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THE EFFECT OF DWARF-SHRUB VEGETATION SUPRESSION ON PINE SWAMP TREE STANDS

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SELOSTE:

ISOJEN VARPUJEN HÄVITTÄMISEN VAIKUTUS RÄMEMÄNNIKÖN KEHITYKSEEN

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In most pine swamp stands growing on drained areas the dwarf-shrubs are rather important biomass producers. The aim of the experiment was to determine the effect of killing-off the dwarf-shrub vegetation on the subsequent development of the pine stand. The dwarf-shrub vegetation was killed-off by means of herbicides. The results show that by removing competition by the dwarf-shrub vegetation on drained pine swamps, it is possible to pass onto the trees at least some of the freed growth potential.

1. INTRODUCTION

Finnish forest and peatland plant communities have been intensively studied during the last few decades. The succession communities which arise as a result of ditching and the subsequent changes taking place in them have been determined a number of times (e.g. Tanttu 1914, Lukkala 1929, 1951, Sarasto 1957, 1961). The most distinct change which occurs in the ground vegetation as a result of draining on most pine swamps and open bogs is a clear upsurge in the growth of the so-called pine swamp dwarf shrubs *(Ledum palustre, Vaccinium uliginosum, Betula nana,* etc), which on oligotrophic sites is fairly permanent, but also on mediumly fertile sites often lasts for decades.

During the last few years researchers have started to pay more and more attention to the total production of biomass and its different compartments on differing types of site under different climatic conditions. Good examples of this trend are the recently completed IBP project and a number of studies presently being carried out in Finland. In the USSR, too, there are some quite comprehensive projects going on concerning the biomass production on different sites. Results concerning drained peatland stands have also been published (e.g. МЕДВЕДЕВА 1974, КАПУСТИНСКАЙТЕ 1976).

The growth pattern, height, age, root structure, etc. of individual species of dwarf shrubs have earlier been studied in Finland (e.g. Keso 1908, Metsävainio 1931). One of the authors of this article (Sarasto 1964) has earlier published a report about an investigation into the biomass and growth of dwarf shrub vegetation and the amount of bound nutrients on certain drained peatlands. The results showed that the woody material production by the above-ground parts of dwarf shrubs may exceed one solid cubic meter /ha/year which is approximately half the amount that a tree stand is capable of producing on a drained oligotrophic pine swamp.

Thus in many stands on drained areas the dwarf shrubs are rather important biomass produceres and are in competition with the tree stands for the available plant nutrients. However, it is not possible using the available data to estimate what effect the artificial removal of the dwarf shrub vegetation would have on the nutrient status of a drained peatland stand and on the development of the trees growing on it.

The aims of this study are to determine

— what is the effect of killing-off the dwarf shrub vegetation on the development of the trees growing on a drained area,
— does killing-off the dwarf shrub vegetation increase the growth reaction of the trees to fertilization,
— what is the effect of killing-off the dwarf shrub vegetation and/or fertilization on the amount of nutrients in the tree stand and the surface layer of the peat.

As it is intended to continue following the progress of the experiment for a number of years more, this report is only concerned with a part of the observations collected when the experiment has been inventoried.

Financial assistance from the Foundation for Research of National Resources in Finland received in 1966 and 1968 and from Kemira Oy in 1973 have made it possible to carry out this study. The fertilizers and herbicides used in the experiments were donated by Kemira Oy, Berner Oy and Gullviks Oy. Viljavuuspalvelu (a soil testing service) has carried out the soil and needle analyses refered to in the text.

2. EXPERIMENTAL FIELD AND THE EXPERIMENTS CARRIED OUT ON IT

21. The experimental field

It was decided while planning the study, that the most practical solution would be one in which the sample series were located in one area. Such an area would have to be rather extensive and the tree stand and dominant dwarf shrub vegetation as uniform as possible.

Of the various sites which the authors had visited while engaged in earlier studies, Rustari swamp situated near Jalasjärvi (62° 90' N, 22° 50' E) was selected as one possible site. The site was inspected in spring 1965 and an area about 10 ha in size was found to satisfy the experimental requirements. It was estimated that the original peatland vegetation corresponded to the dwarf shrub pine swamp type. The dwarf shrub vegetation throughout the experimental area was rather luxurious and uniform. In the center of the swamp, about 150 m from the edge of the experimental area, there was a completely overgrown ditch which had been dug during the Great Famine (1866—67). However, it may still have had some effect on the experimental area. Proper strip ditching was carried out during 1922—23. The condition of the ditch system during the course of the experiment was considered to be satisfactory, but its drainage efficiency as fair only since the average distance between the ditches along the strips is 160 m and across the strips 120 m.

