THE FINNISH FOREST RESEARCH INSTITUTE

DEPARTMENT OF PEATLAND FORESTRY

JAAKKOINSUO AND KAAKKOSUO EXPERIMENTAL AREAS
VILPPULA

Helsinki 1979

THE FINNISH FOREST RESEARCH INSTITUTE

The Finnish Forest Research Institute was founded by law on the 24th of October, 1917. At present it consists of research departments as follows:

- Department of Soil Science
- Peatland Forestry
- Forest Inventory and Yield
- Forest Economics
- Silviculture
- Forest Protection
- Forest Tree Breeding
- Forest Technology
- Mathematics

In addition to these there are an Administrative Office, and an Experimental Forest Office. There are also 4 independent research stations for special regional investigations and 4 experimental stations for special projects (Appendix 1).

The Department of Peatland Forestry was established in 1928 in order to clarify the principles of the utilization of peatlands for forestry purposes and to investigate basic forest-improvement work covering the nutrient balance and need for fertilization, scarification, hydrology and biology of peatlands. Furthermore, the activities of the department include investigations of silviculture on peatlands, the yield of wood after drainage, afforestation methods, development of machines used in forest improvement and the structure of forest roads, among other topics.

For field experiments, the Forest Research Institute has experimental areas (79 860 ha in total) in different parts of Finland (Appendix 1) and a further 62 196 ha in national parks, nature parks and conservation areas.

JAAKKOINSUO EXPERIMENTAL AREA

After the Finnish National Board of Forestry had started systematic ditching activity for the utilization of peatlands for forestry purposes it established in 1909 the Jaakkoinsuo experimental area in order to clarify the principles of forest drainage. The primary aim was to find out by means of experiments, how large a yield of wood can be achieved on sites with different nutrient contents and further, how various drainage efficiensies and stand treatments affect the yield. The first ditchings were carried out in 1909 and since then, they have been extented for various projects. In 1923, the experimental area was placed under the Finnish Forest Research Institute.

Mean values of some climatic factors:	
Mean annual temperature	+ 3.4° C
Mean temperature in July	+16.8° C
Mean temperature in February	- 8.4° C
Sum of daily mean temperatures (>+5°C)	1 220° C
Average duration of growing season (>+5°C)	164 days
Annual precipitation	600 mm
Altitude	120 m
Latitude	62° 04'

The first experiments for determining tree growth after drainage were established as early as 1909 and further experiments have been established: in 1926, experiments in which mineral soil was applied, in 1929, liming experiments and in 1937, ash fertilization experiments. Fertilization experiments using common fertilizers were started in 1949. Strip with experiments as well as ecological experimental fields are also to be found in this area.

Point 1. Production experiment

The tree stand on sample plot 4 has been kept in natural state after drainage in 1909, to find out the development of the original pine stand on a site type of poor fertility. The results (Appendix 7) of the experiment show that the production of a too old tree stand is very poor.

Point 2. Sinking of the peat surface after drainage

There are several series of poles at Jaakkoinsuo which reach down to the mineral soil. The height of the poles is adjusted by levelling. It is possible to find out by means of the pole series, how much the peat layers of different thickness have sunk as a result of drainage.

Point 3. Drainage and wood ash fertilization experiment

The experiment XII consists of two experimental plots of which no. 1 is the control (only drainage), no. 2 has been bertilized in 1937 with 5000 kg-/ha of wood ash. The production results (Appendix 7) show a very clear increase in total production and in annual increment caused by ash fertilization even on site type rather poor in nitrogen, when the drainage is very effective.

Here is also a liming experiment, where in 1929, 0, 2000, 4000, 6000 and 8000 kg/ha of limestone have been applied. The results show a very slight positive effect, which, however, is not statistically significant.

Point 4. Ecological experiments in peatland forests

Here at Jaakkoinsuo as well as in the experimental area of Kivalo in Northern Finland close to the arctic circle, there are ecological experiments on a pine swamp and a spruce-birch swamp. The effect of the growth factors of trees and the differences in the degree of efficiency induced artificially in these factors, on the total growth and the annual rythm of growth has been studied in these experimental fields since 1960. The following growth factors have formed the primary objects of the research: ground water conditions, soil temperature, nutritional state of the ground, air temperature and air humidity. All these factors have been regulated artificially (Appendix 2).

The ground water relations have been changed by regulating the ditch water level at 0, 10, 30, 50 and 70 cm from the ground surface (in the following=drainage depth) on various plots (cf. Appendix 3). The ground temperature has been lowered by removing the snow from the plots throughout the winter, causing the ground to become deeply frozen. In spring the snow has been spread back over the frozen ground and covered with straw in order to prevent the snow and frozen ground from thawing. It has been possible to keep the ground temperature at a higher than normal level by covering the soil with straw before the winter, thus retarding freezing of the soil. The nutrient state of the ground has been regulated by means of various fertilizers. The air temperature has been raised by building plastic shelters around the sample trees and, further, by heating the shelters.

The diameter growth has been measured on the sample plots at intervals of 2-3 days by a banding method. The height growth has also been measured. Further investigations have been made into the biological activity in the ground and the amount and depth distribution of tree roots.

