

METSÄNTUTKIMUSLAITOKSEN  
TIEDONANTOJA 53

SUONTUTKIMUSOSASTO



FINNISH FOREST RESEARCH  
INSTITUTE  
Department of Peatland Forestry



HELSINKI 1982

*Cover: Vilppula, Jaakkoinsuo Experimental Area.  
Photo 1.2.1959 by Kimmo Paarlahi*

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## FOREWORD

When the Finnish Forest Research Institute was established in 1917, the statute carried no mention of peatland forestry. The research in this field did not start until 1928 when also the professorship of peatland forestry was established. That same year O.J. Lukkala, Ph.D., was appointed to the office. He acted as department chief of peatland forestry till 1958.

Under Prof. Lukkala's supervision a wide network of permanent experimental plots was set up in different parts of Finland. The task was to obtain information on the relationship between post-drainage growth in peatland forests and site type, draining efficiency, quality of tree stand and other related factors. The results from these experiments formed the basis for the classification of peatlands for forestry. A large number of experiments was set up to study the regeneration and growing of peatland forests. The first peatland liming experiments were started in 1929, ash fertilization experiments in 1937 and experiments using commercial fertilizers in 1946. Prof. Lukkala published the first textbook of peatland forestry and several research reports.

Olavi Huikari, Dr. For., became the second chief of peatland department in 1958. Prof. Huikari held the office till 1980, after which he became director of the Forest Research Institute. Under his leadership the research and experimental activity expanded and diversified greatly and the staff grew at the department. Prof. Huikari had an important role in the mechanization of forest drainage, the development of extensive fertilization experimentation in practice and in starting experimental activity in forest ecology which elucidates the principles of peatland forestry. He also developed a peatland classification for practical purposes and was active in spreading information of research results of peatland forestry with his numerous publications and excursions. Prof. Huikari paid special attention to developing international relationships in the field of peatland forestry.

Prof. Eero Paavilainen, Dr. For., has been the third chief since 1980.

## ORGANIZATION

By the beginning of the 1980s the central functions of peatland forestry at the Forest Research Institute became well-established in the following research branches and projects (Fig. 1). At least one senior researcher works in each specialized field and a number of researchers work either in the main research unit in Helsinki or in provincial research stations (Fig. 2). Research objects have increased in number, especially since the late 1970s when the expertise of the Peatland Forestry Department has been required in various projects.

In the traditional field of peatland forestry the importance of experiments and research into the classification of old drainage areas, silviculture, ditch cleaning and fertilization are continually growing. The projects are mainly focused on afforestation and coppice investigations associated with energy use of wood, on experiments to find the causes for growth disturbances and their prevention and on investigations dealing with the effect of forest improvement on by-products such as berry and mushroom crops.

The peatland forestry staff in the main research unit at the Forest Research Institute and the research stations numbered on 1st January, 1982:

