

J4. Liming and growth of tree stand

Experiment 1
- Established: 1929
- Area: 0.4 ha

Site type: Dwarf-shrub pine bog/Dwarf-shrub peatland forest
Peat thickness: 2.5 m
$N_{0\text{-}10\,cm}$ 1.26 % (1995)
Mineral subsoil: sand

This site was drained in 1909. The experiment was established in 1929 and its purpose is to study the effect of liming on the tree stand growth and soil nutrient status.

The pine stand growing in this experiment was thinned in 1983 and again in 1992 (at a stand age of 73 years). According to measurements there were no significant differences in growth and productivity between the limed and control plot stands. According to the needle chemical analyses (from 1992) the stand on the control plots suffered from nitrogen and potassium deficiency.

Table J4. Stand characteristics of experiment 1

Plot	Lime v. 1929 kg/ha	Remaining tree stand in 1992 Sn stems/ha	V m^3/ha	$Iv_{(1978-1982)}$ m^3/ha/a	G m^2/ha	D1.3 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

Stand measured in 1992

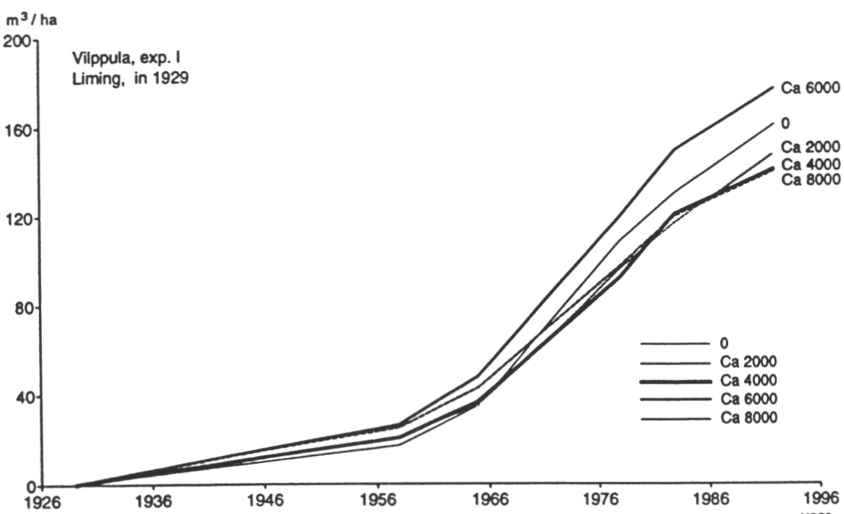


Fig. J4. Stand development after different lime doses.

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

Experiment XII, plots 1 and 2
- Established: 1937 and 1963
- Area: 0.13 ha

Site type:Dwarf-shrub pine bog/Dwarf-shrub peatland forest
Peat thickness: 2.2 m
$N_{0-10\,cm}$ 1.26 % (1994)
- XII/1 = 1.34 %
- XII/2 = 1.59 %
- XII/3 = 1.43 %

Mineral subsoil: clay

Drainage at this site was carried out in 1909, 1915 and 1923. In 1916 it was sown with Scots pine seeds. The purpose of this experiment is to study the effect of drainage and wood ash fertilisation on the development of the tree stand and ground vegetation. The tree stand on plots 1 and 2 was thinned in 1953, 1957, 1984 and 1992. The stand on plot 3 was slightly thinned in 1963. There are minor differences in the ground vegetation between the three plots. Wood ash has almost doubled the total yield compared with the control.

Table J5. Stand characteristics of experiment XII (in 1993)

Sample plot	Wood ash kg/ha	V m^3/ha	$Iv_{(1985-1993)}$ $m^3/ha/a$	Production m^3/ha	G m^2/ha	Measured (year)
XII/1	0 (1937)	92	3,18	207	11,43	1992
XII/2	5 000 (1937)	177	7,76	384	19,23	1992
XII/3	NPK (1963)	188	8,65	190	25,52	1983

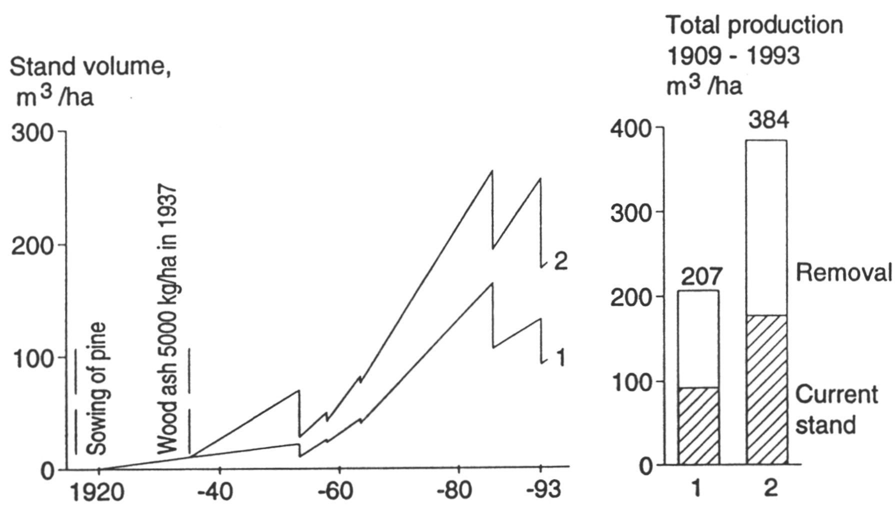


Fig. J5. Development of the tree stand in experiment XII. There is a strong effect of the wood ash fertilization on tree growth. 1 = control, 2 = wood ash fertilization 5000 kg/ha.

J6. Nutrient budget of Scots pine (on peat)

Experiment XXII, sample plots 1-12
- Established: 1963
- Total area: 1.15 ha
- Sample plot area: 960 m^2

Dwarf-shrub peatland forest
Peat thickness: 1.4 m

Drainage of this site was carried out in 1909, 1915, 1923, and 1988. In 1963 an experiment with spot and patch fertilisation was established. In 1987 the planted stand was thinned and refertilized.
The effect of the spot fertilisation on stand growth ended after 4-6 years while the effect of the patch fertilisation is still apparent. The refertilisation in 1987 had a strong effect on the plant stand growth.

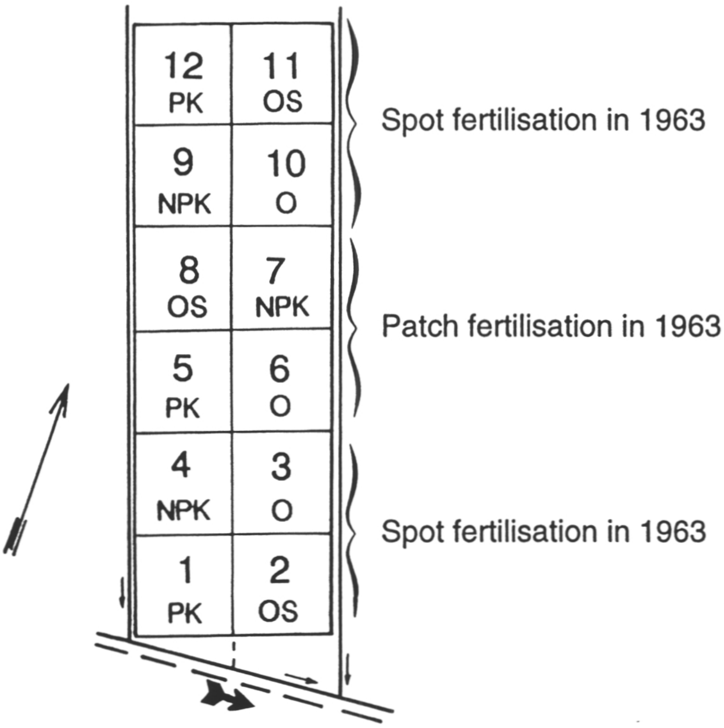


Fig. J6. Location of the sample plots of experiment XXII and the fertilisations of 1987.
PK = PIC fertiliser for peatland forests (N 0 %; p 9 %; K 17 %, B 0.2 %)
OS = Ammonium nitrate with lime (N 27.5 %; Mg 2.2 %)

- - - -➜ Excursion path, direction of route

J7. Drainage and fertilisation experiment of a pine bog stand

Experiment XX
- Established: 1943
- Area: 0.4 ha

Site type: Dwarf-shrub pine bog/Dwarf-shrub peatland forest
Peat thickness: 1.5 m
$N_{0\text{-}10\,cm}$ (1995)
- XXa = 1.28 %
- XXb = 1.37 %
- XXc = 1.27 %
- XXd = 1.40 %

Mineral subsoil: sand

Drainage of this site was carried out in 1909, 1915 and 1953. The purpose of the experiment is to study the effect of drainage and fertilisation on the growth of an old pine bog stand.

In 1992, when the stand age was 116 years, the stand on plots a, b and c was slightly thinned.

In 1960 the stand height on plot d was 0.1 - 4.5 m. When thinned in 1987 and 1992 a total stem volume of 74 m³/ha was removed. It was concluded that preserving and fertilising an old pine stand is not profitable.

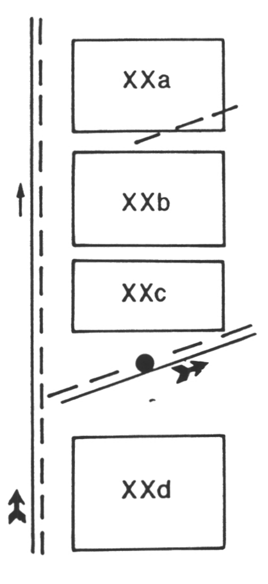
Table J7/a. Fertilisation, experiment XX, kg/ha.

Sample plot	14.9.1949 Rock phosphate (14 % P)	Potassium chloride (33 % K)	12.5.1970 Urea (46 % N)	22.5.1984 PK-fertilser for peatland for. (9 %P, 17 %K, 0,2 % B)	Amm. nitrate with lime (27,5 % N, 2,2 % Mg)	Wood ash v. 1948 kg/ha
XXa	-	300	216	-	-	-
XXb	400	-	216	500	-	-
XXc	200	150	216	500	400	-
XXd	-	-	-	-	-	8000

Table J7/b. Tree stand characteristics of experiment XX.