The results presented in Appendix 4 show that there is a clear positive correlation between the drainage depth and the growth of the basal area of a tree stand on the unfertilized plots. In the peat soil the biological activity and the mobilisation of scarce nutrient resources are the more effective the deeper the ground water table has been regulated.

The results of the fertilized plots (Appendix 4) show that the greatest difference in tree growth is found between the plots of 0 and 10 cm compared with the other drainage depths. Concerning the depths of 30, 50 and 70 cm there are no clear differences in the growth. The lasting period of N-fertilization shows to be about 4-5 years on the N-poor site like this.

The effect of high ground water table in early summer compared with the same in late summer has also been studied here at Jaakkoinsuo.

The results of experiments (Appendix 5) show, that the high ground water level in spring and early summer has had no influence in the growth of trees, but in late summer and autumn it has always been harmful. The major part of the active root system has been above the ground water surface in these experiments although this has been kept as high as possible.

Artificial rising of the temperature surrounding some sample trees has proved that the air temperature does not have any direct influence on the total increment of the tree in Vilppula experimental area. In plastic shelter where the temperature is higher and the trees are sheltered from the wind, the height growth of pine, spruce and birch sample trees has been higher but the circumference growth smaller than that of control trees outside the shelter.

The results of the experiments on soil temperature show, that the time when growth commences is independent of the prevailing soil temperature and is determined solely by the temperature of the surrounding air in spring. Thus, on the plots where the soil has been covered by snow and the ground around the root systems has been entirely frozen the growth starts at the same time as on the normal control plots.

It is worth noting that the straw layer used in soil temperature experiments has in later years improved the tree growth by eliminating the uptake of nutrients by the ground vegetation and by keeping the surface layer humid enough for the decomposition and mobilisation activities of the soil microbes.

Point 5. The distribution and cycling of nutrients in a pine swamp ecosystem

The aim of the study is to clarify the effect of the fertilization on the nutrient cycling in a drainned dwarf-shrub pine swamp. Sample plots have been established as follows:

No.	Fertilization	Refertilization
1	-	-
2	NPK in 1974	-
3	NPK in 1965	-
4	NPK in 1965	NPK in 1974
5	PK in 1965	-
6	PK in 1965	NPK in 1974

N = calcium-ammoniumnitrate (25 % N) 400 kg/ha.
PK = PK fertilizer for peat soils (0-24-15) 500 kg/ha.

The following measurements have been done since June 1974:

- The amount and nutrient content in the litterfall of the trees and ground vegetation
- The nutrient content in the canopy throughfall of the trees and ground vegetation
- Tree growth measured with the banding method
- Ground temperature and other site factors

The biomass and nutrient content of the median trees and the ground vegetation has been determined when beginning the experiment. The microbiology and biological activity in the peat will also be studied in these sample plots.

In Appendix 6, the nutrient content of the soil is presented, as well as examples of the nutrient content of the needles and of the litter.

Point 6. Production experiment (with different stand treatments)

The object of the experiment is to find out how the various stand treatments affect the total yield and the growth of the tree stand. The experiment consists of two experimental plots. Plot 5a has been kept in an unthinned natural state and on plot 5b heavy thinnings have been applied. This explains why there is at present a naturally regenerated spruce stand on the plot 5b. This stand forms the second tree generation after drainage. The information given in Appendix 7 indicates that the largest total yield has been acchieved on the plot which had no thinning treatments (5a). Technically, however, the stand is of very poor quality and so far the cuttings have not produced any income. On the plot which had thinning treatment the stand is of good quality and several cuttings have produced income.

Point 7. Production experiment (with different stand treatments)

The experiment consists of four experimental plots. Plots 7b and 8b have been kept in an unthinned natural state. On plots 7a and 8a the stands have had regular light thinnings.

The information given in Appendix 7 indicates that there is no large difference in total production between different stand treatments. However, the techical quality and economical result are clearly better on thinned plots. We can also clearly see, how the natural regeneration of spruce comes under the thinned overwood, which, especially in Southern Finland, is a necessary cover against frost in early summer.

Point 8. H-culture

A method called H-culture (= high-productive culture) has been developed for forest cultivation on peat. The method is suggested for the regeneration in connection with clear-cutting. The purpose of the method is to make the site as productive as possible by using an intensive treatment consisting of regulation of the water conditions, soil preparation, fertilization, reforestation and forest road building. The treatments applied here in 1974 are as follows:

1. Clear-cutting is carried out in the regeneretion area.
2. Stumps and snags are harvested.
3. Ditches surrounding the blocks as well as ditch bank roads are made.
4. In the area planting is performed in rows by using the tree species that is most suitable for the area. Simultaneously, a sufficient soil preparation and fertilization are carried out alongside the furrows.

On the turf ridges the water and nutritional conditions as well as the physical structure of the soil are in an optimum state for the tree growth.

Point 9. Production experiment

The object of the experiment is to study the natural reforestation and the total yield of tree stands. At the time of ditching (in 1909) there were some small birches and willows growing in the area. After drainage a natural birch stand appeared in the area. Because the birch stand has had regular thinning treatments a natural spruce stand has appeared in the understory. The last of the birches were cut in 1958. Technically, the spruce stand growing at present in the area is of very good quality. The stand increment as well as the total yield of the area are very large as can be seen in Appendix 7.