22. Establishing the experiment

The aim of the experiment was to study the effect of killing-off the dwarf shrub vegetation and/or NPK fertilization on the development of the ground vegetation and middle-aged pine stand growing on the area and on the nutrient status of the swamp. For this purpose, 40 circular sample plots were systematically marked out throughout the experimental area. The distance between the center points on any two adjacent sample plots situated on the same strip was 40 m. The sample plots were randomly divided into the following four treatment groups:

- untreated (1)
- dwarf shrubs killed-off (2)
- NPK fertilization (3)
- dwarf shrubs killed-off + NPK fertilization (4)

Each treatment was thus replicated 10 times. The ground lay-out of the differently treated sample plots can be seen in Fig. 1. The total area treated in this way equals 0.1 ha. However, an area of only 0.08 ha was covered when the stand characteristics were measured.

Mechanical suppression of the dwarf shrub vegetation was tried out in SARASTO's previous study. Owing to its laboriousness, subsequent high costs and the short duration of the obtained effect, cutting back the dwarf shrub vegetation was not considered to be a practical possibility for this experiment. The suitability of ordinary commercially available herbicides for killing-off the dwarf shrub vegetation was investigated instead. Spraying was done twice because only incomplete killing-off of the dwarf was obtained after the first spraying.

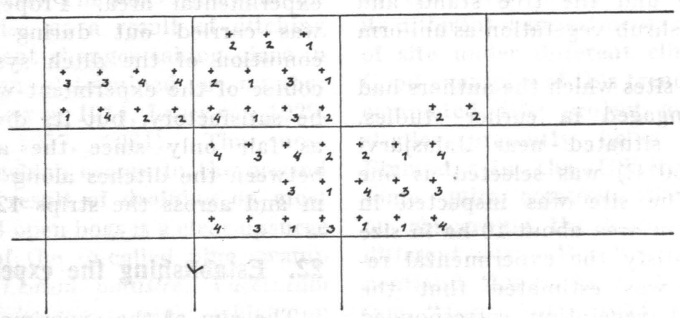

Fig. 1. The lay-out of the experiment.

Kuva 1. Koejärjestely.

In the first spraying, 5 l herbicide/ha of »Hormoslyr asp» was used on 10 of the sample plots (5 sample plots were randomly selected from treatment groups 2 and 4 each). The other 10 sample plots were treated with Berner alder-sprout herbicide (5 l herbicide/ha). In the second spraying, the former 10 sample plots were treated with Gramoxone (4 l herbicide/ha) and the latter with A 1467 (4 l/ha).

All the 20 fertilized sample plots received 500 kg/ha of NPK (14–18–10) fertilizer. The sample plots were marked out in the field during May 1966. The first herbicide spraying was carried out during 12–13. 8. 1966, fertilization during 14–15. 3. 1967, and the second spraying on 21. 7. 1967.

23. Inventorying the sample plots

The sample plot tree stands were measured for the first time in conjuction with the first herbicide spraying, that is the latter half of August 1966. The trees on the sample plots were tallied using 2-cm diameter classes by tree species. Every n:th tree with a diameter greater than the estimated mean diameter and every 2 × n:th tree with a diameter smaller than the mean were taken as sample trees. In cases where there were not enough sample trees in the largest diameter classes, 2–3 of the largest trees were then included as additional sample trees. The number of sample trees on each sample plot varied from 15 to 19.

The diameter at breast height and taper (both to an accuracy of 1 cm), tree height (to the nearest half meter), growth during the previous five year period (to the nearest decimeter) and the double bark thickness (to an accuracy of 1 mm) of the sample trees was measured. All the relevant measurements were taken along a line through the tree at right angles to the radius of the sample plot circle. The sample trees were numbered consecutively, the numbers being painted onto the bark of the trees.

The first measurements to determine the effect of the different treatments were carried out in autumn 1968, at the end of the second growing season after the treatments had been carried out. The annual height growth (to the nearest 5 cm, using binoculars) of the five sample trees belonging to the dominant tree class which were situated nearest to the center point of each sample plot was measured. The size of the cone crop on the same trees was estimated by eye.

In addition, one branch was taken from the upper part of the crown on the SE side of the sample tree nearest to the center of the sample plot.

Tree stand measurements were carried out for the second time on 20–23. 8. 1971, or five growing seasons after the treatments were carried out. The same tree characteristics on each sample plot as in the first measurement were determined. However, at this time the trees were tallied using 1-cm. diameter classes and the diameter of sample trees at breast height measured to an accuracy of 1 mm. In addition, at least 10 core samples (for annual ring measurements) were taken from each sample tree and stored ready to be measured in the laboratory. At the same time, the condition of each of the sample trees was estimated using the following scale:

a) completely healthy tree
b) slightly damaged (up to a quarter of the needles showing needle damage)
c) badly damaged (main shoot dead, more than a quarter of the needles showing needle damage)
d) dead tree.

