

# ABOUT THE RESEARCH CARRIED OUT BY THE ESTONIAN INSTITUTE OF FORESTRY AND NATURE CONSERVATION

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The Estonian Institute of Forestry and Nature Conservation (briefly: Estonian Forest Research Institute) is the only research institute in Estonia which specializes in forestry and classic nature conservation. Most of the forest scientists in Estonia are working in the Institute. Another institution, where some forest projects (in the field of silviculture, forest economy, forest technology and wood research) are also solved, is the Faculty of Forestry and Country Engineering at the Estonian Agricultural University. Since our country's wealth is to a great extent based on forest, the condition and economic management of this natural resource have largely depended on the research done by the researchers of the Institute and the teachers of the Faculty.

In the past years depending on the financial situation considerable changes in the structure and organizational work of the Estonian Forest Research Institute have taken place. The staff of the Institute has been cut by about 40% comparing with that in 1992. At present our staff comprises 30 researchers, of them 25 have academic titles. The finance of the Institute come mainly in the form of basic financing and grants from the Estonian Science Foundation.

The application of forest research into practice is coordinated by the Estonian State Forest Department, and investigation into nature protection by the Estonian Ministry of the Environment. At the same time the Estonian State Forest Department is one of the subordinate institutions in the Ministry of the Environment.

The investigation conducted by the Estonian Forest Research Institute is divided between three research centres: silviculture, forest protection and nature conservation (see figure). The names of the centres reflect our basic research areas. In forest science silviculture and forest protection have been the basic research areas since the establishment of the Institute in 1969.

Much more than previously the researchers of the Institute collaborate with the research institutes of other countries (e.g. with Finnish, Swedish and German institutes). The researches into elucidation of the dynamics of changes in the condition of forests, forest pathology, forest improvement, tree breeding, game management and nature conservation are being carried out within the range of the joint projects or international co-operation programmes.

A short survey of the basic research done during the recent years by the research centres of the Institute will be presented below.

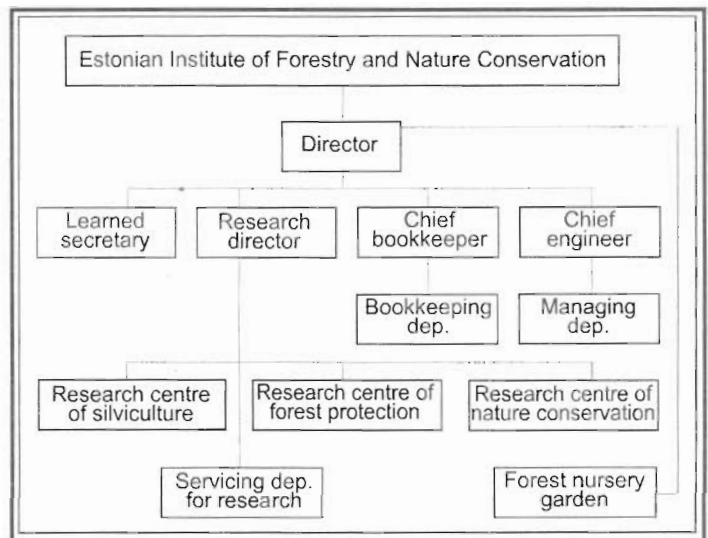


Fig. 1. The structure of the Estonian Institute of Forestry and Nature Conservation

## THE RESEARCH CENTRE OF SILVICULTURE

The centre is carrying out studies in four basic research areas: silviculture, forest improvement, tree breeding and management of protective forests.

In the area of silviculture a research into differences between the actual and potential productivity of various site types and into the factors and causes which prevent the latter from becoming a reality is conducted.

The connections between soil parameters, also their effect and that of meteorological factors on the growth rate of trees are studied by the use of correlation and multiple regression analysis. The parameters of forest humus horizon were the most essential features that reflected the productivity of a stand. The productivity of a stand is in close relation to forest litter and its decomposition, and to the figures (thickness of forest litter, base saturation, acidity, C:N) which characterize the circulating rate of substances. By the use of five soil properties 64% of the total variability of a mean volume increment in the case of pine stands could be described. Of the meteorological factors the winter temperatures below freezing-point are in the closest correlation with the diameter growth of trees.