Sample plot	V m³/ha	$Iv_{(1983–92)}$ m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m	ikä, a
XX/a	93	2,0	143	12,5	18,4	15,0	116
XX/b	94	1,6	143	12,8	20,2	14,7	116
XX/c	88	2,8	142	12,1	14,2	14,6	116
XX/d	69	4,9	143	10,9	15,0	12,3	44

Measured in 1992



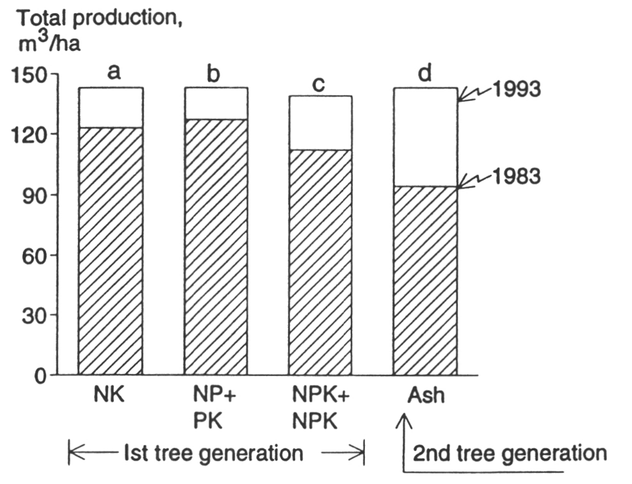


Fig. J7. On the poor pine bog sites the effects of fertilser application are small. The response of the old bog pines is weak. – On the left the layot of the experiment.

● You are here

- - -➜ Excursion path, direction of excursion route.

J8 . A mature pine stand treated with drainage and wood ash fertilisation

Experiment XIII, sample plots 0,1 and 2
- Established: 1937
- Area: 2.7 ha
Site type: Dwarf-shrub pine bog/Dwarf-shrub peatland forest
Peat thickness: 1.2 m
$N_{0\text{-}10\,cm}$ 1.45 % (1995)
Mineral subsoil: sand

Drainage of this site was carried out in 1909, 1923 and 1935. The purpose of the experiment is to study the effect of drainage and wood ash fertilisation on the stand growth and ground vegetation. 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. Tree stand data of experiment XIII.

Sample plot	Wood ash kg/ha	V m^3/ha	Iv $m^3/ha/a$	Production m^3/ha	G m^2/ha	D1.3 cm
XIII/0	-	120	2,2	189	14,6	21,7
XIII/1	5 000	246	3,9	368	23,1	27,3
XIII/2	10 000	213	5,1	380	18,9	30,6

Measured in 1992

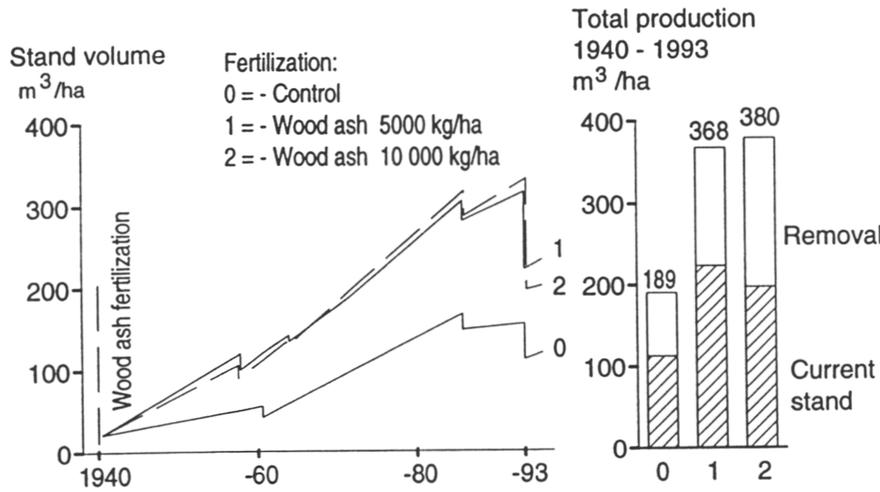


Fig. J8. The effect of wood ash fertilisation on the wood production on experiment XIII.

J9. The ecological experiment fields

Experiments 66 and 67
Site type: Dwarf-shrub pine bog/Dwarf-shrub peatland forest
Peat thickness: 1.5 m
$N_{0\text{-}10\,cm}$ (straw covered plots)
- 10 cm 1.32 %
- 30 cm 1.27 %
- 50 cm 1.35 %
- 70 cm 1.41 %
Mineral subsoil: fine silt

In the 1950s when forest improvement activities increased rapidly in Finland, more knowledge was needed about the combined effect of water table depth and climate on the tree growth. To investigate this, an experiment was established in 1961-1962 on which the hydrology and the nutrient status could be monitored. Some 52 years after the initial drainage in 1909 measurement of tree stand growth began in the sample plots (15 x 40 m) which had had the water level in their surrounding ditches regulated to five fixed levels: 0 cm (1 plot), 10 cm, 30 cm, 50 cm and 70 cm (3 plots each) from the ground level. Five plots were repeatedly fertilised. On two plots the soil temperature was lowered by covering the plot with a straw cover during three winters (1962-64). The straw cover has decomposed a long time ago, but its effect is still visible on the tree stand growth.

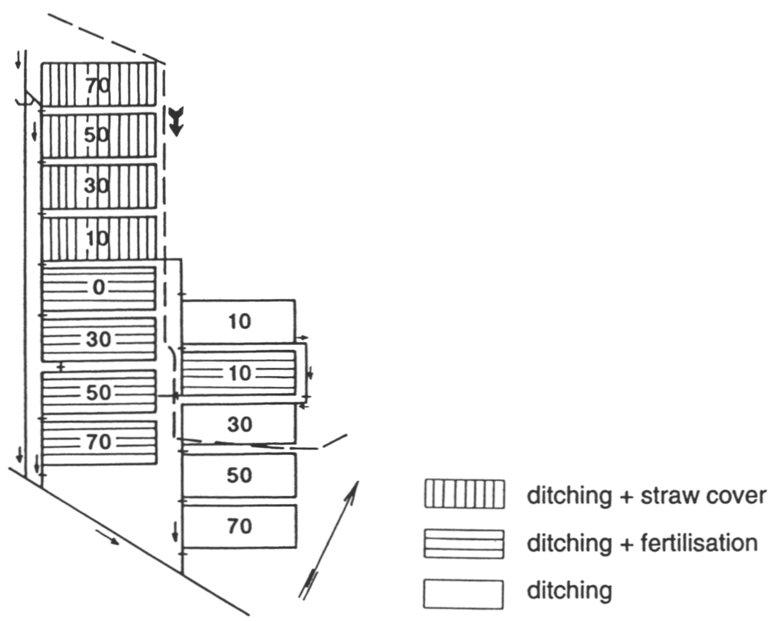


Fig. J9. Layout of the experiment. The figures within the plots indicate the regulated water depth in the ditches surrounding the sample plots.

On each plot measurements of the ground water level (from 9 points) and soil temperature (from 3 points at 4 depth levels each) has been made at regular intervals. The tree stand has also been measured several times.
The response of the Scots pine to the treatments is particularly interesting. Without fertilisation, the stand growth was stronger the deeper the regulated water table was during the first decades of the experiment. On the fertilised plots, on the other hand, the tree stand growth was the same on the plots with the regulation depths 30, 50 and 70 cm while it was clearly smaller on the plots with 10 and 0 cm depths. The conclusion drawn from this is that drainage has both a direct effect and an indirect effect on stand growth. The direct effect is an improvement in aeration through lowering of the water table and the indirect effect is an improvement in the nutrient status of the peat through increased decomposition. On the dwarf-shrub pine bog part of Jaakkoinsuo there seems to be enough oxygen for the tree roots with a regulation water level of 30 cm. Now, after almost 40 years since the experiment was started, the effect of the fertilisation is no longer apparent (Table J9).

The straw cover which was used for regulating the soil temperature clearly increased the tree stand growth. It is unclear whether this effect is a consequence of decreased competition by ground vegetation or a mulching effect of the decomposing straw mass.

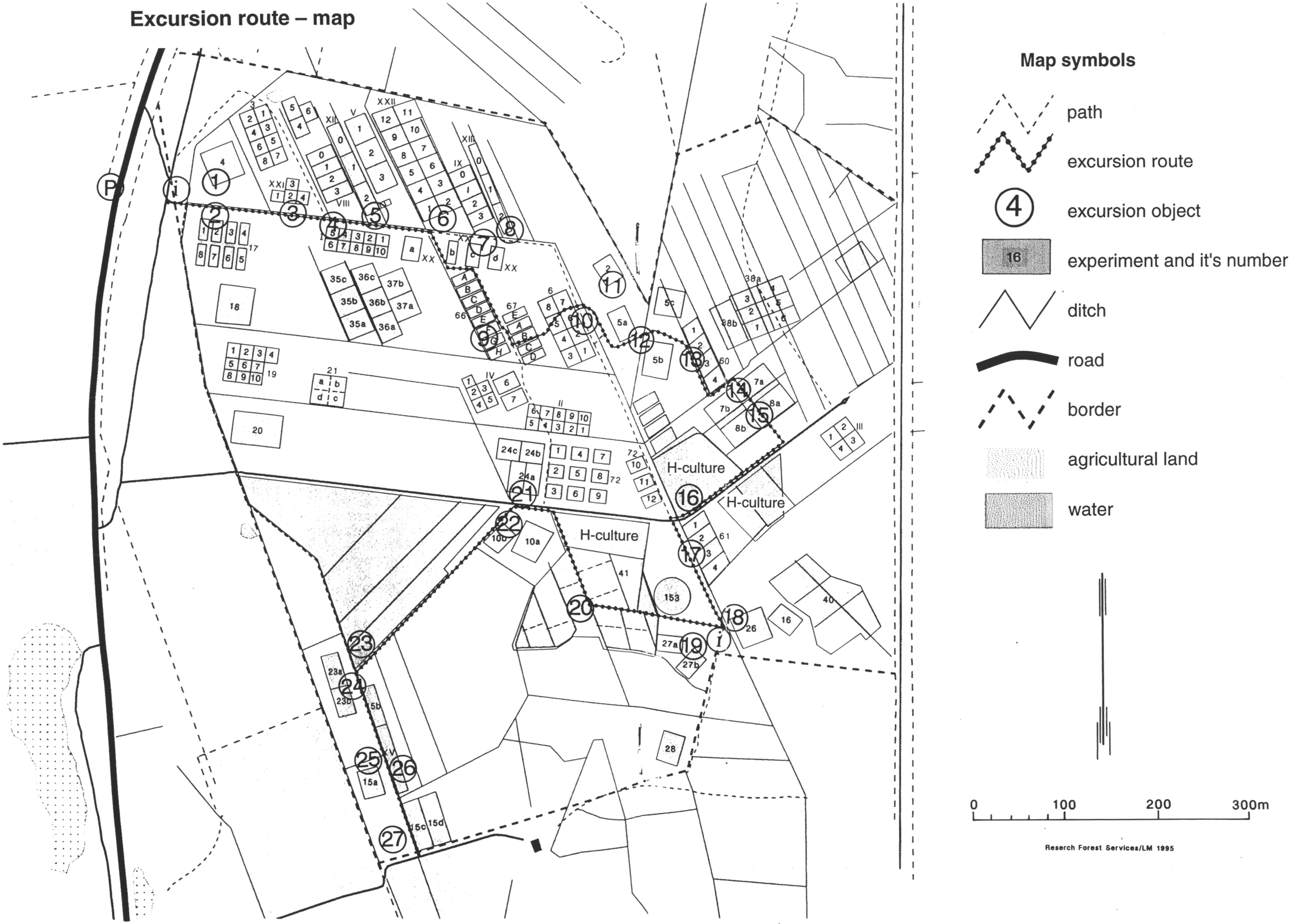
Table J9. Tree stand data from1993.