New samples for needle analysis were also taken in autumn 1971 in the same way as described earlier. Six peat samples were taken at the same time from the 0–20 cm layer on each sample plot. The sampling points were distributed systematically with respect to the center point of each sample plot. The samples were subsequently kept in a deep freeze until they could be analysed.

Stand measurements were carried out for the third time on 30. 9–2. 10. 1976 using the same methods as in 1971.

3. RESULTS

31. General observations

Plant coverage analyses were made on the sample plots at the same time as the tree stand measurements were carried out in summer 1966. This was before the various treatments had been carried out. The following table shows the homogeneity of the dominant species on the sample plots. The first figure corresponds to the mean coverage for each of the plant species, and the second figure to the occurrence-% (frequency).

Table of the dominant species present on the experimental area before the start of the experiment

1 = control sample plots	(10)
2 = herbicide treated sample plots	(10)
3 = fertilized sample plots	(10)
4 = fertilized and herbicide treated sample plots	(10)
5 = all sample plots	(40)

It can be seen from the table that in addition to the plant species normally to be found in the field layer, i.e. the so-called dwarf shrubs, *Eriophorum vaginatum* and *Rubus chamaemorous* are also present. *Pleurozium schreberi*, *Polytrichum strictum* and *Sphagnum parvifolium* occurred rather uniformly throughout the bottom layer.

A quick inventory was carried out at

	Treatment				
	1	2	3	4	5
Andromeda polifolia	5 : 60	1 : 50	5 : 60	1 : 40	2 : 60
Betula nana	30 : 100	35 : 100	27 : 100	25 : 100	29 : 100
Calluna vulgaris	6 : 40	20 : 80	22 : 80	14 : 90	14 : 80
Empetrum nigrum	27 : 100	23 : 100	20 : 100	15 : 90	22 : 98
Ledum palustre	40 : 100	38 : 100	36 : 100	38 : 100	38 : 100
Vaccinium myrtillus	1 : 20	1 : 20	2 : 20	— —	△ : 8
V. oxycoccus	△ : 50	△ : 60	△ : 20	— —	△ : 30
V. uliginosum	11 : 40	1 : 10	8 : 50	1: 20	6 : 45
V. vitis-idaea	3 : 70	1 : 60	5 : 50	3 : 60	3 : 60
Rubus chamaemorus	32 : 100	4 : 60	36 : 90	15 : 90	20 : 85
Eriophorum vaginatum	14 : 100	15 : 100	15 : 100	17 : 90	15 : 86
Pleurozium Schreberi	35 : 100	35 9 0	12 : 90	28 : 100	29 : 98
Polytrichum strictum	2 : 80	8 : 70	21 : 80	16 : 80	10 : 78
Sphagnum parvifolium	31 : 80	26 : 90	26 : 100	25 : 90	27 : 90

the end of the first growing season after the first herbicide treatment. Over half of the dwarf shrubs were found to be dead. Following the second herbicide treatment, over 80 % of the dwarf shrubs had been killed-off. The results of plant coverage analyses carried out in 1968 are presented in the following table. The table shows the changes which have taken place in the coverage of the different species of dwarf shrub on the herbicide treated and herbicide fertilized sample plots.

	Decrease in the average coverage of the dwarf shrubs following herbicide treatment (2) and herbicide treatment/fertilization (4) by 1968	
	2, %	4, %
Betula nana	79	78
Calluna vulgaris	100	87
Empetrum nigrum	90	90
Ledum palustre	62	64
On an average	83	80

There did not appear to be any differences between the different types of herbicide used. The variations in the mortality rate of the dwarf shrubs seemed to be dependent on the original species composition of the dwarf shrub vegetation.

A visual estimate of the extent to which the dwarf shrub vegetation was killed-off was made at the same time as the second and third tree stand measurements. The results of this visual examination can be seen in the following table.

Treatment	Proportion of dwarf shrubs killed-off, %	
	year	
	1971	1976
Herbicide	66	61
Herbicide + NPK fertilization	77	75

Fertilization has to some extent increased the effect of killing-off the dwarf shrubs with herbicides. The effect of herbicide treatment seems to last quite a long time. It appears that only the *Betula nana* vegetation is now showing some signs of recovery. As far as the other dwarf shrubs are concerned, the situation has remained relatively unchanged during the second five year period. This is partly due to the fact that the plant species found in the surrounding areas, especially ***Rubus chamaemorus***, ***Eriophorum vaginatum*** and ***Vaccinium vitis-ideae***, rapidly take up a dominant position in the growing space vacated by the dwarf shrubs. In some parts, the places free of dwarf shrub vegetation have developed a dense undergrowth of naturally regenerated *Betula pubescens* saplings.