Professor

Senior research specialists: Helsinki 1, Stations 1

Researchers: Helsinki 10, Stations 9

Forest technicians and foremen: Helsinki 3, Stations 5

Other staff members: Helsinki 18

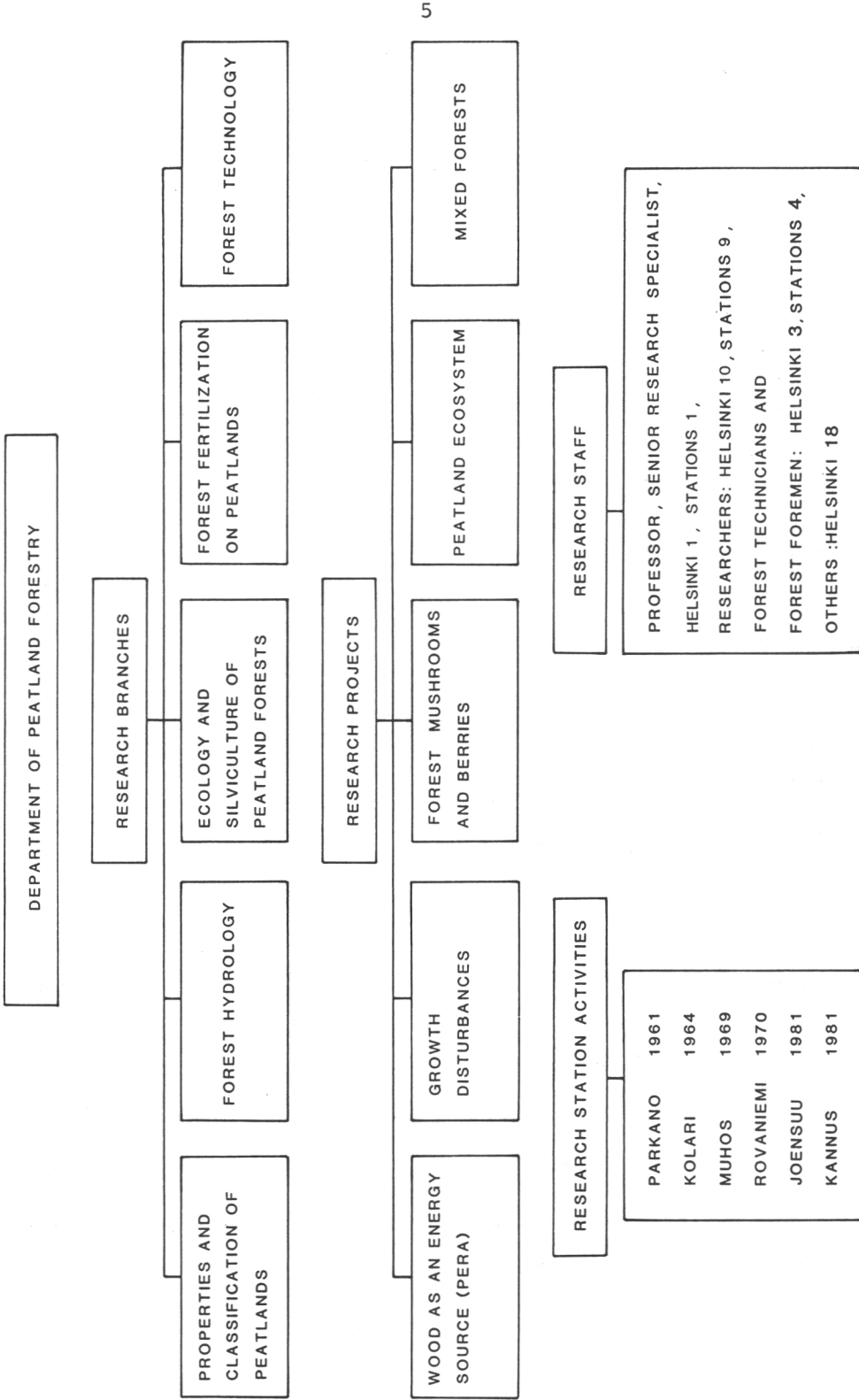


Fig. 1. Organization at the Department of Peatland Forestry.