An essential criterion for the formation of silvicultural policy is the optimization of a forest profit in stands on the soil-

typological basis. The main tree species and optimum felling age differ in site types, in normal and modal stands, and as economic categories they are in great dependence on the market situation. According to our calculations the higher the real interest rates, the more essential the optimization of management regime to cut the expenditures on forest cultivation and tending, and the shorter the felling cycle.

The second area of studies involves the recultivation of ground spoil by open-cast oil-shale mining. In Estonia the oil-shale mining by open-cast pits in the area of 23,000 hectares will be envisaged. On January 1, 1994, we had 10,713 hectares of land spoil by open-cast oil-shale mining, of that 8,221 hectares have already been technically recultivated. The aim of technical recultivation is to level the ground spoil by stripping of overburden layers of oil-shale. The afforestation of levelled oil-shale pits was initiated in 1960 and by now 7,422 hectares have been recultivated. To study the species suitable for the afforestation of pits test plantations with 52 tree and bush species were established. The Scots pine is a wide spread tree species used for the afforestation of levelled oil-shale pits. It roots well and is resistant to extreme growing conditions. Scots pine plantations account for about 80% of the areas afforested so far. In the case of pine plantations 5,000-6,000 two-year-old seedlings per hectare are planted. With the cultivation of pine plantings in places abundant in deciduous trees (willows, poplars, birches) it is of great importance in time to carry out the light and cleaning cuttings.

In the areas of oil-shale pits *Larix europae*, *L. sibirica*, *L. kurilensis* have been of the very rapid growth. In test plantations larches at the age of 30 years exceed the height growth of pines of the same age by 38 m and in diameter by 510 cm. The initial density suitable for larches is 1,200-1,800 two-year-old seedlings per hectare, in that case there will be no need for light and cleaning cuttings. Of deciduous trees the silver birch (*Betula pendula*) grows well in the areas of oil-shale pits. In 3-year-old silver birch plantations an average height of trees exceeds that of pines of the same age by 47 m.

The cultivation of black alder (*Alnus glutinosa*), the best tree species for stimulating the process of soil formation, needs more attention. The content of total nitrogen in the well decomposed litter of alder forests exceeds that of pine stands by 23 times. According to the date of test plantations the alders up to the age of 30 years have also the faster growth rate than pines, being only overcome by silver birches. The initial density the best suited to the cultivation of black alder is 3,100 - 4,000 two-year-old seedlings per hectare.

The research into forest improvement includes two areas: forest draining and fertilization. In Estonia forest draining has been carried out in the areas of more than 0,5 million hectares. The long-term (several decades) effect of drainage on the stands has increased their productivity and stability, and has given rise to changes in site types in large areas. But the cultivation of coniferous species in drained swamps turned out to be more expensive as it was planned out, and the growth of seedlings planted is often stunted.

With the management of forests growing in drained swamp soils the cultivation of birch stands, especially that of silver birches, needs more attention. To obtain the highest productivity of birch stands growing in drained peat bog soils the best time for felling

is at the age of 70 - 80 years in stands of the highest quality and at the age of 40-50 years in those of the lowest value. We also consider the fact that due to drainage the site type has often changed, and comparing with the previous evaluation an increase in productivity and quality of stands in thin peatland areas has taken place.

Instructions on the fertilization of forest nurseries and young growths have been compiled. A system of the application of fertilizers into the stands of site *Cladonia*, *Vaccinium*, *Myrtillus* types, drained transitional bog and raised bog has been worked out. The full-sized timber assortment yield can considerably be increased by the use of a repeated fertilization system, but the cost price of this material will be comparatively high.