The herbicide treatment also had some undesired effects on the tree stands. The trees on the herbicide treated sample plots showed some temporary signs of damage. However, as can be seen from the following table, some individual trees even died.

Treatment	Volume of dead trees, m³ with bark/ha		
	Year		
	1966	1971	1976
Control	0.4	0.6	0.9
Herbicide	0.1	0.6	1.1
Fertilization	0.3	0.7	0.7
Herbicide + fertilization	0.1	1.2	1.3

The number of dead trees has increased on all the plots since the only cutting which has ever been made in the stand, a light thinning, was done at least ten years before the experiment was started.

Despite this fact, it is quite clear that although the number of dead trees on the untreated and fertilized sample plots has doubled during the last ten years, the number on the herbicide treated sample plots has increased almost ten-fold. Furthermore, the number of badly damaged trees (cf p. 33) has been the greatest on the herbicide treated sample plots, as is evident from the following table.

	Treatment			
	1	2	3	4
Damaged trees, as % of number of stems	4.5	7.8	4.1	6.3

The figures are based on the results of measurements made in 1971. When the trees were inspected immediately after the treatments had been carried out it was apparent that over half of the trees were suffering from some sort of needle damage. These signs, however, disappeared rather quickly.

32. Reaction of the tree stands

321. Initial observations

The tree stands were measured for the first time two growing seasons after the start of the experiment. The most important results of these measurements are shown in the following table.

	Treatment			
	1	2	3	4
Height growth in 1968, cm	6.9	7.0	8.7	8.1
Length of needles in 1968, mm	34.8	38.7	34.7	54.8
Cone crop, number of cones/tree	7.2	8.1	8.4	9.1

A paired t-test was used to determine the statistical significane of the differences between the various parameters measured. Both NPK fertilization and herbicide/NPK fertilization have clearly increased the height growth of the trees and the length of the needles. There were no such differences between the trees on the untreated sample plots and those on the ones treated with herbicides. The size of the cone crops on the sample plots treated with the herbicide/fertilization combination were greater (at the 5 % risk level) than those on the untreated sample plots.

The various treatments have also clearly had an effect on the nutrient contents of the needles, as can be seen from the following table.

	Treatment			
	1	2	3	4
Nitrogen content of needles, %	1.08	1.17	1.35	1.45
Phosphorous content » %	0.104	0.108	0.158	0.163
Potassium content » %	0.371	0.500	0.548	0.531
Calcium content » %	0.146	0.153	0.179	0.173

Herbicide treatment alone has increased the nitrogen and potassium content of the needles. NPK fertilization alone, and combined with herbicide spraying, has increased the amounts of all four macro-nutrients in the needles in comparison to both the untreated and herbicide treated sample plots. The contents of various trace elements (Mg, Cu, Mn, Fe and Zn) in the needles was also determined. There were no significant differences, as regards the contents of these nutrients, between the different treatments.

The results of the analyses carried out on the needles collected in 1971 are as follows:

	Treatment 1	2	3	4
Nitrogen content of needles, %	1.21	1.28	1.19	1.29
Phosphorous content of the needles, %	0.103	0.103	0.122	0.128
Calcium content » » » %	0.210	0.212	0.237	0.217

Owing to a mistake made in the soil analysis laboratory, no results were obtained for the potassium contents. It is clear that the initial differences in the nutrient contents between treatments have almost disappeared after five growing seasons: only the phosphorous content of the needles from the fertilized and herbicide treated sample plots are significantly greater (at the 5 % risk level) than those from the untreated plots.

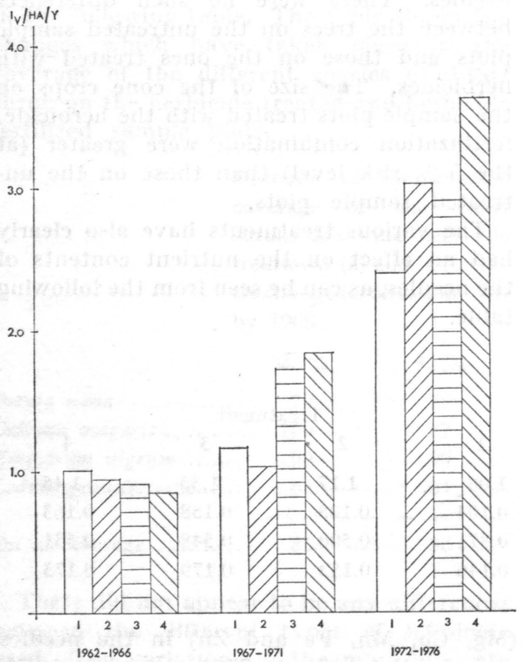

Fig. 2. The current annual volume growth of the tree stands during the years 1962–66, 1967–71, and 1972–1976.