Point 10. Production experiment

The purpose of the sample plot 29 is to find out the production after drainage and with regular thinnings on the site type of medium fertility and of thin peat layer. Results are shown in Appendix 7.

Point 11. Reforestation experiment using controlled burning

The object of the experiment is to study how controlled burning may be applied in the reforestation of peatlands. The pine stand originally on the site was cut in 1956 and controlled burning was carried out in 1958. The stand has been naturally regenerated with seed from the surrounding forests. Because the dense birch stand almost suppressed the pine seedlings the stand of birch seedlings has been controlled with a herbicide application and later mechanically.

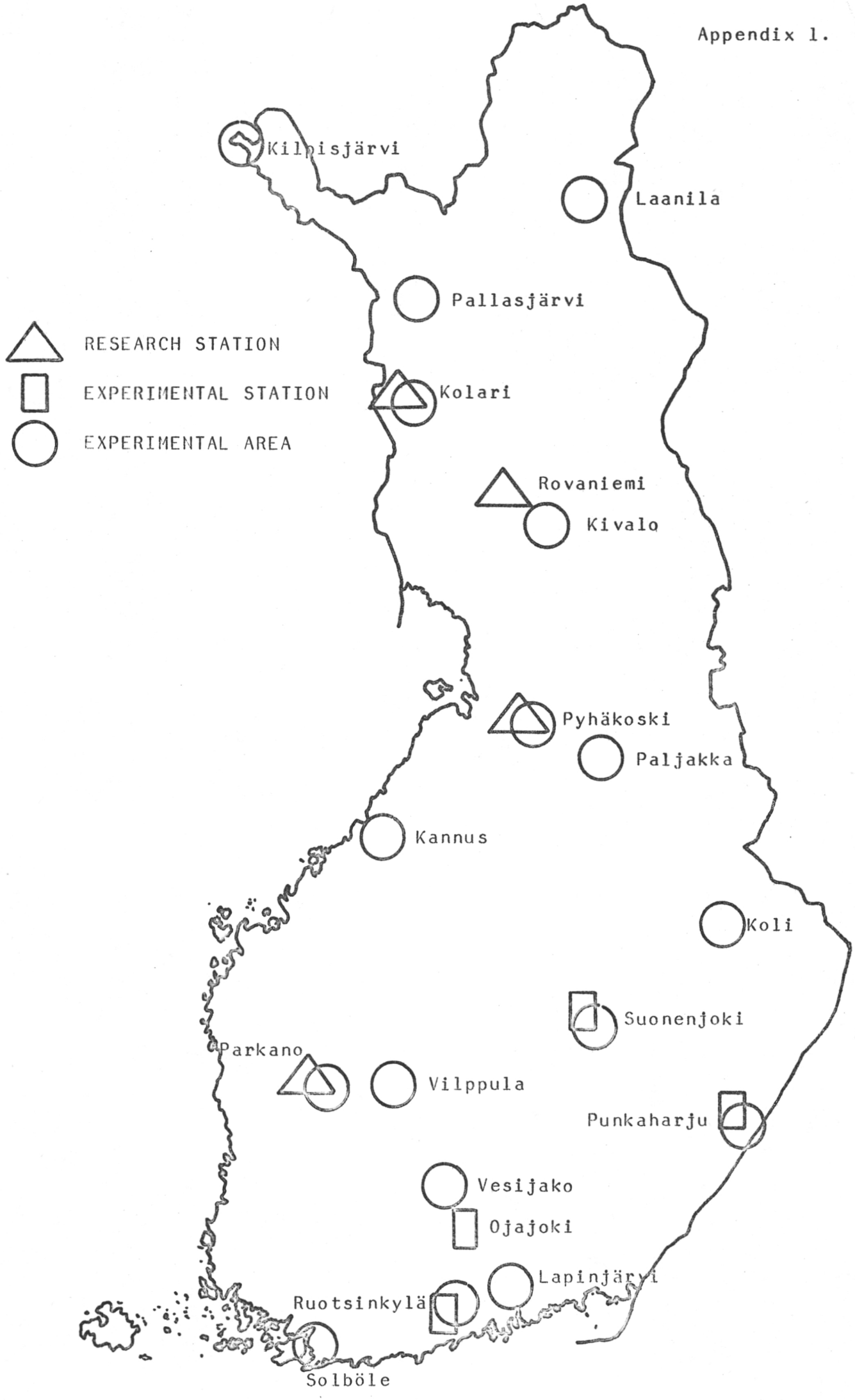
Point 12. Production experiment

The peatland site type on plot 23a is the most fertile site at Jaakkoinsuo. At the time of ditching (in 1909) there were some small-sized pines of poor growth growing in the area. It can be seen in Appendix 7 that the total yield after drainage has been very good and the annual mean growth after drainage has been calculated to be 7.5 solid m^3 per hectare. The experiment shows that even a swamp with a fairly thick peat layer can be made to produce very highly productive stands of large timber trees.