Regulated water level, cm	Ditching			Ditching+strawcover			Ditching+fertilisation		
	Sn stems/ha	V m³/ha	Iv m³/ha/a	Sn stems/ha	V m³/ha	Iv m³/ha/a	Sn stems/ha	V m³/ha	Iv m³/ha/a
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

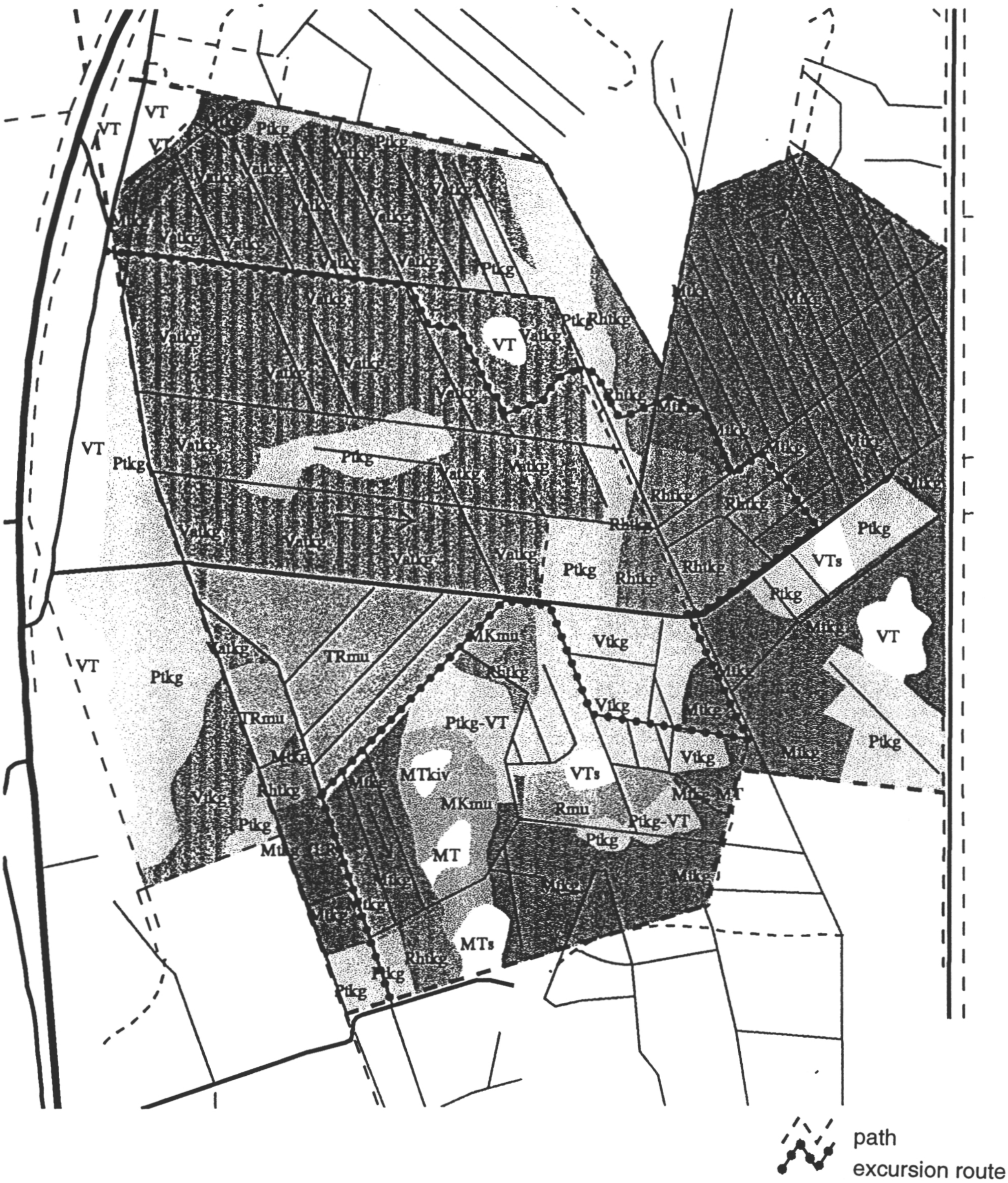
1) the original tree stand died after raising of the water level

The regulation of the ditch water level has had an effect also on the ground vegetation and surface level of the sample plots. The plot with 0 cm water level is now much wetter than originally and has transformed from a pine bog transition site type to a (cotton-grass) low-sedge bog. On the plot some small pine plants grow that have developed after the experiment started the old stand having died after the raising of the water level. During 30 years (1962-1992) the peat has grown 8.2 cm thicker. On the other plots the ground vegetation has undergone minor changes. The peat thickness has changed the most on the plots with the 70 cm water level, where it has decreased by 10 cm. The carbon store of the peat profile has remained the same in all treatments despite the changes in peat surface levels indicating that the subsidence of the peat layer is more due to compaction than decomposition

Excursion route – map



Distribution of site types



Map symbols

Spruce swamp transition
Pine bog transition

Rhtkg = Herb rich peatland forest (developed from meso-eutrofic site types)
Mtkg = *Vaccinium myrtillus* peatland forest (developed from oligo-mesotrophic site types)
Ptkg = *Vaccinium vitis-idaea* peatland forest (developed from oligotrophic site types)
Vatkg = Low shrub peatland forest (developed from ombro-oligotrophic site types)
VT = Vaccinium vitis-idaea upland forest

J10. Distribution and cycling of nutrients in a pine stand on a dwarf-shrub peatland forest

Experiment no 6
Dwarf-shrub cottongrass pine bog/Dwarf-shrub peatland forest
Peat thickness: 1.1 m
Mineral subsoil: fine silt
$N_{0\text{-}20\,cm}$ 1620 kg/ha

This experiment consists of six sample plots with different fertilization treatments (Table J10). Between 1974 and 1978 the nutrient allocation (N ,P ,K, Ca, Mg, Mn, B, Cu and Zn) and cycling on this drained, nutrient poor peatland forest was studied. The effects of both basic and refertilisation were studied (Paavilainen 1980). The amounts of nutrients in the tree stand, field layer of the ground vegetation, and soil were determined.

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

Refertilisation with NPK increased the annual biomass production and amount of litterfall. 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 strips and needle litter.

Table J10/a. Experiment 6, fertilisers used

Sample plot	Fertilisation in 1965: PK fertil. for peatland for. (7,2 % P, 13,7 % K)	Fertilisation in 1965: Y fertiliser for peatland forests (14 % N, 7,8 % P, 8,3 % K)	Fertilisation in 1974: Amm.nitr. with lime (26 % N)	Fertilisation in 1974: 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 for exp. 6.

Sample plot	Sn stems/ha	G m²/ha	D1.3 cm	H m	$V_{(1974)}$ m³/ha	$V_{(1993)}$ m³/ha	Growth 1974–93 m³/ha/a
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

Measured in 1993

J11. The growth of a spruce swamp forest

Experimental plot 2
- Established:1928
- Area 0.12 ha

Herb-rich spruce swamp
Vaccinium myrtillus-herb-rich peatland forest
Mineral subsoil: fine silt
Peat thickness: 0.5 m
$N_{0\text{-}10\,cm}$ 1.96 %

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

According to the needle chemical analysis in 1993, the stand suffered from severe phosphorus and potassium deficiencies. The zinc concentrations were also low.

Table J11. Data of the spruce stand on sample plot 2 from 1993.

	V m^3/ha	$Iv_{(1984\text{–}93)}$ $m^3/ha/a$	Production m^3/ha	G m^2/ha	D1.3 cm	H m
Birch	-	-	193	-	-	-
Pine	-	-	28	-	-	-
Spruce	162	7,7	292	20,3	18,5	16,0
Total	162	7,7	513	20,3	18,5	16,0

Measured in 1993

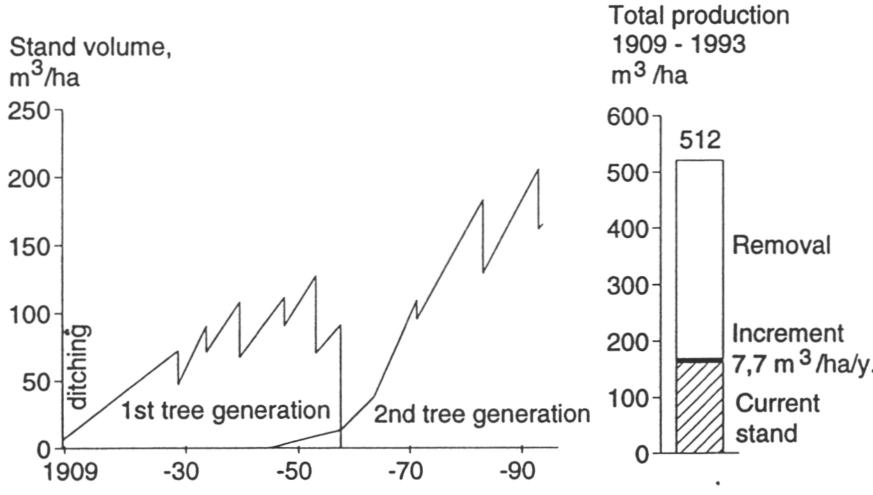


Fig. J11. Development of the tree stand on sample plot 2.