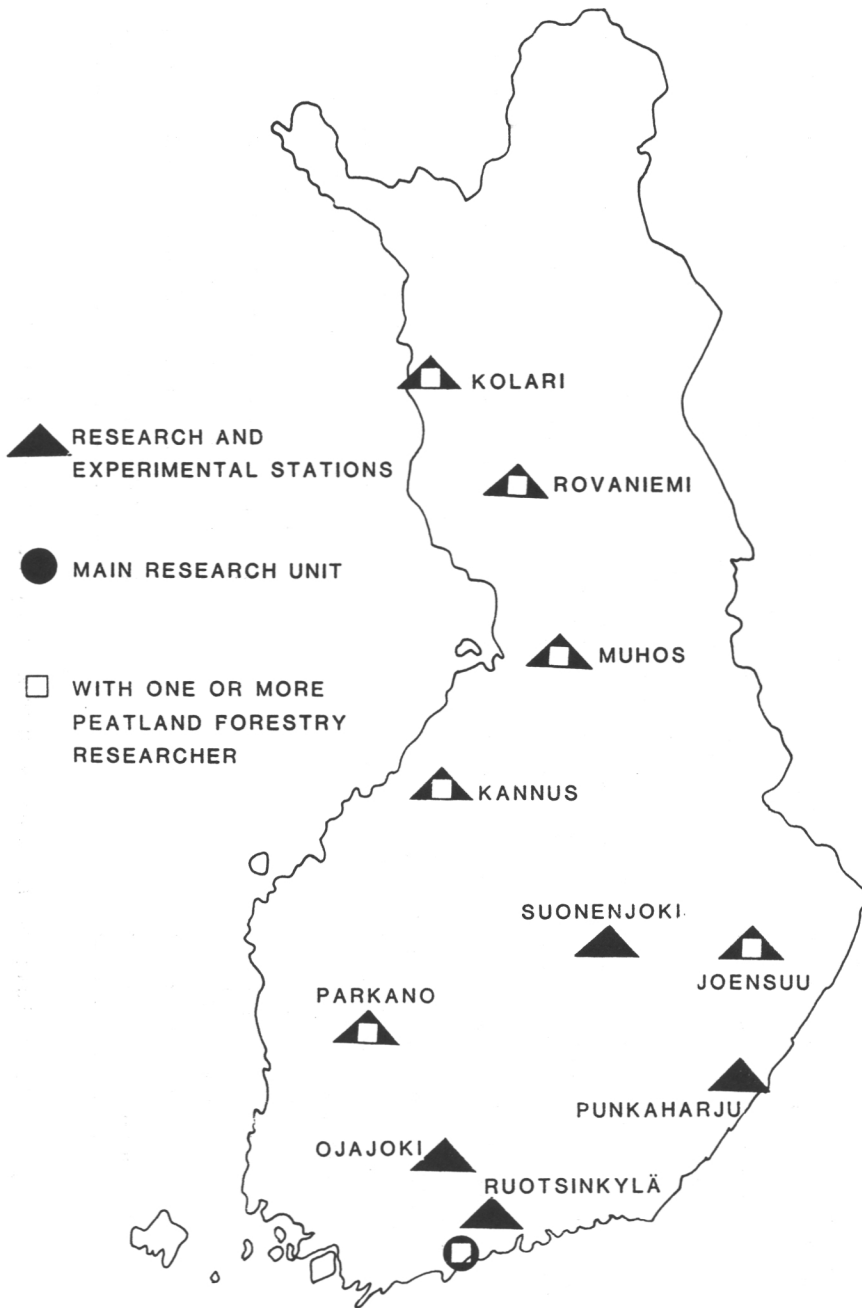


Fig. 2. Research units of Peatland Forestry Department of the Finnish Forest Research Institute.

## RESEARCH BRANCHES

### PROPERTIES AND CLASSIFICATION OF PEATLANDS

#### Peat properties

The research field is divided into chemomicrobiological and physicohydrological parts. The microbiological research aims at obtaining information to increase the possibilities of using natural nutrient reserves of peat, especially nitrogen, for growing forests. An intensified utilization of natural nutrient reserves either by improving drainage or by applying missing nutrients may lead to a situation where the focus could be shifted on more profitable and long-affecting measures. A further aim is to find out how different nutrient applications affect the microbial body and how the microbial body influences the conversion of fertilizer nutrients in soil. Changes in the microbial body may explain the observed differences of fertilization effect, thus helping to assess the suitability of different fertilizers for peatland forests.

The purpose is to intensify the research of the chemical properties of peat as soon as the department and the main laboratory of the Institute receive new research facilities.

The physicohydrological research aims at obtaining information of peat subsidence caused by drainage and consequent changes in water regime. The research into the physical properties of peat helps understand the changes in the substrate caused by drainage. Not until the basic processes are well-known can we undertake measures to eliminate harmful phenomena.

### Peatland classification

The primary goal of the classification is to determine the forest productivity of both virgin and ameliorated peatlands. The classification of the complex peatland habitat requires more diagnosis and prognosis than the more stable mineral soils. The task of peatland forestry is to keep the peatland classification, and especially that of ameliorated peatlands, in those respects up to date.

The classification standard of virgin peatlands can be considered adequate enough for forestry. The effects of drainage and fertilization on classification criteria have not been sufficiently followed up. The present classification which is applied to all peatlands and peatland forests is not well applicable to old forest improvement areas. Consequently the site type classification of drained and heathy peatlands has become the central problem in peatland forestry.

As representative sampling of old forest improvement areas as possible is to be collected in 1982-83, to include all the parameters that have been proved useful for the fertility classification and growth factor diagnosis of peat soils. The permanent experimental plots established by the Departments of Peatland Forestry at the Forest Research Institute and the University of Helsinki will form the frame of these studies. A site type classification with 4-6 fertility classes is aimed at drained and heathy peatlands by means of the material consisting of vegetational descriptions, nutrient analyses of peat and needles and characteristics of tree stands. Additional definitions will denote the growth factors that impair productivity but which can be eliminated.