Kuva 2. Koealametsiköiden juokseva vuotuinen kuutiokasvu vv. 1962–66, 1967–71 ja 1972–76.

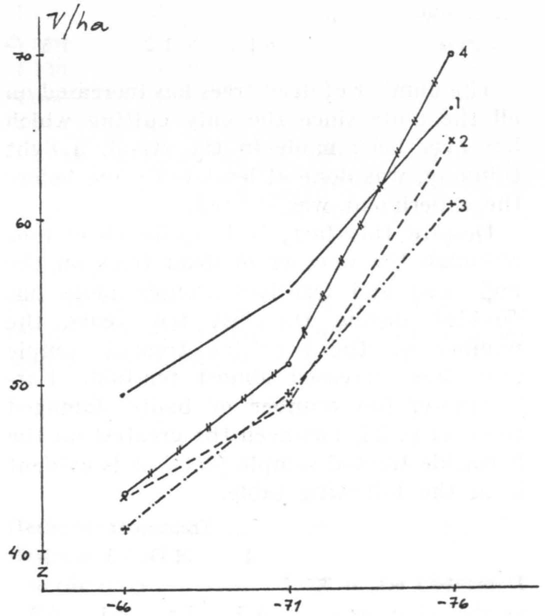

Fig. 3. The development of stand volumes from 1966 to 1976.

Kuva 3. Koealametsiköiden kuutiomäärän kehitys vuodesta 1966 vuoteen 1976.

322. Development of the stands throughout the experiment

The current annual volume growth of the tree stands on the sample plots during the five year period before and the two five year periods following the start of the experiment are shown in Fig. 2.

The volume with bark of the living trees on the different sample plots at the start of the experiment and at the end of the following two five year periods are shown in Fig. 3.

Growth of the stands on all the treated sample plots, as well as on the untreated ones, has shown an increasing trend especially during the second five year period after the experiment was started. This is obviously partly due to the development stage at which the stands were in at the time of the experiment, and partly due to the favourable effect of the warm and dry summers during this five year period.

Despite the fact that the herbicide treatment caused the greatest damage on the herbicide/fertilizer sample plots, the volume growth of the stands on these sample plots during the first five year period was greater than that of any of the other plots, although the absolute differences are only small. In addition, growth of the tree stands on the NPK fertilized sample plots is greater than that on the untreated plots. On the other hand, the negative effects caused by herbicide treatment alone during the first few years have hidden the positive effects of killing-off the dwarf shrub vegetation during the first five year period. The tree growth on the sprayed sample plots has hence been slightly less than that on the untreated sample plots.

The positive effect, as far as tree growth is concerned, of the killing-off of the dwarf shrub vegetation becomes clearly apparent during the second five year period after the start of the experiment. At that time, tree growth on the herbicide/fertilized sample plots is more than one cubic meter without bark/year/ha, on the herbicide treated plots 0.7 m^3/ha/yr and on the fertilized plots 0.5 m^3/ha/yr greater than that on the untreated sample plots.

The results shown in Fig. 3 substantiate this statement. The volume of the stands on the plots treated only with herbicide are smaller during the first five years after the start of the experiment than that on the fertilized ones, despite the fact that the situation at the start of the experiment was quite the opposite and was again so in 1976. In this study, the herbicide/fertilizer combination was found to have the greatest positive effect on the subsequent development of the tree stands.

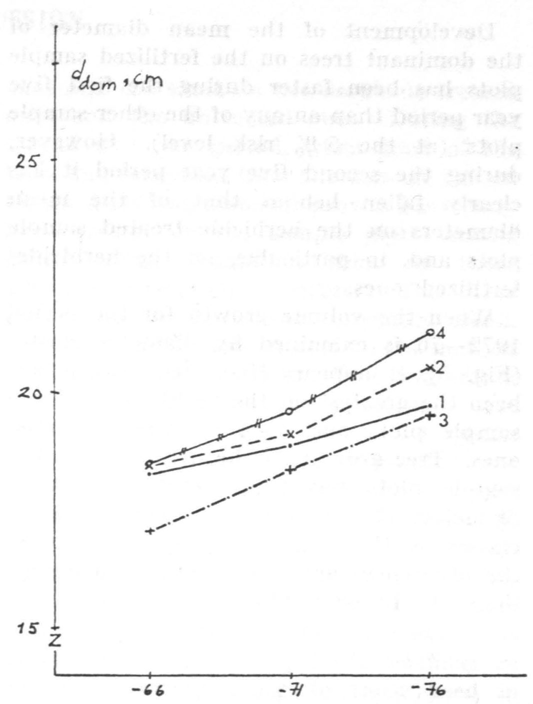

Fig. 4. The development of the mean diameter of the dominant trees from 1966 to 1976.