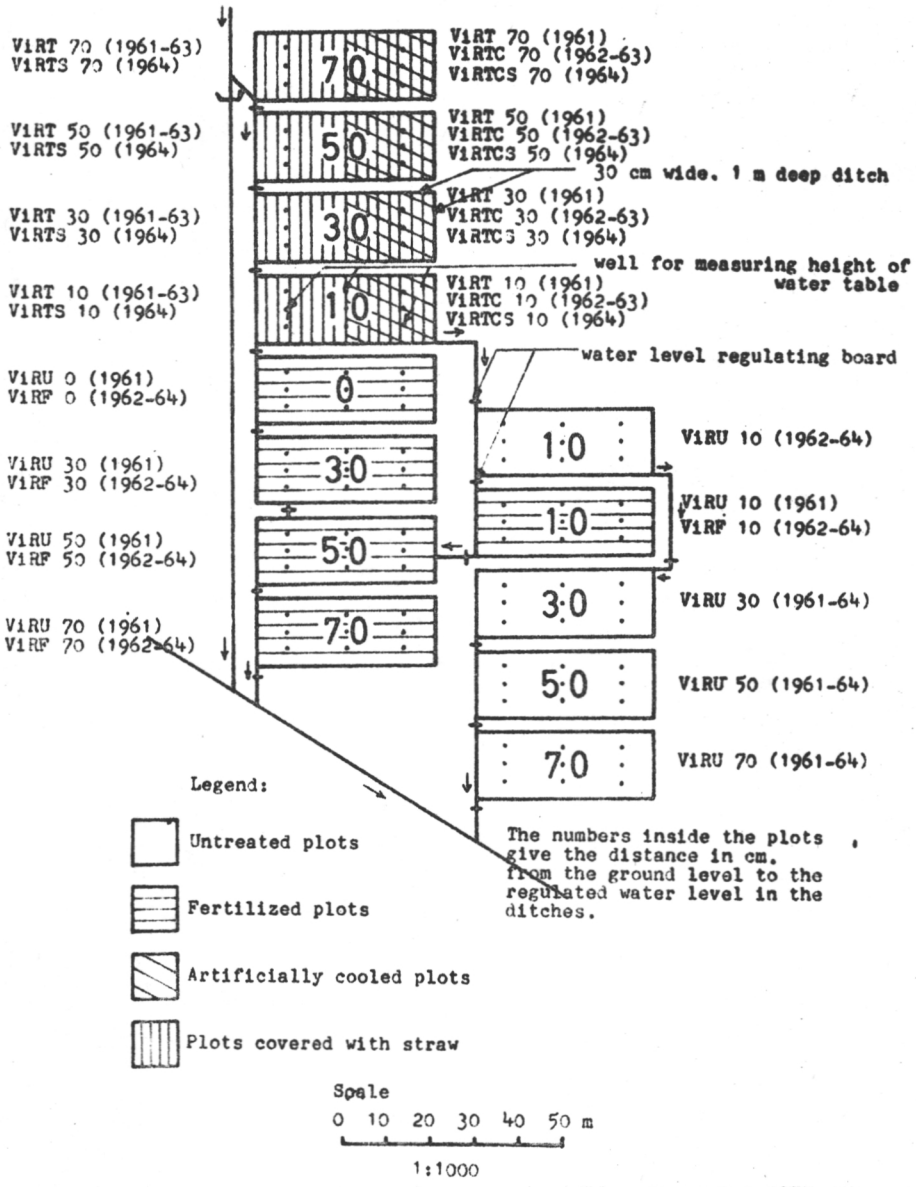
Point 13. Production experiment

At the time of ditching plot 15a was an entirely treeless bog. However, up to now, it has produced 280 m^3 of wood and the present stand consists of large timber trees of fairly good quality. The importance of the nutrient content of the site for wood production after drainage can clearly be seen in Appendix 7. The total yield and the growth of the stand on plot 23a are nearly twice those of plot 15a.

Appendix 1.


RESEARCH STATION
EXPERIMENTAL STATION
EXPERIMENTAL AREA
Kilpisjärvi
Laanila
Pallasjärvi
Kolari
Rovaniemi
Kivalo
Pyhäkoski
Paljakka
Kannus
Koli
Suonenjoki
Parkano
Vilppula
Punkaharju
Vesijako
Ojajoki
Lapinjärvi
Ruotsinkylä
Solböle

Appendix 2.



Jaakkoinsuon rämeen koekenttä.

Experimental area of pine swamp at Jaakkoinsuo.