J12. Comparison between a pristine and treated spruce stand.

Experiment nr 5, sample plots a and b
- Established: 1928,
- Area 0.35 ha
Herb-rich tall sedge pine fen/
Vaccinium myrtillus peatland forest
Peat thickness: 0.4 m
$N_{0\text{-}10\,cm}$ 2.01 % /1994)
Mineral subsoil: fine silt

This site was drained in 1909 and the distance between the ditches is 90 m. At the time of drainage the stand on the plot consisted of a mixed, 37 year old pine-spruce stand with a stand volume of 5 m³/ha. On plot 5a the stand has remained untreated while the stand on plot 5b has been treated relatively intensively. In 1963 the shelterwood of plot 5 b was removed leaving the naturally developing spruce stand.
In 1994 the stands were measured. The stand age on plot 5a was then 123 years and on plot 5b 57 years. The fact that the stand on plot 5a has not been treated is reflected in the development of the mean stand diameter. According to needle chemical analysis, the stand on plot 5b suffers from severe phosphorus and potassium deficiency.

Table J12. Tree stand data for plots 5a and 5b.

	Sn stems/ha	V m³/ha	$Iv_{(1984\text{-}94)}$ m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m
Sample plot 5a (pristine)							
Pine	27	8	0,03	10	0,9	22,6	19,2
Spruce	633	105	1,08	146	12,6	19,7	16,9
Birch	520	170	1,65	229	18,7	23,3	20,1
Small spruce	1 353	3	0,03	3	1,1	5,0	4,6
Total	2 533	286	2,79	388	33,3	20,3	18,5
Sample plot 5b (treated with cuttings)							
Spruce	1 680	142	5,75	430	23,0	14,5	12,1

Measured in 1994

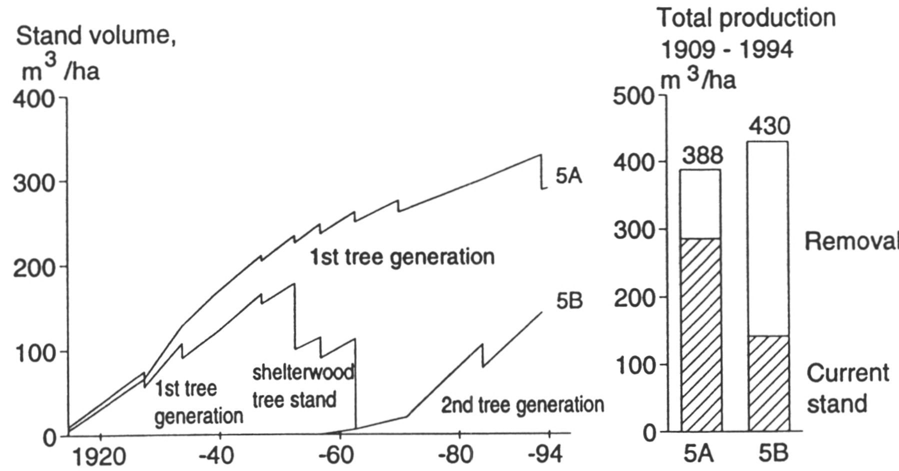


Fig. J12. Development of the tree stand on sample plots 5a and 5b.

J13. Regeneration of a birch stand

Experiment nr 60
- Established: 1985
Vaccinium vitis-idaea peatland forest
Peat thickness: 0.4 m

Drainage of this site was carried out 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 1985. In winter 1987 the shelterwood stand was removed and in spring 1988 the downy birch and silver birch seedlings were planted as presented on the map in Fig. J13.

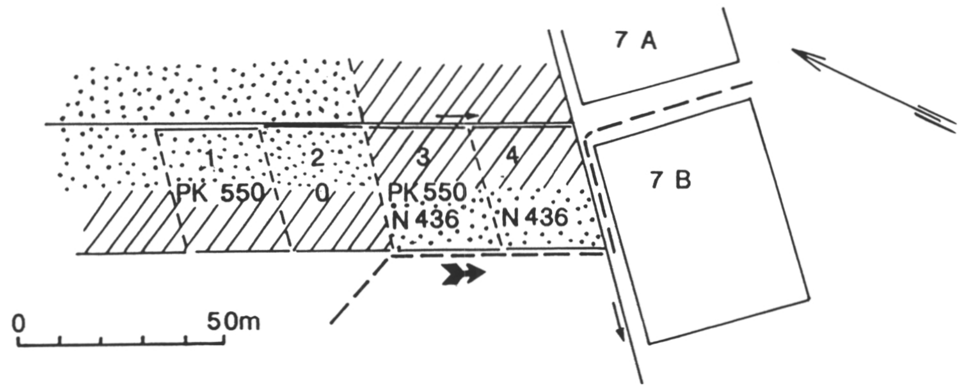


Fig. J13. Treatments on the sample plots of experiment 60.
Fertlisers (spread May, 22nd, 1985)
PK fertiliser for peatland forests
Ammonium nitrate with lime

Planting with downy birch seedlings
Planting with silver birch seedlings
excursion path, direction of route

J14. The effect of cuttings on the productivity of a mixed forest

Experiment nr 7, sample plots a and b
- Established: 1928,
- Area: 0.2 ha per sample plot

Tall sedge pine fen/ *Vaccinium myrtillus* peatland forest
Peat thickness: 0.4 m
$N_{0-10\ cm}$ 2.32 % (1995)

Drainage of this site was carried out in 1909, 1915 and 1986. The distance between the ditches after 1986 was 45 m. The purpose of this experiment is to study the effect of drainage and thinning on the growth and development of the tree stands. The stand on sample plot 7a has been thinned six times (in 1928, 1934, 1939, 1945, 1953 and 1957). In 1984 the remaining dominant birches were removed from over the new naturally developing spruce stand. The stand on sample plot 7b has remained in its pristine state and there the only removal has been through self-thinning.

According to the needle chemical analyses (in 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 for exp. 7.

		Sn stems/ha	V m^3/ha	$Iv_{(1984-94)}$ m^3/ha/a	Production m^3/ha	G m^2/ha	D1.3 cm	H m
Sample plot 7 a, thinned	Birch	-	-	-	159	-	-	-
	Pine	-	-	-	133	-	-	-
	Spruce	2 083	110	7,3	140	20,3	13,4	10,6
	Total	2 083	110	7,3	432	20,3	13,4	10,6

		Sn stems/ha	V m^3/ha	$Iv_{(1984-94)}$ m^3ha/v	Production m^3/ha	G m^2/ha	D1.3 cm	H m
Sample plot 7 b, pristine	Pine	350	162	1,7	213	15,9	23,6	22,1
	Spruce	1 910	54	0,9	56	10,0	18,0	13,3
	Birch	495	142	1,2	175	16,4	23,2	20,8
	Total	2 755	358	3,8	444	42,3	23,7	22,0

Measured in 1994

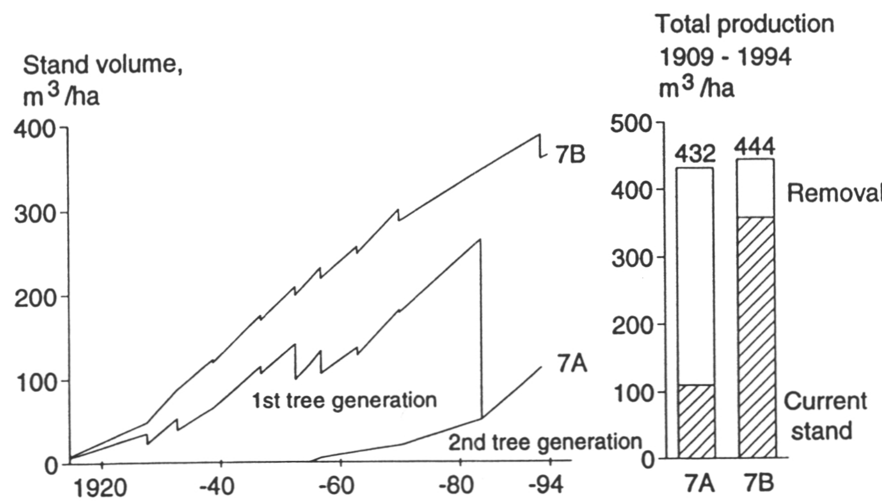


Fig. J14. Tree stand development of sample plot 7a and 7b.

J15. Comparison between a pristine and thinned mixed forest

Experiment 8
- Established: 1928
- Area: 0.2 ha per sample plot

Tall sedge pine fen/ *Vaccinium myrtillus* peatland forest
Peat thickness: 0.4 m
$N_{0\text{-}10\,cm}$ 2.29 % (1995)
Mineral subsoil: fine silt

Drainage of this site was carried out in 1909, 1915, 1936 and 1986. The distance between the ditches after 1986 was 45 m. The purpose of this experiment is to study the effect of drainage and thinning on the tree stand and ground vegetation. The tree stand on sample plot 8 has been thinned six times (in 1928, 1934, 1939, 1947, 1953 and 1957). In 1985 the last trees of the first stand generation were removed. The stand on the sample plot 8 b has remained in its pristine state and there the only removal has been through self-thinning.
In fact, Experiment 8 is a replicate of experiment 7 (J14). However, the sample plots of Experiment 8 are situated in the middle between two ditches while the sample plots 7a and b are alongside the ditch, dug in 1915. The initial distance between the ditches was 125 m.
According to needle chemical analyses, the spruces on plot 8a do not suffer from nutrient deficiencies.