Kuva 4. Valtapuiden läpimitan kehitys vuodesta 1966 vuoteen 1976.

The volume of the trees on the untreated sample plots has right from the start been greater than that of the other sample plots because they are located in a more favourable position, as regards the position of the ditches, than the other sample plots (cf. Fig. 1, p. 32).

The development of the mean diameter of the dominant trees on the different sample plots (diameter at breast height of the 100 thickest trees/ha) during the period 1966–76 can be seen in Fig. 4. The increase in the mean diameter is also shown in the following table.

	Treatment 1	2	3	4
	Mean diameter growth, mm/5 yrs.			
In years 1966–71	6.2	6.5	13.2	11.1
In years 1972–76	8.7	14.5	11.5	17.1

Development of the mean diameter of the dominant trees on the fertilized sample plots has been faster during the first five year period than on any of the other sample plots (at the 5 % risk level). However, during the second five year period it has clearly fallen behind that of the mean diameters on the herbicide treated sample plots and, in particular, on the herbicide/fertilized ones.

When the volume growth for the period 1972—76 is examined by diameter classes (Fig. 5), it appears that tree growth has been the greatest on the herbicide/fertilized sample plots and least on the untreated ones. Tree growth on the herbicide treated sample plots has been greater in many diameter classes than in corresponding classes on the fertilized ones, even though the differences are rather small and exceptions are to be found.

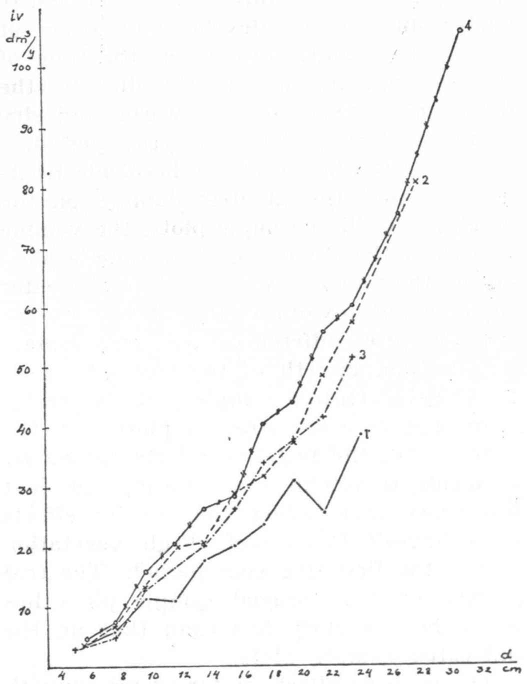

Fig. 5. The volume growth of the sample trees by diameter classes for the period 1972—76.

Kuva 5. Koepuiden kuutiokasvu viisivuotiskautena 1972—76 läpimittaluokittain tarkasteltuna.

33. Effect of the treatments on the nutrient content of the surface peat

Five growing seasons after the start of the experiment, peat samples were taken from the surface peat down to a depth of 20 cm. Prior to analysis, the samples were milled and the samples taken from the different layers mixed separately. Each sample was analysed separately but during statistical analysis the means of the results were calculated for each sample plot.

The amounts of different macro-nutrients in the surface peat are as follows:

	Treatment			
	1	2	3	4
	% of dry weight			
Nitrogen	1.55	1.60	1.58	1.62
Phosphorous	0.0735	0.0752	0.0799	0.0804
Potassium	0.0623	0.0577	0.0584	0.0504
Calcium	0.213	0.213	0.222	0.240

The amount of phosphorous on the fertilized plots is slightly greater than on the unfertilized ones (differences significant at the 5 % risk level). On the other hand, the amount of potassium is the smallest on the herbicide/fertilized sample plots and greatest no the untreated ones. There were no longer any significant differences between the amounts of nitrogen and calcium five years after the start of the experiment. The decrease in the potassium content is presumably caused by the increased vitality of the treated stands (formation of new plant tissue, increase in the cone crop, etc.) and the increased leaching caused by destruction of the ground vegetation (cf. Kormondy 1969, pp. 70—71).