In the case of studies on tree breeding the focus is on the management of seed orchards. In Estonia the first pine seed orchards were established in 1965. To store the genofond of plus trees the seed orchards have been established as clonal archives. Besides the provision of seeds they can be used for the evaluation of heritable qualities of plus trees, at the same time they also supply us with grafts for the establishment of new seed orchards. At present in Estonia there are 163 hectares of Scots pine and 32 hectares of Norway spruce seed orchards. To renew the Estonian forests 1,700 kg of pine and 400 kg of spruce seeds per year are needed. To supply our republic with a qualitative seed further 150,200 hectares of vegetative seed orchards of Scots pine should be established. The seed production of the existing seed orchards can be increased by loosening of the soil, fertilization, crown pruning, thinning, etc.

A maximum production of qualitative seeds can be obtained from 50-year-old seed orchards and after this age the seed production there markedly decreases. For that reason it is high time to start the renewing of the seed orchards and establishing those of the second generation. To work out a sound scientific base for the establishment of the second generation seed orchards those of pines were thoroughly examined and the best clones were ascertained.

In the area of protective forests the natural regeneration of pine stands as a result of cuttings based on regeneration under the shelter of the uncut stand is studied, the status and function of coastal protective forests are examined and a base for their management is worked out.

Due to the omission of regenerative cuttings the role of the overstay stands in the coastal forests in the South-West of Estonia is rather high. It is accompanied by a decline in increment and a deterioration in sanitary-hygienic qualities of protective forests. In pine forests of *Cladonia* site type spread on coastal dune sands the total timber volume per hectare of 170-year-old stands accounts for 71% and a volume increment 54% of the corresponding figures of 130-year-old stands. The existence of protective forests should be ensured by their regular natural regeneration. At present only 41.1% of the forests above have the satisfactory pine upgrowth.

The members of the same research group are also working at methods of increasing the productivity of wild berries cultivating red whortleberries in culture. By now 7 fertile varieties of red whortleberries have been selected and tested for variety comparison.

#### RESEARCH CENTRE OF FOREST PROTECTION

The research involves three projects on the main insect pests causing forest damages, on the ecology of fungus diseases

and on the dynamics of damage in the changing environmental conditions.

The population dynamics of pine weevils (*Hylobius abietis*, *H. pinastri*) and *Hylastes* bark beetles, the main pests causing damage to forest plantations, was studied using the baited traps. Equalizing the number of *Hylobius* spp. directly after a clear cutting with 100%, then with the 3-year-old felling area it was 30,6%, and in the case of that 5 years old 4,5%. Of all the insects trapped *Hylobius* spp. formed 63%, bark beetles - 30% and the others 7%.

Fauna of the bark beetles of Estonia was studied. According to the revision of several collections available in 6 museums and research institutes, and in 9 private collections comprising in all more than 11,300 specimens, 59 species of bark beetles were found in Estonia. A study of population dynamics of *Polygraphus* bark beetles causing damages in spruce stands was initiated. Especially the role of predators and parasitoids in the population dynamics of the pest was examined.

In the Vihterpalu and Aegviidu Forest Districts, the population dynamics as well as the dynamics of damages caused by bark- and wood-boring insects (mostly by *Tomicus* spp.) in the stands damaged in 1992 by forest fire were studied. Likewise the damages caused by *Hylobius* spp. in forest plantations set up on the burnt woodlands were examined.

The main control measure for *Hylobius* spp. and *Hylastes* spp. is to treat the forest plants with insecticides before their planting. In 1994 the treatments with 1,0% and 0,5% pyrethroid preparations Cyperkill 10 and F Permetrin were tested. Using the 0,5% preparations for treatments of spruce plants on the newly felled clear cutting areas, 63-77% of the plants were damaged by *Hylobius* spp. but only 3-7% of them were dead after the treatment. On the untreated control area 100% of the plants were damaged and 87% of them were perished.

As a comparatively safe for the environment control measure to avoid damage caused by *Hylobius* spp., water extracts of several plant species were experimentally used. According to the preliminary results only the extract of *Tripleurospermum inodorum* had some repellent effect on *Hylobius* spp.