### Determination of fertilization and drainage need

Fertilization of peatland forests is an extensive activity requiring high investments. Yet, incorrect fertilization may lead to nutritional imbalance and even harmful growth disturbances, etc., in which case the investments may be wasted.

The need for the first fertilization can be reliably enough determined by peatland site types, but it has proved useful to employ additional methods to define refertilization need. Such would be the visual observation of nutrient deficiency symptoms, which to an expert interpreter would reveal much about nutrient deficiencies i.e. fertilization need. A preciser notion of fertilization need is provided by chemical foliar analyses, although sufficient fundamental knowledge exists only for pine (Pinus sylvestris). The most important and urgent task would therefore be to obtain basic information on foliar analyses for spruce (Picea abies) and possibly also birches.

Various photographing methods such as aerial photography by using different film materials and interpretation methods, and possibly also remote sensing will provide means to determine the need for drainage (excess soil moisture) and fertilization. The research into the application and technique of these methods has only barely started, which means that plenty of follow-up and research work is still needed.

#### FOREST HYDROLOGY

The forest hydrology research aims at finding out the effect of forest drainage on runoff, that of forest drainage and fertilization on water regime, at investigating runoff regulation and the hydrological effect of supplementary drainage and ditch cleaning.

The effect of forest drainage and fertilization on runoff and water quality is studied with experiments involving different ditch spacings. An investigation dealing with the effects of drainage on runoff is near its completion. The water quality investigations will involve the calibration and

fertilization (1983-84) of eleven experiments set up on land owned by the State Board of Forestry. The fertilizers under study are urea and PK fertilizer for peatlands.

Possibilities to regulate runoff and its effect on the growth of tree stands are investigated in three experimental areas and in association with the project involving runoff, the growth of wild berries and the habitat of game animals on normal and regulated ditch networks.

An investigation concerned with the effects of supplementary drainage and ditch cleaning is being planned. The investigation will be a collaboration with the National Board of Waters and the State Board of Forestry. The purpose is to set up an experiment in 1982 to collect information on the hydrological characteristics of ditch cleaning and control areas. In addition to old ditch cleaning areas (owned by the State Board of Forestry) will be inventoried to find out how the growth of tree stands and water regime have been influenced by this maintaining measure.

#### ECOLOGY AND SILVICULTURE OF PEATLAND FORESTS

##### Basic ecological research

Special experiments dealing with the ecology of peatland forests have been established in Vilppula ( $62^{\circ}3'N$ ,  $24^{\circ}34'E$ ) and Rovaniemi ( $66^{\circ}27'N$ ,  $26^{\circ}50'E$ ) in 1960-61. The following growth factors have been artificially regulated: ground water level, soil temperature and nutrient status of soil. In both these areas experiments have been set up both on pine- and spruce-dominant peatlands. The regulated growth factors have been surveyed through different measurements and their effect on the annual growth rhythm of trees, total growth, number and penetration of roots, microbiology and nutrient status of soil, etc. The results have been published in several reports.



Later the Department of Peatland Forestry, mainly in the Lammi Biological Station of the University of Helsinki, has participated in the diverse investigations of the peatland ecosystem dealing with microbiology and fauna of soil, flora, energy flows, etc. Several reports have been published.

Naturally, different ecological observations and measurements are carried out in association with the other investigations by the Department of Peatland Forestry.

#### Establishment of stands and silviculture of young stands on peatlands

Up till the beginning of the 1960s experiments were set up mainly to investigate the natural regeneration of peatland forests. Subsequently, in the 1960s and 70s the chief research capacity was directed to investigating the afforestation problems of open peatlands. The regeneration of tree-growing peatlands became again a research topic in the 1970s when the so-called high productivity experiments and other regeneration experiments on tree-growing peatlands were set up to serve practical forestry. After great increase in fuel peat production in the mid 1970s, the research was also focused on the afforestation of peat cut-away areas.

Presently there is enough knowledge of afforestation experiments on open peatlands and numerous reports have been published. It is the refertilization that creates problems chiefly in seedling stands on open peatlands. However, enough refertilization experiments of seedling stands already exist, representing different peatland site types and nutrient combinations. The task is to collect and analyze more material, although several reports have already been published.