Table J15. Tree stand data for exp. 8.

		Sn stems/ha	V m³/ha	$Iv_{(1984\text{–}94)}$ m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m
Sample plot 8a, thinned	Pine	-	-	-	297	-	-	-
	Birch	-	-	-	83	-	-	-
	Spruce	1 244	67	3,8	79	13,9	14,1	9,6
	Total	1 244	67	3,8	459	13,9	14,1	9,6

		Sn stems/ha	V m³/ha	$Iv_{(1984\text{–}94)}$ m³ha/v	Production m³/ha	G m²/ha	D1.3 cm	H m
Sample plot 8b, pristine	Pine	445	240	3,7	293	22,3	26,7	23,6
	Birch	385	82	0,5	97	9,3	22,9	21,5
	Spruce	1 235	78	1,1	84	10,6	21,8	17,1
	Total	2 065	400	5,3	474	42,2	22,5	17,9

Measured 1994

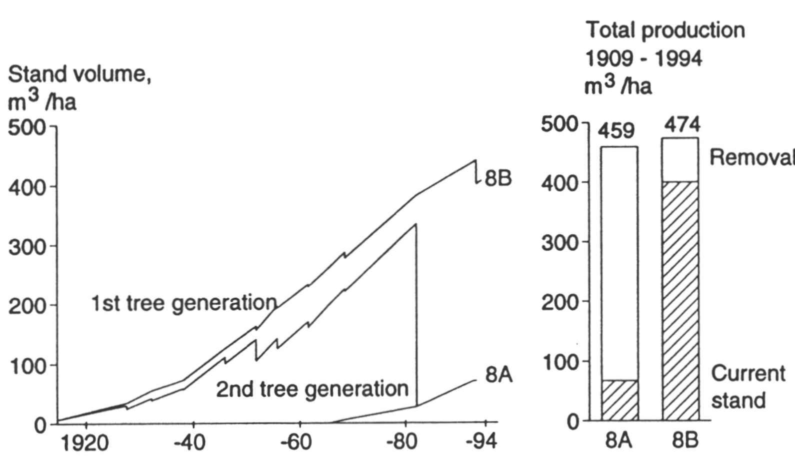


Fig. J15. Tree stand production on sample plots 8a and 8b.

J16. 'H Culture'

<u>Blocks I and II</u>
Dwarf-shrub-*Vaccinium myrtillus* peatland forest
Peat thickness: 0.5 - 1.0 m
Mineral subsoil: fine silt
$N_{0\text{-}10\,cm}$ 1.80 % (1984)

<u>Blocks III and IV</u>
Vaccinium myrtillus - herb-rich peatland forest
Peat thickness: 0.5 - 1.0 m
Mineral subsoil: fine silt
$N_{0\text{-}10\,cm}$ 2.34 % (1984)

<u>Block V</u>
Vaccinium vitis-idaea-V.myrtillus peatland forest
Peat thickness: 0.2 - 0.4 m
Mineral subsoil: fine silt
$N_{0\text{-}10\,cm}$ 1.91 % (1984)

In the mid-1970's new forest regeneration experiments were initiated at Jaakkoinsuo. These hydro-culture experiments became known as the 'H-cultures'. This method of aims at producing a highly productive and rationalised forest by including the regeneration, planting, and future thinnings in the planning. The tree crop is grown in the hydrologically and nutritionally most favourable part of the drained area, that is along the ditches, while access to the stands is from the middle of the strip (roadway) where growth conditions are less favourable.

The H-culture method works best in the regeneration of old drained peatland forests, but it can also be used in planted stands on recently drained sites.

At Jaakkoinsuo, the H-culture experiment was established in 1973-74 in three blocks. In winter 1973 the old tree stands were felled. Besides the stems, also the stumps and snags were removed. The density of the ditch network was increased to a distance of 10 m between the ditches and the ditch spoil was spread between the ditches. In spring 1974 two year old Scots pine seedlings were planted in rows alongside the ditches, leaving a roadway in the middle for access. Along with planting, the seedling rows were fertilised along a 0.5 m broad strip with PK fertiliser for peatland forests to an amount corresponding to 1000 kg/ha on the fertilised strip.

In spring 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. The survival rate varied a little between the different blocks.

Fertilisation with micronutrients did not affect the growth or survival rate of the plants. There was a relatively high rate of growth disturbances in the experiment with a rather high frequency of twisted stems. These were most prominent on the blocks III and IV which had the highest amounts of nitrogen in the peat. The growth disturbance symptoms did not occur after fertilisation with micronutrients.

In 1994 a fertilisation trial was established in the experiment. The treatments included P, K, PK and NPK (N 100 kg/ha, K 80 kg/ha and P 45 kg/ha). All treatments received the same amount of boron (B). The control plots were divided into two subplots of which one was treated with boron.

In principle, all nutrient deficiencies in H-culture stands should be dealt with immediately as they appear.

There are several peatland site types that do not require afforestation after drainage. This site would probably have developed a natural spruce stand as the mean spruce seedling number/ha was 11000, the progeny of seed trees in the vicinity.

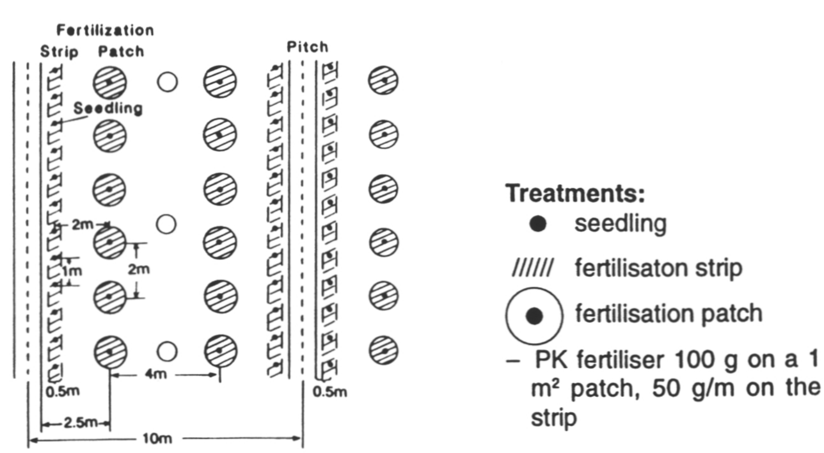


Fig. J16a. The 'H culture' experiment.

Table J16. Fertiliser treatments of the 'H culture'

Fertilizer treatment		kg/ha	Blocks/sample 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. Micronutrient fertiliser with potassium *3	(K)	267	4	7	1	9	4
5. Apatite	(P)	281	2	8	5	7	5
Micronutrient fertiliser with potassium	(K)	267					
6. Amm. nitrate *4 with lime	(N)	364	1	10	3	6	2
Apatite	(P)	281					
Micronutrient fertiliser with potassium	(K)	267					

Fertilisers used:
*1 Boron fertiliser (B 0,5 %, Ca 19 %, S 18 %, Mg 2 %)
*2 Apatite (P 16 %, Ca 36,5 %)
*3 Micronutrient fertiliser with potassium (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 %)

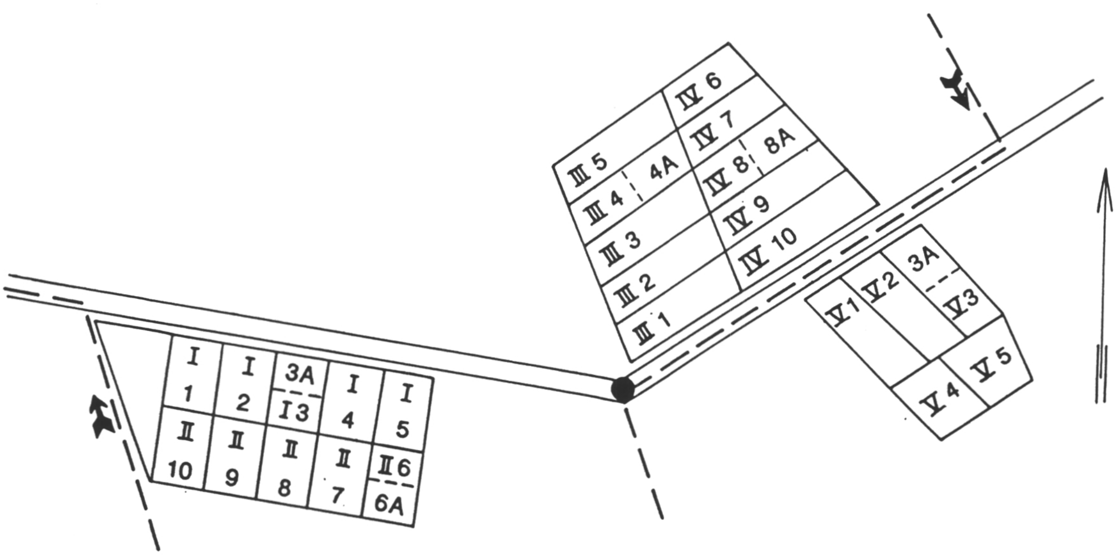


Fig. J16b. Blocks of the experiment.
● you are here
- - - -➧ excursion path, direction of excursion route

J17. Effect of fertilisation on the natural regeneration of spruce

Experiment nr 61
- Established: 1985
- Area: 0.3 ha

Herb rich peatland forest
Peat thickness: 0.3-0.4 m
N0-10 cm (sample plot 1) 2.19 % (1995)
Mineral subsoil: fine silt

Drainage of this site was carried out in 1909 and 1938. The distance between the ditches is 90 m.

In 1982 shelterwood cutting was carried out that aimed at naturally regenerating spruce. About 200 stems/ha of spruce shelterwood (V = 150 m³/ha) was left on the plot. In 1985 a fertilisation trial was established to enhance the regeneration.