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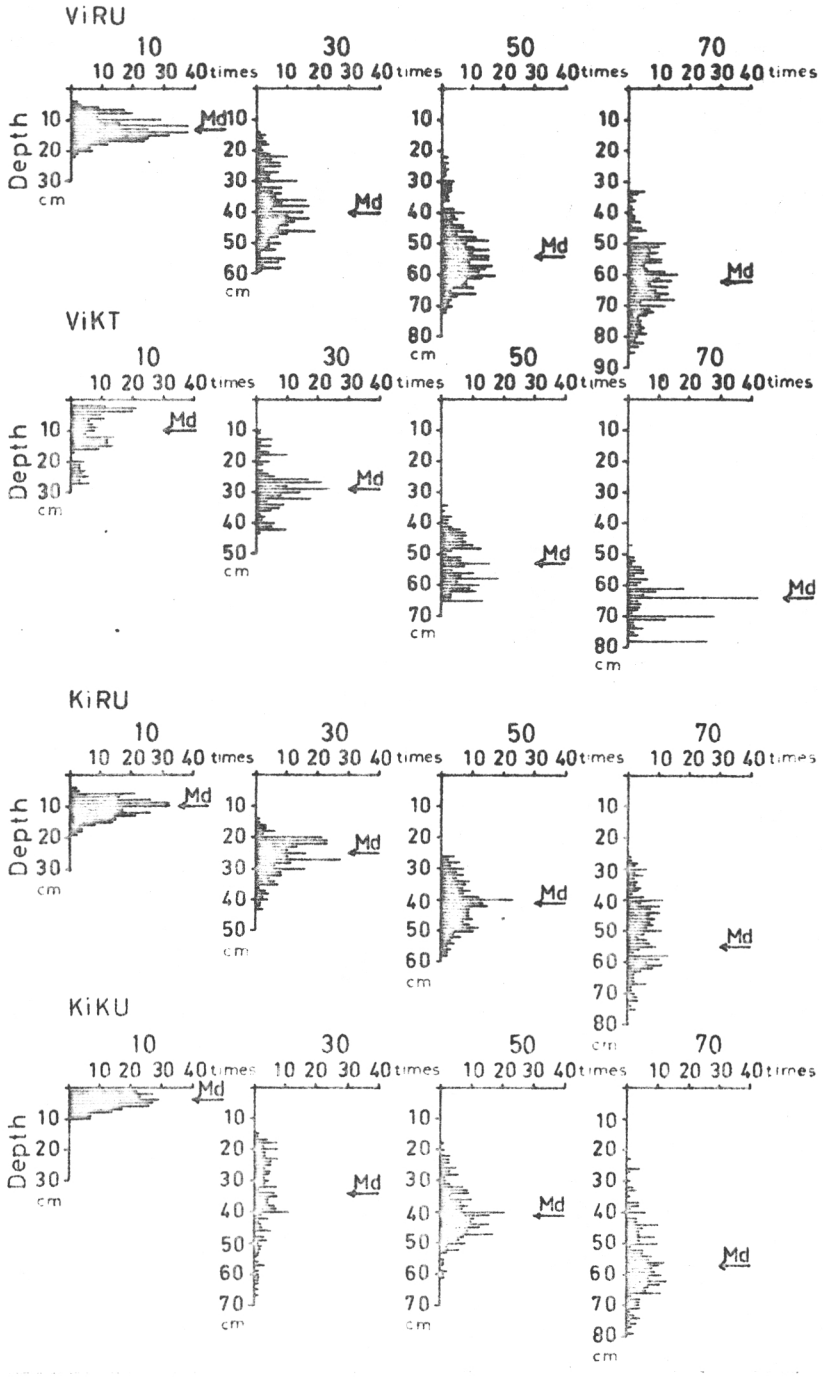
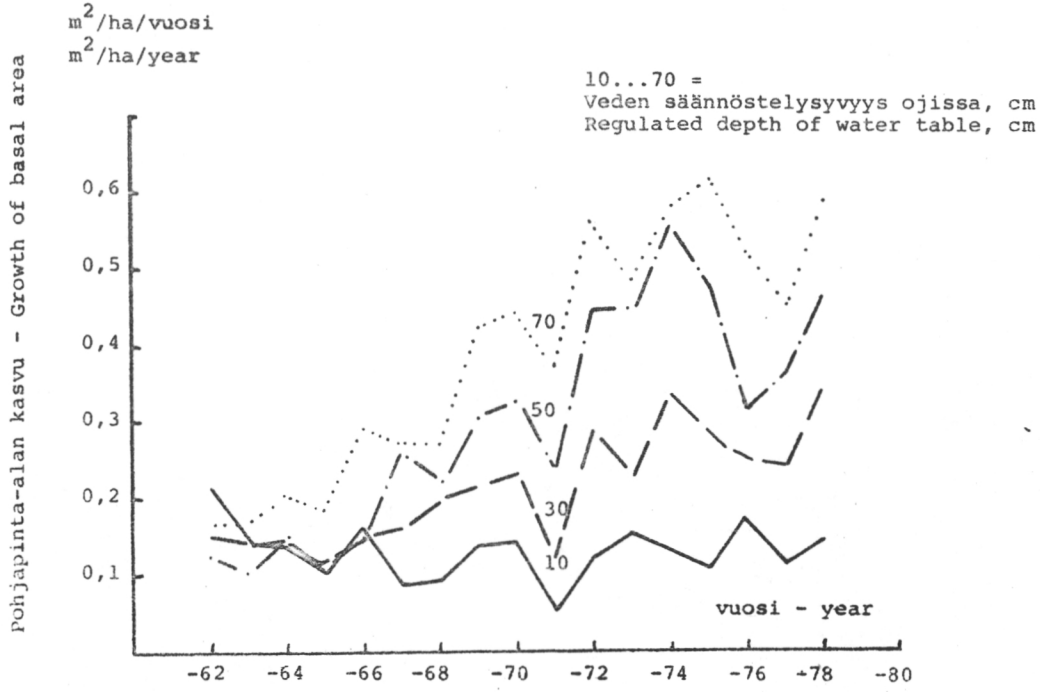