Most of the experiments dealing with the afforestation of peat cut-away areas are only a few years old although some

experiments were established already in the mid 1960s. The new experiments are concerned with the quality of the site (peat nutrients, esp. nitrogen, pH, the quality and proximity of subsoil, use of subsoil), drainage, tree species, fertilization, site preparation, growing trees for either timber, pulpwood or energy wood, afforestation methods and density. Only one experiment of this type was established before the 1970s. The experimental activity has, however, increased a good deal in the last few years. In 1979 and thereafter five experiments dealing with the conventional wood production and a few experiments with energy wood production have been set up, and five more will be completed in 1982 occupying a. 30 ha in all.

The regeneration experiments on tree-growing peatlands deal with both natural and artificial regeneration. In natural regeneration experiments the focus is on site type, tree species, drainage, felling method (seeding felling, nurse tree cutting, clear cutting), site preparation, treatment of nurse crop, and in artificial regeneration on site type, tree species, drainage, site preparation, need for nurse crop, afforestation methods, seedling type and density.

A long-term aim is to create a network of experiments dealing with the regeneration of tree-growing peatlands in the whole southern Finland. Other aims include the compilation of instructions for the refertilization of young stands on open peatlands, afforestation of peat cut-away areas and reforestation of both spruce growing peatlands and heathy peatlands.

#### Growth, treatment and follow-up of peatland forests

Forests are drained in order to improve their growing conditions. As drainage on the one hand is an economic investment but on the other hand an activity that greatly changes the

ecosystem, it is necessary to study the growth of stands and changes in the ecosystems and such relating factors as the importance of the peatland type, climatic factors, draining efficiency, tree species, tending of forests, etc.

Ever since the start of draining activity, experimental draining areas and follow-up plots to investigate the above-mentioned factors have been established first by the State Board of Forestry and then by the Forest Research Institute. The oldest experiments are over 70 years old and the follow-up plots number several hundreds. A large number of the experimental plots have reached the stage of heathy peatland and the second tree generation after drainage is already growing on a number of plots. Thus draining activity has been furnished with a scientific foundation of changes and their causal factors.

Changes caused by drainage take place in the course of tens of years and a completely stabilized situation is hardly attainable because of the changes in the composition of tree stands and water regime of the soil (changes in ditch condition, etc.). To follow the progress of drainage areas can, therefore, be considered an unending research project.

#### FOREST FERTILIZATION ON PEATLANDS

Special attention in the forest fertilization investigations by the Department of Peatland Forestry is paid to the clarification of the biological principles of fertilization. The most important research topics are the nutrient cycle, nutritional balance of trees and methods for determining fertilization requirements. The development of the analytical methods based on foliar analysis is closely related to these topics and in the future the application of nutrient physiological methods to the investigations. One of the main fields of research at this department is to investigate the factors leading to growth increment after fertilizer application.

Plenty of knowledge has accumulated about the growth responses of pine to fertilization. Currently material is being gathered of how spruce and birch and mixed tree stands respond to fertilization. A new topic dealing with the effect of fertilization on the growth of tree species used in energy wood production has emerged.

Nitrogen and phosphorus fertilizers have been investigated most thoroughly, which is the reason for shifting the focus of research on the role of the other main nutrients and micro-nutrients, in particular. Reasonably good basic knowledge already exists on the effect of fertilizer rates and timing, but the new fertilizers such as wood ash still require further studies. Frequent fertilizer applications i.e. refertilizations are being investigated. In order to compile recommendations for practical forest fertilization, the resources for tackling the problems of refertilization should be increased in the immediate future.

The use of mensurational characteristics of tree stands as predicting the fertilization response is included in the programme of peatland forestry, as well as the distribution of growth increment to different parts of trees (investigations of nutrient cycle) and the investigations dealing with the relationships between fertilization and other silvicultural measures such as natural and artificial regeneration, afforestation, and thinnings.

A fairly extensive research project dealing with the spreading techniques of fertilizers has been completed. Research into the environmental effects is focused on the effect of fertilization on water quality, the project of which is being continued in co-operation with e.g. the National Board of Waters. The effect of fertilization on forest by-products, such as berries and mushrooms, is being investigated by a researcher specialized in the multiple use of forests in the Joensuu station. The prof-

itability of fertilization is investigated by the Department of Forestry Business Economics by utilizing the sample material of Peatland Forestry Department and taking into consideration the research requirements set by this department.

#### FOREST TECHNOLOGY

Investigations on forest improvement techniques belong to the wood productional section of the work studies of the Forest Research Institute. Investigations on the basis of payment, e.g. in practical drainage work, have made it possible to go from contract competition to recommended wages prenegotiated by labour market parties.