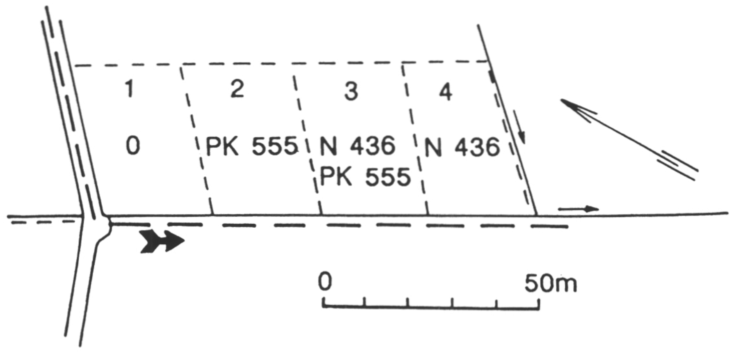


Fig. J17. Fertiliser treatments of exp. 61.

1. Unfertilised control
2. PK fertiliser for peatland forests 555 kg/ha (P 9 %, K 17 %)
3. PK fertiliser for peatland forests 555 kg/ha (P 9 %, K 17 %) Ammonius nitrate with lime 436 kg/ha (N 27,5 %, Mg 2,2 %)
4. Ammonium nitrate with lime 436 kg/ha (N 27,5 %, Mg 2,2 %)

- - - -➡ excursion path, direction of excursion route

J18. A spruce stand growing on a thin peat layer

Sample plot 26
- Established: 1935
- Area: 0.25 ha

Tall sedge spruce swamp/ Herb-rich peatland forest
Peat thickness: 0.3 m
$N_{0\text{-}10\,cm}$ 1.97 % (1940)
N_{org} 2.56 %
Mineral subsoil: fine silt

Drainage of this site was carried out in 1909. The distance between the ditches is 120 m. At the time of drainage the tree stand consisted of a sparse, uneven downy birch forest. The purpose of this experiment (established in 1935) was to study the effects of drainage and cuttings on site type changes and also on the growth and regeneration of the stand. When the experiment was established, the sparse and recently thinned downy birch forest had a developing spruce undergrowth. The total stand volume was 112 m³/ha.

The tree stand has been thinned in 1916 and 1934, and after establishing of the experiment, also in 1935, 1940, 1947, 1953, 1958 and 1982. The last birches were removed in 1958. The stand was measured in 1992 at the mean age of 90 years.

This stand has the highest productivity on the Jaakkoinsuo mire.

Table J18. Tree stand data for sample plot 26.

	Sn stems/ha	V m³/ha	$Iv_{(1983-93)}$ m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m
Birch	-	-	-	199	-	-	-
Spruce	508	297	11,4	470	27,05	27,2	24,6
Total	508	297	11,4	669	27,05	27,2	24,6

Measured in 1993

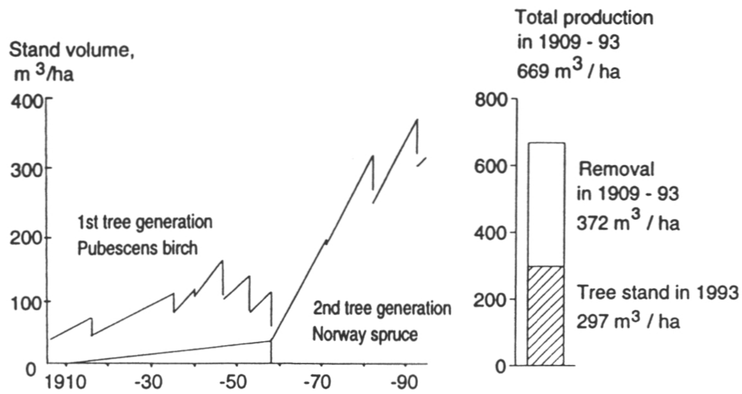


Fig. J18. Tree stand development on sample plot 26.

After site J18 we reach the 'recreation centre' of Jaakkoinsuo, the so-called Anttila hotel. Here you can rest for a while and study the information boards about the mire.

J19. Recovery of spruce stand after removal of shelterwood

Experiment nr 27, sample plots a and b
- Established: 1935
- Areas: 0.1 ha per sample plot

Tall sedge pine fen/
Vaccinium myrtillus
peatland forest
Peat thickness: 0.4-0.8 m
$N_{0\text{-}10\,m}$ 2.11 % (1995)

Drainage of this site was carried out 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 five more times after that (in 1940, 1947, 1953, 1957, and 1963). Sample 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 the tree stand growth. The stands were measured in 1982 after which 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. The response of the undergrowth stands is currently being followed up.

According to needle chemical analyses (1993), the spruce stand under the shelterwood (27a) suffered from a severe phosphorus deficiency and from mild 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.

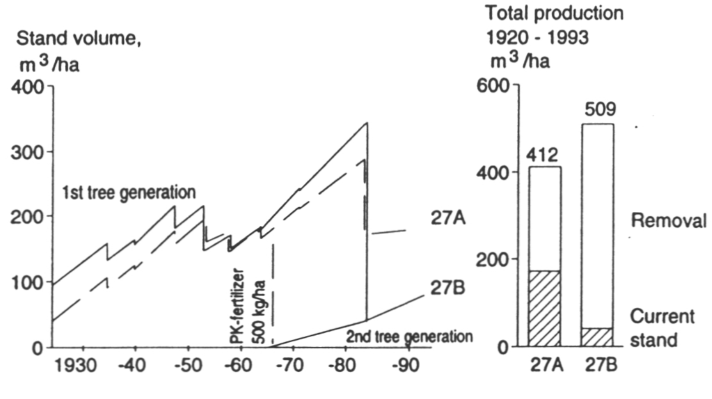


Fig. J19. Tree stand development on sample plots 27a and 27b. The fertiliser treatment has increased the stand growth with about 3.2 m2/ ha/a.

J20. Regeneration experiment on a pine bog

Experiment nr 41
- Established: 1983
- Area: 2.5 ha

Carex globularis pine swamp/Dwarf-shrub-*Vaccinium myrtillus* peatland forest
Peat thickness: 0.2-1.0 m
Mineral subsoil: fine silt

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

In winter 1983, the old tree stand was cut into a seed tree position on some parts of the area (leaving 40-50 seed trees/ha) while the other parts were clear-cut. The soil preparation was done with a Fiskars' cultivator with 4-5 m between the cultivation strips. The cultivator forms a 50-60 cm wide ridge while leaving a 20-25 cm deep and 20-30 cm wide furrow. In spring 1984 the clear-cut areas were afforested with Scots pine origin Ruovesi in Central Finland); part of the area was sown and part planted with two-year-old seedlings. The seed trees were removed in winter 1992-93.

In 1994 the planted and sown parts of the experiment were inventoried. The mean survival rate of the planted seedlings was 2380 plants/ha (11 % of the plants had died). The corresponding rates for the sown seedlings were 1690 (on 30 % of the sowing spots seeds had not germinated or the seedlings had not survived). There was a statistically significant difference between the survival rates of the planted and sown areas. The other measured variables, cultivation, distance from the nearest ditch and peat thickness had no effect on the survival rate or on the plant height growth.

By natural seeding there had developed an average of 1600 plants/ha on the planted and sown areas. On the areas with a thick peat layer there were more seedlings than on the areas with thinner peat. The most common growth disturbances recorded on the planted and sown seedlings were twisted stems and leader change; these features were more common in the planted seedlings. Leader change was more common in the sown than in the naturally seeded seedlings. Leader die-back was most common on the cultivated strips.

In summer 1992 the areas with natural seeding were inventoried. The average results of natural seeding on both Jaakkoinsuo and three other experiments that were inventoried simultaneously were very poor. However, the differences between the different experiments were considerable. On Jaakkoinsuo the number of seedlings worth growing was only 1010 seedlings/ha on both the cultivated and not cultivated areas. The success of the regeneration was not significantly affected by soil preparation, thickness of the raw humus layer or cover of Sphagnum mosses or cotton-grass.

Treatments:

SMPH = seed tree position
AVOH = clearcutting
IST = planting
KY = sowing
////// = cultivation
= ditch
- - - - = excursion path
● = you are here
➡ = direction of excursion route

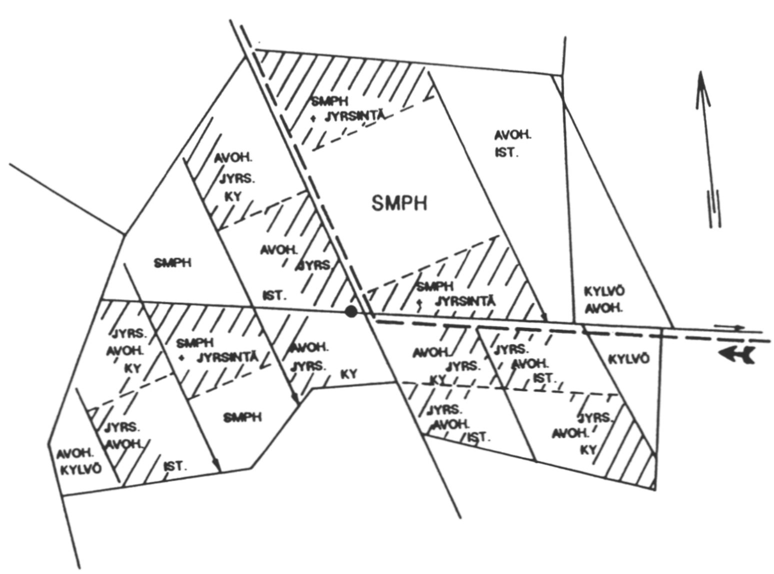


Fig. J20. The regeneration experiment.

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

J21. Experiment with drainage and prescribed burning

Experiment 24, sample plots A1 and A2
- Established: 1935
Dwarf-shrub cotton-grass pine bog/Dwarf-shrub peatland forest
Peat thickness: 0.5 m
N0-10 cm (24 a) 2.08 % (1995)
Mineral subsoil: fine silt

Drainage of this site was carried out 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 the regeneration and subsequent stand growth. In 1956 the stand (V=76 m^3/ha; I=1.8 m^3/ha/a) was clear-cut and two years later the area was burned.

In 1978 the tree stand was cleared. On sample plot A1 a mixed pine-birch stand was left growing while only pines were left on plot A2. The tree stands were measured in 1994 when the stand was 35 years old. After that, in winter 1995 the stands were lightly thinned.