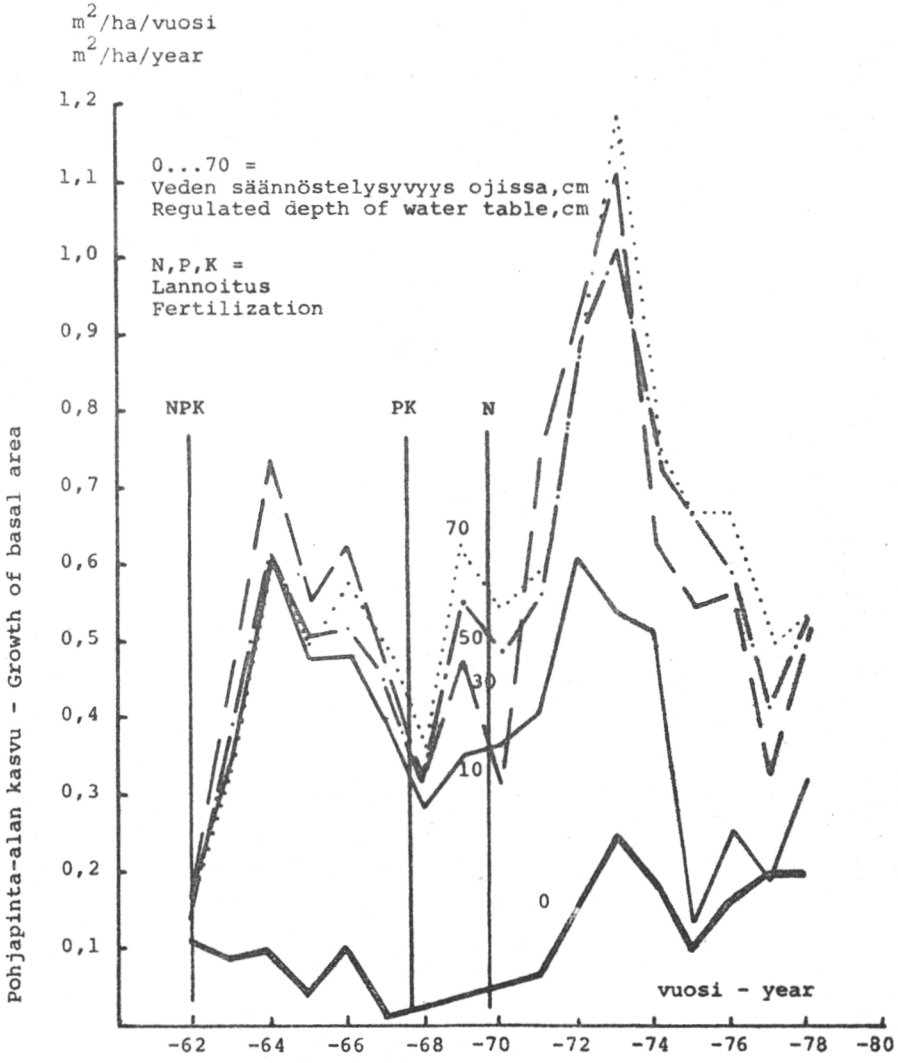
Kuva osoittaa kuinka monta kertaa pohjavesi on havaittu eri syvyyksiltä havaintokautena 1964. Md = mediaani.

Figures revealing how many times the ground water was observed at different depths during the observation period in 1964. Md = median.



Mäntypuuston pohjapinta-alan kasvu rämeen koekentällä.

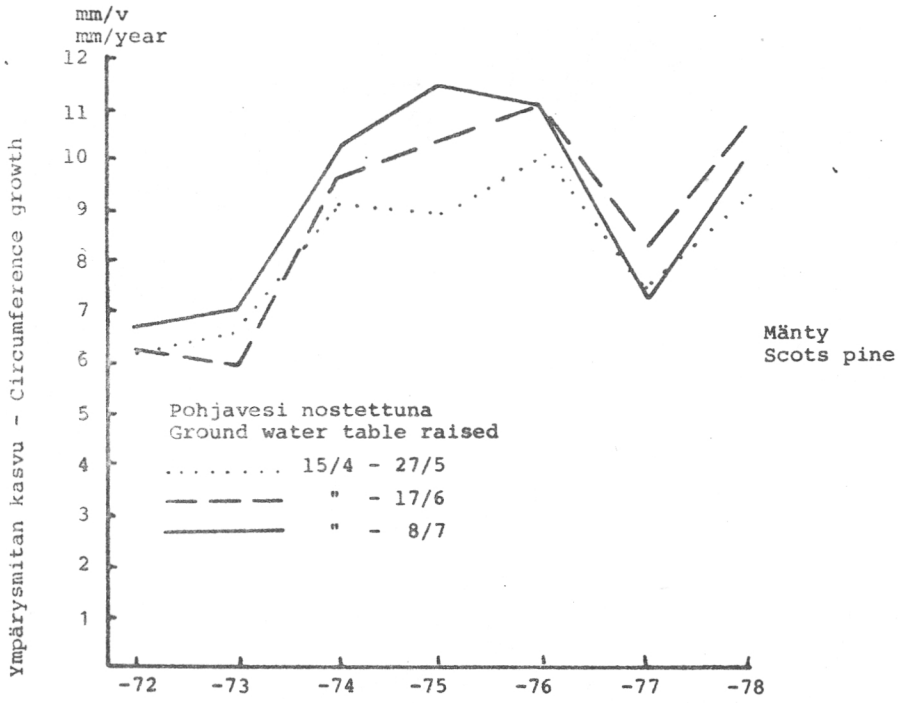
Growth of the basal area of tree stand on the pine swamp experimental area.