The investigations aimed at improving the techniques of forest drainage deal with different rotary ditchers, tractor diggers and excavators, draining plows and combined machines.

The focus has shifted from new drainage on maintaining old drainage areas. The investigations on open ditches will be accompanied by those dealing with the use and machinery of covered drains.

The investigations of fertilizer spreading methods have involved different manual spreading methods, mechanical and particularly aerial spreading. Also the follow-up methods of spreading evenness and distance have been developed for research and practical purposes.

The investigations of forest lorry roads have dealt with stabilization, strengthening of the base with fibre materials, the use of crushed moraine, developing measuring methods of bearing capacity and different constructions and dimensioning of culverts.

## PEATLAND FOREST RESEARCH IN NORTHERN FINLAND

Since the 1930s the Department of Peatland Forestry has investigated the forestry use of peatlands in Lapland, at first in the experimental forest of Kivalo in the rural commune of Rovaniemi. Subsequently the activity has spread almost over the entire forest-growing Lapland.

The following research problems are worth mentioning: The growth of tree stands on different peatland site types as affected by drainage, reforestation of stands and site preparation, fertilization of shelterwood, ditch spacing and the hydrological effects of drainage. Ecological experiments on peatland study the importance of the ground water table, air and soil temperatures and other growth factors. Energy wood investigations have also been set up in Lapland.

In the next few years the purpose is to obtain information of growth increment brought on by refertilization and the effect of ditch spacing on the growth of tree stands in northern Finland. The post-drainage productivity in different peatland site types is also under continuous study.

Important future research topics are the classification of the most common peatland site types, forest management and regeneration and the factors affecting productivity such as supplementary drainage, ditch cleaning, fertilization, etc. Special attention is required by rich-fens in calcareous areas and their nutritional problems. Being at the climatic border zone of profitable forestry, the research into other uses of undrained and drained peatlands should not be omitted.

Especially in northern Finland the important task of peatland forestry is to produce biological-mensurational information which can also be used in the business and social economic calculations and further in deciding the range and intensity of peatland forestry and other uses.

## RESEARCH PROJECTS

### WOOD AS AN ENERGY SOURCE (PERA)

In 1978 the Forest Research Institute started the PERA project which studies the growing and harvesting of wood for obtaining raw material for energy production. The project is planned to go on till 1987. It has been divided into four subprojects (A, B, C and R) according to research problems: the Department of Peatland Forestry participates in subprojects B and C.

Subproject B studies the possibilities of producing energy wood as main or by-products of forestry by applying traditional silvicultural methods. A special research topic is the broad-leaved stands on peatlands which are aimed at rather short rotation and regeneration by sprouts.

The investigations are primarily concerned with setting up coppices and producing wood biomass suitable for producing energy. Simultaneously the regional inventory methods of energy wood will be developed to obtain quickly and at low cost information on broadleaved and smallwood resources and find stands suitable for coppice forestry.

Subproject C investigates the possibilities of producing wood biomass suited for energy production in intensively managed and centralized plantations. The central goal of this method is high productivity per hectare, which is attainable by using fast-growing, improved broadleaved species and varieties and short rotation. The development of new harvesting and utilizing methods is part of this energy production process.

The whole concept of energy tree plantations calls for a profound research of fundamentals and application of the obtained information in a new manner. The departments of the Forest Research Institute taking part in the project are those

of Silviculture, Peatland Forestry, Forest Genetics, Forest Protection and Soil Science. With the increase of experimental fields and accumulation of research results, the departments of Forest Technology and Forest Economics will take part in the energy wood investigations. In co-operation with the Microbiological Department of the University of Helsinki an investigation has started dealing with the possibility of decreasing the nitrogen fertilization of energy plantations by using natural nitrogen fixation, and with the Biological Department of the Joensuu University by using sludge from population centres.

#### GROWTH DISTURBANCES

The purpose of the project on growth disturbances is to define, in collaboration with different research branches, the reasons for the abnormal development, bushy growth and death of forest trees (also in nurseries) and their crowns and to develop methods to fight and prevent damages in cases where growth disturbances are not caused by biotic or other known factors.

Departments of Peatland Forestry, Soil Science, Silviculture, Forest Pathology and Forest Inventory participate in the project as well as researchers in the Parkano, Suonenjoki and Muhos research stations.

The main focus in 1982 will still be on the growth disturbances of forest drainage areas, but research will also be intensified in nurseries and improvement areas on mineral soil. The activity will continue in the other sections according to the programme planned for 1982-86.