On a relatively poor soil like this, the competition from birch is too severe for pines and not even the better wood quality of the pines can compensate the losses in growth.

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 the needle weight, Ca and Zn concentrations but decrease the Mg, Cu and Mn concentrations (1993).

From here you can return to the forest plough. The path goes between sites J23 and J27.

Table J21. Tree stand data for sample plots 24 A1 and 24 A2.

		Sn stems/ha	V m^3/ha	$Iv_{(1978-94)}$ m^3/ha/a	G m^2/ha	D1.3 cm	H m
Sample plot	Pine	736	33	1,2	6,2	11,3	10,3
24 A1	Birch	984	37	1,9	6,8	9,1	11,1
	Total	1 720	70	3,1	13,0	10,8	10,7
Sample plot 24 A2	Pine	1 712	95	4,6	16,5	12,5	10,7

Measured in 1994

J22. Comparison between a pristine and treated tree stand

Experiment nr 10, sample pots
- 10 a (area 0.2 ha) and
- 10 b (area 0.1 ha)
- Established: 1928

Tall sedge pine fen/ *Vaccinium vitis-idaea* peatland forest
Peat thickness: 0.3 m
N0-10 cm 2.31 % (1995)
Mineral subsoil: fine silt

Drainage of this site was carried out in 1909 and 1938. Prior to the first drainage the tree stand consisted of a mixed forest with a volume of about 8 m³/ha. An experiment with the purpose of studying the development of a pristine and treated pine stand was established.

The stand on sample 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 second stand generation started. The stand on plot 10b has been left to develop naturally.

According to the needle chemical analyses, 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 for sample plots 10a and 10b.

		Sn stems/ha	V m³/ha	$Iv_{(1983-94)}$ m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m
Sample plot	Pine	-	-	-	308	-	-	-
10a, thinned	Spruce	1 375	68	2,8	73	13,2	13,1	10,0
	Birch	-	-	-	88	-	-	-
	Total	1 375	68	2,8	469	13,2	13,1	10,0

		Sn stems/ha	V m³/ha	$Iv_{(1983-94)}$ m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m
Sample plot	Pine	510	262	3,5	379	24,2	25,7	23,1
10b, pristine	Spruce	2 950	70	2,3	70	11,8	19,1	19,6
	Birch	600	96	0,6	106	11,6	20,3	19,4
	Total	4 060	428	6,4	555	47,7	23,6	21,7

Measured in 1994

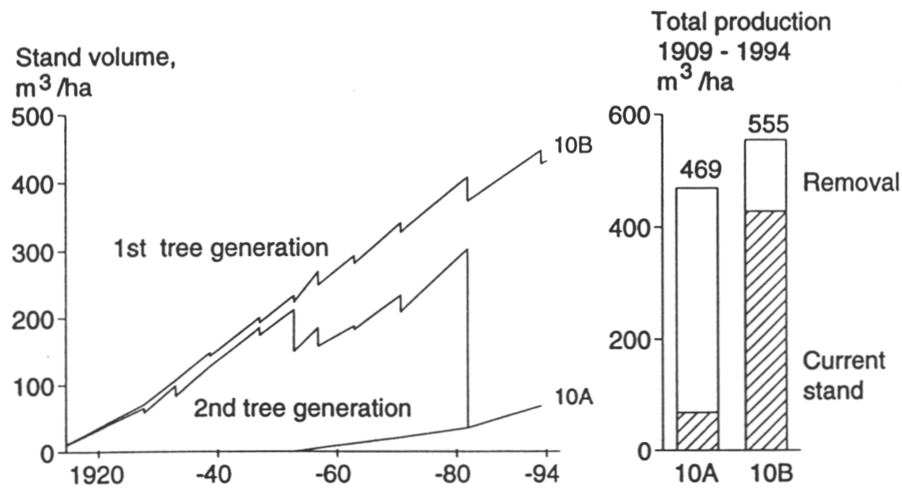


Fig. J22. Tree stand development on sample plots 10a and 10b.

J23. Leaching of fertilisers and suspended solids

Experiment nr 40
Dwarf-shrub-
Vaccinium vitis-idaea
peatland forest
Peat thickness: 0.4-1.0 m
N0-10 cm 0.89-1.74 % (1984)
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 weir dams in the middle ditch of each catchment (see map of Fig. J23a). Since then, the quantity and quality of the runoff waters have been monitored by sampling the overflow of the runoff water at the weirs.

In the early winter 1995, the four catchment areas south of the road were clear-cut while the single catchment north of the road was left as a control. During summer of the same year, one of the clear-cut areas was ditch mounded so that the ditches reached down to the mineral subsoil (clay). 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.

The only treatment that caused a considerable increase in the erosion, measured as the suspended load in the runoff, was the ditch mounding down to the mineral subsoil. The other treatments had no effect on the leaching.

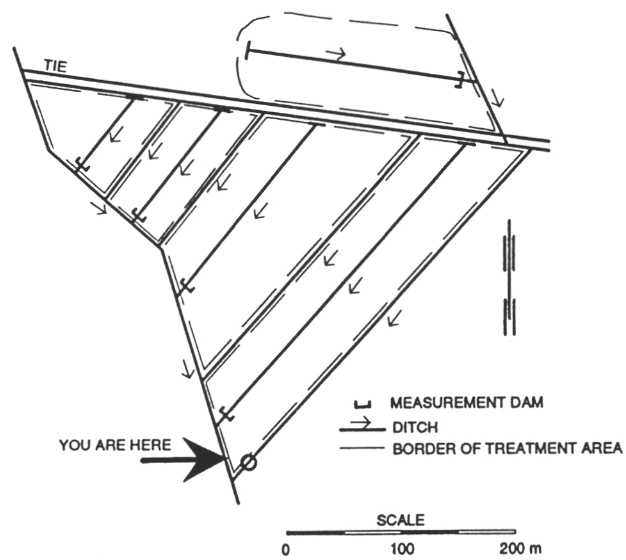


Fig. J23a. Layout of the experiment

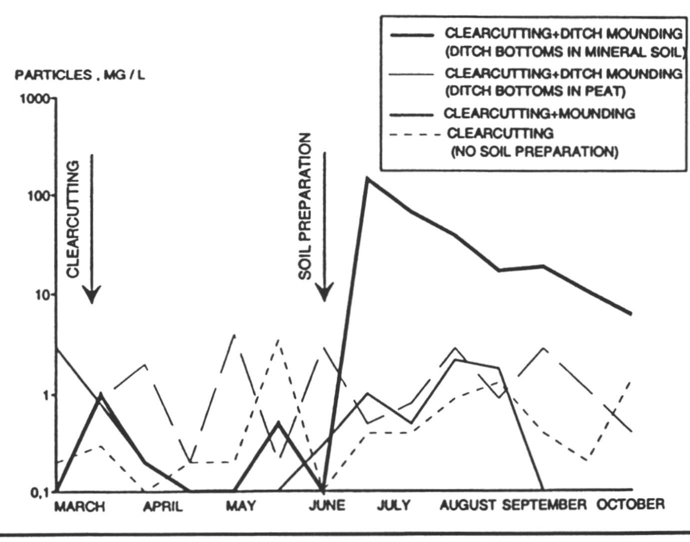


Fig. J23b.

J24. Productivity and natural regeneration on a herb rich peatland forest

Experiment 23, sample plots
- 23 a (area 0.125 ha) and
- 23 b (area 0.1 ha)
- Established: 1934

Herb-rich peatland forest
Peat thickness: 0.8-1.0 m
N0-10 cm 2.40 % (1995)
Mineral subsoil: fine silt

Drainage of this site was carried out three times, in 1909, 1915 and 1935. An experiment for studying wood productivity was established in 1934. The tree stand has been thinned several times; the thinning in 1982 was strong and aimed at initiating a natural regeneration. Sample plot 23b was fertilised in 1965 (PK fertiliser, 600 kg/ha). In 1994 the plot stands were cut into a seed tree position and the remaining stands and undergrowth measured.

Table J24. Tree stand data for sample plots 23a and 23b.

		Sn stems/ha	V m³/ha	Iv m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m
Sample plot 23a	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

		Sn stems/ha	V m³/ha	Iv m³/ha/a	Production m³/ha	G m²/ha	D1.3 cm	H m
Sample plot 23b, fertilised 1965, PK fertiliser 600 kg/ha)	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

Measured in 1994

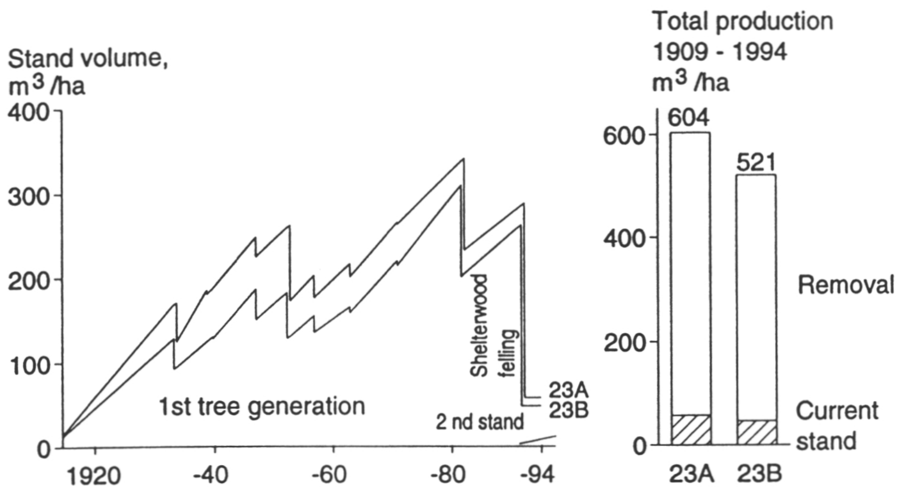


Fig. J24. Tree stand development on sample plots 23a and 23b.

J25. Thinning experiment of a peatland forest stand

Experiment 15, sample plots
- 15 a (area 0.125 ha) and
- 15 b (area 0.120 ha)
- Established: 1928

Tall sedge fen/*Vaccinium vitis-idaea* peatland forest
Peat thickness: 0.7-0.8 m
N0-10 cm (1985)
- sample plot 15 a 2.31 %
- sample plot 15 b 2.65 %

Mineral subsoil: fine silt-clay

Drainage of this site was carried out three times, in 1909, 1935 and in 1951. The distance between the ditches is 25 m.