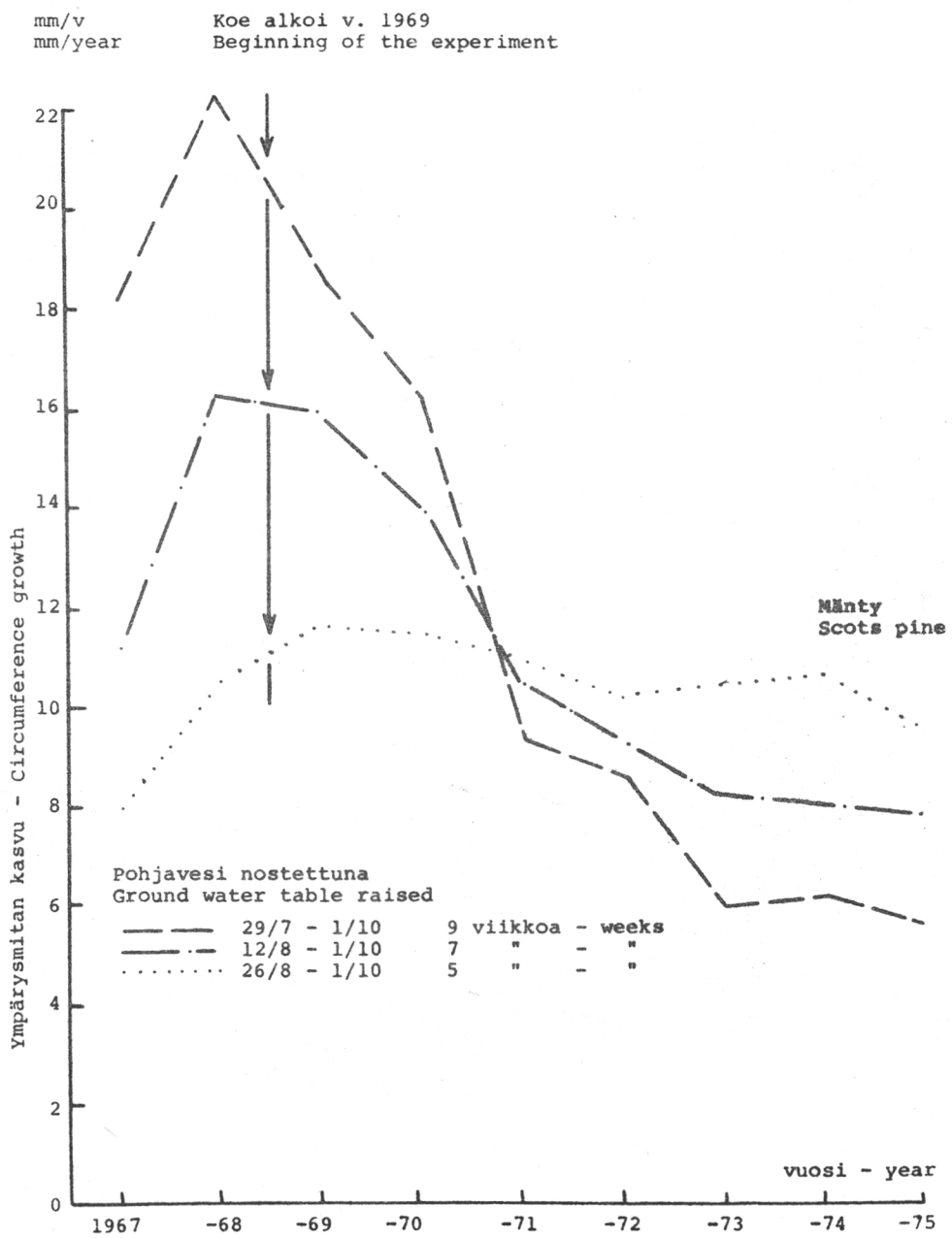
Mäntypuuston pohjapinta-alan kasvu lannoitetulla rämeen koekentällä.

Growth of the basal area of tree stand on the fertilized pine swamp experimental area.

Appendix 4.



Alkukesällä korkealla olevan pohjaveden vaikutus männyn kasvuun.
The influence of high ground water table (in early summer) on the circumference growth of Scots pine.



Loppukesällä korkealla olevan pohjaveden vaikutus männyn kasvuun.
The influence of high ground water table (in late summer) on the circumference growth of Scots pine.

Appendix 5.