4. DISCUSSION

The position held by dwarf shrubs in the ecosystems of drained peatlands, especially pine swamps and open bogs, is rather noticeable both as a component of the vegetation and as nutrient consumers. Using the results of Sarasto's (1964) study as a basis, it is evident that biomass production by dwarf shrubs on dwarf shrub dominated pine swamps may be as high as one quarter, even almost one third, of the total biomass production. Капустинскайте (1976) and Ouni (1977) have obtained almost the same results. An attempt has been made in this study to determine whether it is possible, by killing-off the dwarf shrub vegetation and thus eliminating its competition, to transfer some part of the freed growth potential to the tree stand. Sarasto's earlier experiments (mentioned earlier) have shown that mechanical suppression of the dwarf shrub vegetation has only a short term effect: already by the end of the third growing season after treatment the biomass of the dwarf shrub vegetation is almost the same as before. Herbicide treatment has thus been used in this experiment to kill-off the dwarf shrub vegetation.

After two herbicide treatments, more than three quarters of the dwarf shrubs had been killed-off and on some sample plots almost complete killing-off was achieved. However, the herbicide treatment had some undesirable effects on the trees: the trees on almost all the sample plots treated with herbicide suffered from needle damage, the leaders of some trees died, and in individual cases the whole tree was killed. The damage was restricted primarily to the dominant trees. This has obviously meant that the favourable effect of the killing-off of the dwarf shrub vegetation on the tree stand is eliminated during the first five year period after the herbicide treatment was carried out. For example, the diameter growth of the dominant trees during the five year period following treatment is fastest on the NPK fertilized sample plots, slightly less on the herbicide/fertilized ones and the same on the herbicide treated ones and the untreated ones. During the second five year period, when most of the trees had recovered from the damage caused by the herbicide, diameter growth has clearly been greater on the sample plots lacking dwarf shrub vegetation than on those which received only fertilizer. The other growth characteristics show a similar trend.

Even if the damage caused by the method used to kill-off the dwarf shrub vegetation is not taken into account at all, it is still clear that by eliminating dwarf shrub competition on dwarf shrub dominated pine swamps, quite a large part of the freed growth potential passes to the trees. In this experiment, killing-off the dwarf shrub vegetation has meant that during the first ten year period the growth of the tree stand has increased to the same extent as is obtained when using NPK fertilizer in amounts corresponding to those used in normal forest fertilization. In addition, it appears that the change which takes place in the growth conditions lasts for a long time since the biomass of the living dwarf shrubs on the herbicide treated sample plots remained almost constant throughout the second five year period. The plant species which have taken over the growing sites vacated by the dwarf shrubs, in this case especially *Eriophorum vaginatum* and *Rubus chamaemorous*, are not presumably able to compete so successfully with the trees for nutrients as the dwarf shrubs are.

However, it should not be considered that the authors would recommend the use of herbicides instead of, or as a supplement to, fertilization on a drained pine swamp area. The experiment does show though, that biomass production by the different components in an ecosystem can be to some extent regulated. If it would be possible to find some way of reducing the competitivity of dwarf shrub vegetation without having any adverse effects on other vegetation or the environment, then it would obviously mean an improvement in the productivity of the tree stand.

REFERENCES

KESO, A. 1908. Über Alter und Wachstumsverhältnisse der Reiser in Tavastland. Acta soc. pro Fauna et Flora Fenn. 31. Helsinki.

KORMONDY, E. J. 1969. Concept of Ecology. Prentice-Hall, Inc. Englewood Cliffs. New Jersey.

LUKKALA, O. J. 1929. Tutkimuksia soiden metsätaloudellisesta ojituskelpoisuudesta erityisesti kuivatuksen tehokkuutta silmälläpitäen. Referat: Untersuchungen über die waldwirtschaftliche Entwässerungsfähigkeit der Moore mit besonderer Rücksicht auf den Trocknungseffekt. Comm. Inst. Forest. Fenn. 15.1.

— » — 1951. Kokemuksia Jaakkoinsuon koeojitusalueelta. Summary: Experiences from Jaakkoinsuo Experimental Drainage Area. Comm. Inst. Forest. Fenn. 39.6.

METSÄVAINIO, K. 1931. Untersuchungen über das Wurzelsystem der Moorpflanzen. Selostus: Tutkimuksia suokasvien juuristoista. Ann. Bot. Soc. Vanamo. 1.1.

OUNI, K. 1977. Kasvibiomassan ja sen vuotuisen tuotoksen määrä ja jakaantuminen luonnontilaisella ja ojitetulla varsinaisella saranevalla. Manuscript at the Department of Silviculture in Helsinki University.

SARASTO, J. 1957. Metsän kasvattamiseksi ojitettujen soiden aluskasvillisuuden rakenteesta ja kehityksestä Suomen eteläpuoliskossa. Referat: Über Struktur und Entwicklung der Bodenvegetation auf für Walderziehung entwässerten Mooren in der südlichen Hälfte Finnlands. Acta Forest. Fenn. 65.7.