## WILD BERRIES AND MUSHROOMS

The project of wild berries and mushrooms started in 1981 when it received its own appropriation for planning. The investigations themselves started at the Joensuu research station in 1982. The Joensuu Research Station has focused its research activities chiefly on forest biological and silvicultural topics including also berry and mushroom investigations. This research is led by the Joensuu Research Station and the most important research task next year is to set up a network of sample plots for berry and mushroom investigations in northern Karelia.

The research station at Rovaniemi and Kolari have been in close co-operation since the start of the project.

The goal of the wild berry and mushroom project is, through a long-term research programme (10 y.), to obtain information about the total crop of Finland's forest and bog berries and mushrooms and its variation in different species, site types and regions, the current utilization level of the crop and possibilities of extending the utilization, the effect of wood productional measures (silviculture, forest improvement, harvesting) on crops and possibilities of modifying these measures in order to improve crops and the economical significance, both national and regional, of berry and mushroom picking.

## PEATLAND ECOSYSTEM

This project aims at investigating the functional changes in peatland ecosystem as caused by forest improvement measures. A simultaneous aim is to develop a system, in which changes occurring in peatland and forest nature could be surveyed to a large extent throughout the country. An important task in the next few years is to produce simulable dynamic models of the central subfunctions of the peatland ecosystem: primary production, decomposition and nutrient cycle.

The project of peatland ecosystem in 1973-1981, mainly financed by Finland's Academy, in collaboration with the Biological Department at the University of Helsinki, has produced basic information on the before-mentioned subfunctions of undrained and ameliorated peatlands. Models will be based on this material. The derived simulation models are going to be connected with the environmental material from the ecological experimental fields at Vilpula and Kivalo, through which a better predictability of forest improvement effects is expected. In collaboration with the Department of Forest Inventory a development of the follow-up method was started in the summer of 1981 to be joined with the National Forest Survey.

#### MIXED FORESTS

The project aims at investigating the biological, wood productional and economic significance of growing birch in conifer stands. Departments of Silviculture, Peatland Forestry and Soil Science as well as the Wood Production, Forest Pathology and Business section of Forest Economics all participate in the project.

The research will continue in different research branches using both permanent and temporary sample plots. Naturally the greatest emphasis is on wood productional investigations, since the economic calculations are based on the results of these investigations. Business economic calculations associated with the growth and yield investigations of mixed pine-birch stands are being under study.



# DEPARTMENT OF PEATLAND FORESTRY

List of researchers; office and special field

## HELSINKI

Address: Unioninkatu 40 A, SF-00170 Helsinki 17

- |   |   |
|---|---|
| Paavilainen, Eero, DF<br>Professor  | Päivänen, Juhani, DF<br>Senior research specialist,<br>hydrology of peatland forests  |
| Aitolahti, Matti, MF<br>Technology of peatland forestry                               | Heinonen, Riitta, MA<br>Statistics, ADP   |
| Karsisto, Marjut, MF<br>Microbiology  | Kolari, Kimmo, MA<br>Nutrient physiology of trees,<br>growth disturbances             |
| Paarlahti, Kimmo, LF<br>Management and yield of peatland forests                      | Reinikainen, Antti, LA<br>Ecology of peatland forests                                 |
| Silfverberg, Klaus, MA<br>Ash fertilization of peatland,<br>ecological investigations | Veijalainen, Heikki, BSc<br>Fertilization of peatland forests,<br>growth disturbances |

## PARKANO RESEARCH STATION

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| Kaunisto, Seppo, DF<br>Senior research specialist,<br>regeneration of peatland forests and<br>afforestation of peatlands | Ahti, Erkki, LF<br>Hydrology of peatland forests |
|--|--|

## JOENSUU RESEARCH STATION

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| Virtanen, Jaakko, DF<br>Technology of peatland forestry | Salo, Kauko, MA<br>Berry and mushroom research in forests |
|---|---|

## KOLARI RESEARCH STATION

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## MUHOS RESEARCH STATION

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| Moilanen, Mikko, MF<br>Fertilization of peatland | Pietiläinen, Pekka, MA<br>Nutrient physiology of trees |
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- Penttilä, Timo, MF  
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## EXPERIMENT STATION FOR ENERGY WOOD AT KANNUS

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- |  |  |
|--|--|
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|--|--|