At the time of the first drainage the tree stand was a sparse pine-birch plant forest with a mean age of 20 years.

The purpose of this experiment is to study the production and development of the three stands. The stands have been thinned several times. In the last thinning in 1982 the stand treatment on plot 15 aimed at initiating natural regeneration. On plot 15b all the dominant trees were removed and the second stand generation became the focus of the experiment.

Table J25. Tree stand data for exp. 15.

Sample plot	Remaining stand m^3/ha	Removed in thinnings m^3/ha	Total production m^3/ha
15a	142	136	278
15b	38	270	308

J26. Experiment with T-notch planting and fertilisation of spruce

Experiment XV, sample plots 1-4
- Area: 0.2 ha

Tall sedge fen/*Vaccinium myrtillus* peatland forest
Peat thickness: 0.1-0.2 m
Mineral subsoil: fine silt

Drainage of this site was carried out in 1909 and 1953. The area was planted (T-notch planting) with 2+2 year-old spruce seedlings in 1939. In 1964 the experiment was divided into four parts and treated with different dose levels of a mixed fertiliser with nitrogen, phosphorus and potassium ("Y"-fertiliser). In 1992 the tree stands were measured and the first thinning was made.

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

Table J26. Tree stand data 1992.

Sample plot	Y-fertiliser, kg/ha	Sn stems/ha	V m^3/ha	Production m^3/ha	G m^2/ha	D1.3 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 % ja K 8,3 %)
Measured in 1992

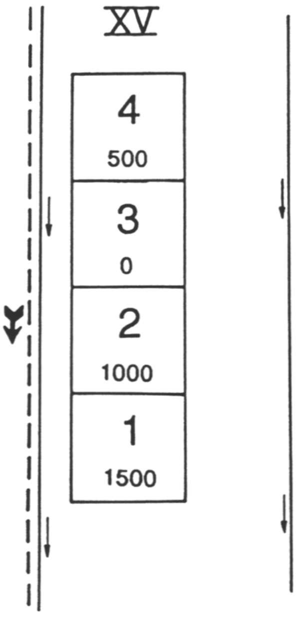


Fig. J26. Layout of experiment XV.
- - - -➜ excursion path,
direction of excursion route

J27. A grafted birch stand

Experiment XIX
- Area: 0.5 ha
Vaccinium myrtillus peatland forest
Peat thickness: 0.1-0.2 m
Mineral subsoil: fine silt

Drainage of this site was carried out in 1909 and 1935. The mixed forest stand that grew on this site burnt in May 1946. In 1949 the remaining stand was clear-cut and the harvest residues piled and also burnt.

The site was regenerated by planting downy birch and silver birch seedlings; the downy birches succeeded considerably better than the silver birches. This resulted in the appearance of clearings in the centre of the site. In the mid-1950s, 'mixed' birch seedlings were planted in these clearings. 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 on the excursion path in the Jaakkoinsuo mire. We hope you have enjoyed the tour and that you will visit the mire again.

List of subjects

	site no
Scots pine, or pine (*Pinus sylvestris*)	1, 2, 4-8, 10, 12, 20, 21
Downy birch or birch (*Betula pubescens*) or	13, 27
Silver birch (*Betula pendula*)	27
Norway spruce, or spruce (*Picea abies*)	11, 12, 17, 18, 19, 22, 25, 26
mixed tree stands	12, 14 ,15, 21, 22, 24, 25
natural regeneration	13, 17, 20, 24, 25
sowing or planting	1, 13, 16, 20, 26
seedling stands	1, 6, 14, 15, 22
untreated tree stands	2, 12, 14, 15, 22
tree stand growth and production	practically all
vegetation succession, monitoring of vegetation	15
hydrology	9
flooding experiment	9, 23
fertilisation	1, 6, 7, 9, 10, 13, 14, 16, 17, 19
liming	1, 4
wood ash fertilisation	5, 8
subsidence of peat	3
prescribed burning	21, 27
soil preparation	23
nutrient cycle, nutrient budget	10
leaching	22
herb-rich peatland forest	17, 18, 24
Vaccinium myrtillus peatland forest	11, 12, 14, 15, 19, 26, 27
Vaccinium vitis-idaea peatland forest	13, 20, 22, 25
dwarf-shrub peatland forest	1-8, 20, 21

List of sites

		experiment number
J1.	Pine stand preserved in pristine state	4
J2.	Regeneration of peatland forest, development of plant stand and fertilisation	17
J3.	Subsidence pole study	
J4.	Liming and growth of tree stand	I
J5.	Drainage and wood ash fertilisation in a pine stand on a bog	XII /1 and XII /2
J6.	Nutrient budget of Scots pine (on peat)	XXII /1–12
J7.	Drainage and fertilisation experiment of a pine bog stand	XX /a–d
J8 .	A mature pine stand treated with drainage and wood ash fertilisation	XIII / 0, 1 and 2
J9.	The ecological experiment fields	66
J10.	Distribution and cycling of nutrients in a pine stand on a dwarf-shrub peatland forest	6
J11.	The growth of a spruce swamp forest	2
J12.	Comparison between a pristine and treated spruce stand.	5a and 5b
J13.	Regeneration of a birch stand	60
J14.	The effect of cuttings ont the productivity of a mixed forest	7a and 7b
J15.	Comparison between a pristine and thinned mixed forest	8a and 8b
J16.	'H Culture'	
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 stand after removal of shelterwood	27a and 27b
J20.	Regeneration experiment on a pine bog	41
J21.	Experiment with drainage and prescribed burning	24A1 and 24A2
J22.	Comparison between a pristine and treated tree stand	10a and 10b
J23.	Leaching of fertilisers and suspended solids	40
J24.	Productitvity and natural regeneration on a herb rich peatland forest	23a and 23b
J25.	Thinning experiment of a peatland forest stand	15a and 15b
J26.	Experiment with palleplanting and fertilization of spruce	XV /1–4
J27.	A varte birch stand	XIX

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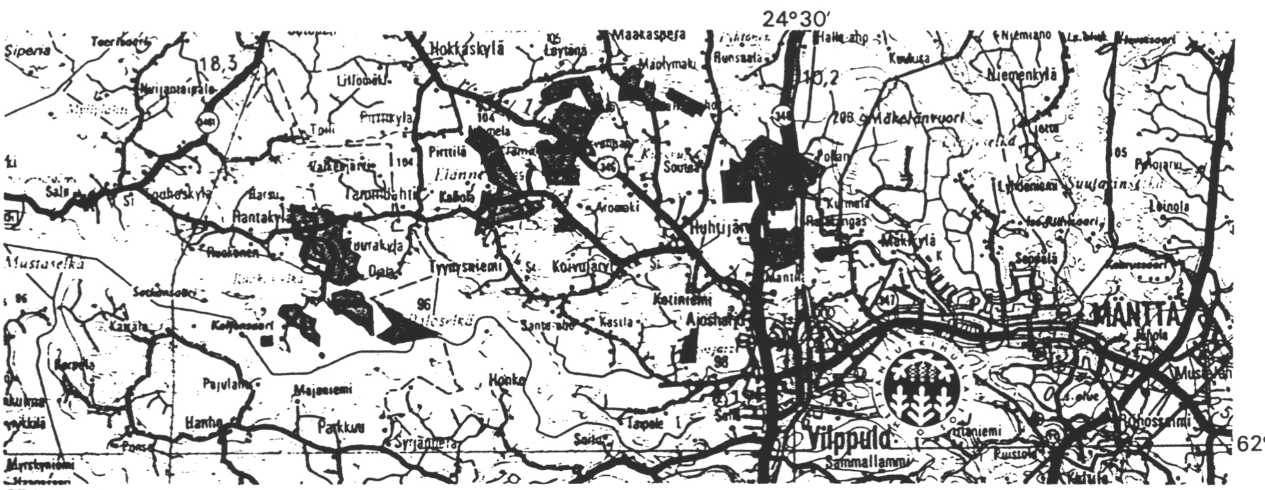
Vilppula Research area

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 2543 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 serving the research needs. There are 228 ha of protected areas. 10 % of the Research area consists of experiments or sample plots and these have their own specially designed forest plannig. 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 380 000 m^3. The mean volume is 154 m^3/ha and the mean annual increment about 7 m^3/ha. The annual cuttings from the experiments and normal forests is about 9000 m^3.



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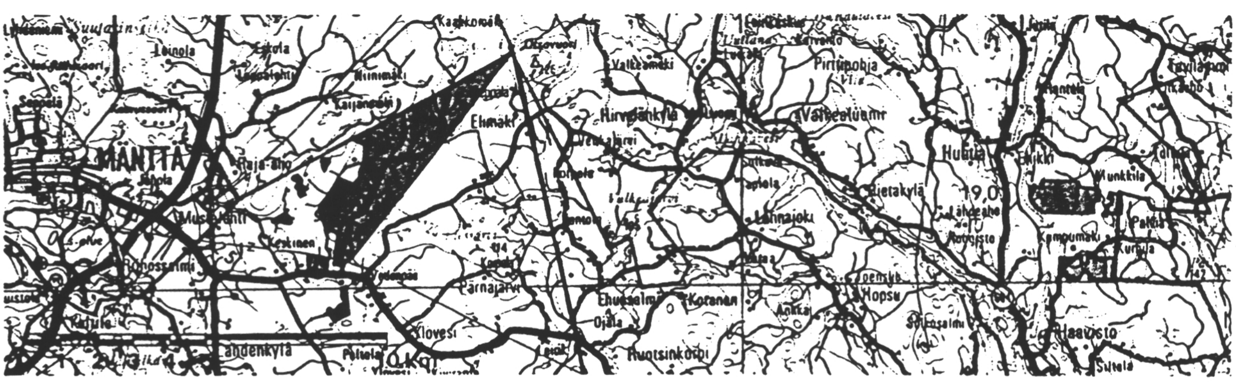

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Finnish Forest Research Institute (METLA)

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 multi-disciplinary 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. Currently, Metla has stewardship over three national parks: Koli, Pallas-Ounas and Pyhätunturi 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.