1961. Über die Klassifizierung der für Walderziehung entwässerten Moore. Selostus: Metsän kasvattamiseksi ojitettujen soiden luokittelusta. Acta Forest. Fenn. 74.5.

— » — 1964. Tutkimuksia ojitettujen soiden varvustosta ja sen vaikutuksesta männyn kylvöihin. Suo. 4.

TANTTU, A. 1915. Tutkimuksia ojitettujen soiden metsittymisestä. Acta Forest. Fenn. 5.2.

Капустинскайте, Т. К. 1976. Продуктивные лесные фитоценосы на торфяных почвах. Лесное Хозяйство 11, 1976.

Медведева, В. М. 1974. Фитомасса сосновых заболоченных лесов различного возраста в подзоне средней тайги Карелии. В сборнике »Пути изучения и освоения болот северозапада Европейской части СССР». Издательство »Наука». Ленинград.

SELOSTE:

ISOJEN VARPUJEN HÄVITTÄMISEN VAIKUTUS RÄMEMÄNNIKÖN KEHITYKSEEN

Esitellyn kokeen tarkoituksena on ollut selvittää, miten varvikon hävittäminen vaikuttaa ojitetulla isovarpuisella rämeellä kasvavan männikön kehitykseen.

Varvikko on kokeessa hävitetty kaupan olevia tekohormonivalmisteita käyttäen. Vertailtavana metsänparannustoimena on kokeeseen sisällytetty myös NPK-lannoitus (14—18—10) 500 kg/ha annoksena.

Koe sijaitsee Jalasjärven kunnassa Rustarin valtionpuistossa runsaat 40 vuotta ennen kokeen aloittamista ojitetulla isovarpuisella rämeellä. Se käsittää 40 ympyräkoealaa, joilta puustot on mitattu 8 aarin mutta käsittelyt tehty 10 aarin alalla. Kokeessa neljännes koealoista jätettiin vertailuiksi, neljännekseltä hävitettiin varvut, neljännes lannoitettiin ja yhdellä neljänneksellä tehtiin molemmat käsittelyt. Varvustoruiskutus tapahtui ensi kerran elokuussa 1966 ja se uusittiin heinäkuussa 1967, lannoitukset suoritettiin keväällä 1967 ennen kasvukauden alkua.

Varpujen hävittäminen onnistui sinänsä varsin hyvin. Kasvukauden lopussa 1967 elävien varpujen osuudeksi arvioitiin yksi viidennes alkuperäisestä määrästä. Käsittelyllä on myös pitkä vaikutusaika; kymmenen vuotta kokeen perustamisen jälkeen tuhoutumisprosentiksi arvioitiin vielä 70. Samalla aiheutettiin ensimmäisinä käsittelyiden jälkeisinä vuosina kuitenkin myös puille neulasvaurioita, kasvainten ja jopa koko puun kuolemia, jotka ovat sekoittamassa kokeessa saatuja tuloksia. Koe on inventoitu useita kertoja, viimeksi lokakuussa 1976.

Eri tavoin käsiteltyjen koealametsiköiden juoksevan vuotuisen kuutiokasvun luvut koetta edeltäneenä ja kahtena sen jälkeisenä viisivuotiskautena esitetään kuvassa 2, kuutiomäärän kehitys kokeen aikana kuvassa 3 ja valtaläpimitan kehitys kuvassa 4.

Ensimmäisellä käsittelyjen jälkeisellä viisivuotiskaudella lannoitettujen koejäsenten puuston kasvu on ollut selvästi parempi kuin lannoittamattomien. Syntyneiden puuston vaurioiden vuoksi pelkästään tekohormonikäsittelyn saaneiden metsiköiden kasvu on jäänyt käsittelemättömien tasolle. Vaurioiden mentyä pääosin ohi puuston kasvuluvut nousevat korkeimmiksi sekä tekohormonikäsittelyn että lannoituksen saaneilla koealoilla samalla kun tekohormonikäsitellyt koejäsenet nousevat kasvussaan lannoitettujen tasolle, jopa hieman ohikin (kuvat 3 ja 5).

Välittömästi käsittelyitä seuranneella kasvukaudella neulasten makroravinteiden pitoisuudet kasvoivat (asetelma s. 35). Muutokset menivät pääosin ohi varsin nopeasti. Viiden kasvukauden jälkeen eri käsittelyiden väliset erot sekä neulasten (asetelma s. 36) että pintamaan (asetelma s. 38) makroravinteiden pitoisuuksissa olivat vähäisiä.

Kokeen seuraamista on tarkoitus vielä jatkaa. Tähänastiset tulokset osoittavat että eliminoimalla ojitetulla rämeellä isojen varpujen kilpailu saadaan ainakin osa niiden sitomasta kasvupotentiaalista siirtymään puiden käyttöön.