Nutrient content of the soil (November 1976)

Sample plot n:o	pH	N_{tot}, %	P_{tot}, mg/l	K_{tot}, mg/l	Ca_{tot}, mg/l
1	3,3	1,32	202	85	641
2	3,3	1,34	178	87	682
3	3,2	1,26	168	77	467
4	3,3	1,15	130	68	486
5	3,3	1,20	175	84	593
6	3,1	1,15	195	78	779

Nutrient content of the needles (March 1977)

Sample plot n:o	N, %	P, mg/g	K, mg/g	Ca, mg/g	Mg, mg/g	Mn, mg/g	Cu, mg/kg	Zn, mg/kg	B, mg/kg
1	1,60	1,45	5,49	2,61	1,15	243	1,42	37,6	18,4
2	1,60	1,69	5,38	2,93	1,32	290	1,25	57,5	18,4
3	1,57	1,63	5,71	2,35	1,14	225	1,25	44,2	13,6
4	1,57	1,76	5,27	2,42	1,32	240	0,89	48,7	16,0
5	1,48	1,64	5,77	2,61	1,25	225	1,33	50,9	12,8
6	1,46	1,69	5,54	2,93	1,34	275	1,07	46,5	13,6

TREE LITTER

Amount of nutrients in the litter (15.10.1975-14.10.1976)

Sample plot n:o	Amount of the litter kg/ha	N, kg/ha	P kg/ha	K, kg/ha	Ca, kg/ha	Mg, kg/ha	Mg, kg/ha	Cu, g/ha	B, g/ha
1	2004	13,38	0,90	1,47	8,22	0,95	0,73	11,4	20,1
2	1796	13,29	0,89	1,77	8,09	0,98	0,77	10,1	15,2
3	1542	11,10	0,73	1,37	7,08	0,82	0,55	8,6	13,7
4	1879	13,34	0,86	1,50	9,29	1,07	0,71	10,1	16,0
5	1427	8,88	0,65	1,08	6,69	0,76	0,51	7,9	13,0
6	1865	13,32	0,91	1,83	9,09	1,14	0,74	10,1	17,2
Fertilization 1973									
0	1658	11,12	0,76	1,30	7,33	0,85	0,60	9,3	15,6
NPK	1847	13,32	0,89	1,70	8,82	1,06	0,74	10,1	16,1

Point no.	Sample plot no.	Original peatland site type	Peat layer m	Stand treatment	Tree stand	Annual increment	Total production after drainage
					Solid m^3/ha (measured in 1977)		
1	4	Dwarf-shrub pine swamp	2,5	In natural state	160	3,1	175
3	XII 1	Dwarf-shrub pine swamp	2,2	Thinned (Control)	125	6,0	140
	2			- " - (Ash fert.)	266	9,3	207
6	5a	Herb-rich sedge pine swamp	0,4	In natural state	278	2,5	337
	5b			Regenerated	62	5,3	323
7	7a	Ordinary sedge pine swamp	0,4	Thinned	242	9,4	350
	7b			In natural state	320	4,9	373
	8a			Thinned	304	11,8	386
	8b			In natural state	348	10,3	381
9	26	Ordinary sedge spruce swamp	0,3	Regenerated	262	11,5	493
10	29	C.globularis pine swamp	0,5	Thinned	267	6,4	332
12	23a	Fen-like pine swamp	0,9	Thinned	315	7,1	522
13	15a	Ordinary sedge bog	0,7	Thinned	201	4,7	280

Appendix 7.

KAAKKOSUO EXPERIMENTAL AREA

The experimental activity of Kaakkosuo area consists mainly of fertilization experiments. The first ditchings of the area were carried out in 1915 and they have been completed later on. The first fertilization experiments were established in 1937 and the last ones were established in recent years. The excursion points are situated on that part of the swamp area where the original peatland site types have been rich in nitrogen. In the area, there are "rimpis" which are characteristics of swamp types with a disadvantageous physical structure of soil. The thickness of the peat layer is approximately 1,6 m.

Point 1. Wood ash fertilization

On plot VI:10, a pine seeding was carried out in 1931 and a birch seeding in 1936. In 1937, 7200 kg/ha wood ash was applied to the area. This experiment as well as other experiments have shown that wood ash is a very effective fertilizer on sites rich in nitrogen. Furthermore, wood ash has an alcaline effect, which decreses the activity of soil and increses the microbial decomposing activity and, consenquently, changes the physical structure of the surface layer of peat. The total yield of the area fertilized with wood ash has been 280 m^3/ha, whereas the unfertilized plots are almost improductive. It is very interesting to see now, 42 years after the fertilization, how the growth and vitality of the tree stand clearly has decreased. So far, it is not known which are the reasons for this phenomenon, but studies on this question are going on.

Point 2. N, P, K, and Ca fertilizations

In 1941 and 1951, very small doses of fertilizers were applied to experimental plots VI:5 and VI:8. The results show that as small doses as these have decisively improved the growth of the stand, whereas the adjacent unfertilized

area is almost improductive. On experimental plots VI:7-14, NPK-fertilization and liming were carried out in 1953. A comparison with plots VI:15-30, fertilized with only micronutrients shows that macronutrient, especially P and K, fertilization is absolutely necessary for forest growth on site types like this.

Point 3. P and K fertilizations

This fertilization experiment consists of 10 experimental plots, where in 1953, various amounts of phosphorus and potassium were applied separately as well as both together. From the results can be concluded that the area is extremely poor in both phosphorus and especially potassium. Given together P and K fertilizations have improved the growth significantly. The results of this experiment show very clearly the importance of the balance between different available nutrients.