In collaboration with Finnish researchers the seasonal changes in the concentrations of terpene, resin acid and total olic acids in young Scots pine plants representing nine pine provenances from Finland and Estonia and cultivated in three forest nurseries in a gradient of about 1,000 km were examined. It became evident that the origin of the seed material is not so important in affecting the secondary metabolites of the plants as the environmental factors are.

The most dangerous disease in our forests is root rot (*Heterobasidion annosum*). The occurrence of root rot in Scots pines and Norway spruces, the formation of gaps of root rot in stands with different species composition and age, and the role of coniferous stumps as a source of infection were studied. An essential difference in the frequency of occurrence of the types of pine (P) and spruce (S) root rot can be seen in Norway spruce. In Estonia it is in the ratio of ca 250:1 in favour of the spruce type, in the South of Finland 9:1, respectively. Towards the south and west from Estonia the role of the pine type in spruce is even higher.

The renewal of Estonian forests, where the majority of coniferous stands of the 2nd and 3rd generation had severely been

damaged by root rot already before the final felling, causes serious problems. The spruce stands where more than 40% of the trees are infected should be reforested with deciduous trees, e.g. with birches. In the case of slight root rot damage to a pure spruce stand it can be replaced with a spruce-birch or spruce-pine forest. Pure spruce or pine stands cannot be established on former arable lands. Such areas should be planted with mixed or deciduous stands.

In recent years a research into the health state of the Estonian pine forests, reasons for their degradation and measures to improve their condition has been carried out. The theme has been rather actual since the mid-80s, when an extensive decline in the health state of Scots pine forests in some parts of Estonia was observed. In most cases a widespread dying off of trees in middle-aged pine stands growing in sandy soils poor in nutrients became apparent. To study the causes of damage in detail a lot of sample plots were established in the most damaged pine forests in the North and South of Estonia. In the majority of cases the degradation of stands was caused by a complex agent, whereby biological factors have been of great importance to the development of the extent of damage. The health state of pines in particular can easily be affected by needle and shoot infectious diseases such as *Scleroderris* shoot canker and needle cast disease. In some regions also needle-eating insects have had a significant role in degradation of the health state of pines.

Although no considerable effect of acidic precipitation on the Estonian forest ecosystems has been observed, some slight changes in a pH value of forest soils can also give rise to negative alternations in the condition of stands. As it is known, the majority of pine stands of *Vaccinium* and *Cladonia* site types grow in podzolic soils with a strongly acidic forest humus layer. In the case of an increase in soil acidity a deficiency of several essential elements for plant food in the soil and a simultaneous release of exchangeable Al<sup>3+</sup> toxic to plant cells in the root zone of trees can often be observed. The lowering of a pH value of the soil by spreading lime over land has been a method widely applied into farm practice. In several countries good results in the improvement of the state and growth of forests have been achieved by the joint use of fertilization and liming. To work out the methods for the improvement of the health state of pine stands a research into the application of fertilizers and lime into stands, where the degradation was already of hotbed character, was conducted. Rather good results were obtained by liming the forest soil with powdered oil-shale ash (with a rate of 10,000 kg/ha). Powdered oil-shale ash had a quick effect on the lowering of all soil acidity characteristics (pH<sub>H<sub>2</sub>O</sub>, pH<sub>KCl</sub>, H<sub>8.2</sub> and H<sub>5.6</sub>) and also on the reduction of soil exchangeable Al<sup>3+</sup>. Under the influence of powdered oil-shale ash fertilizers had also a somewhat higher effect on the growth of trees.

Game research project included studies about changes in cervid population, their mortality, feeding and forest damage caused by them. The mortality rate of moose (*Alces alces*) calves was especially high in summer, due to the action of great predators. Under the joint effect of several unfavourable factors the total number of mooses is decreasing.

According to the observations mooses remove the bark from spruces mainly in autumn and spring, i.e. in the periods



when they go over from a summer food to that of winter and the other way round. Lesser damage to trees can be seen also in midwinter, probably during the thaw. Moose damage to the Estonian spruce stands was the highest in the second half of the 80s, by now it shows a downward tendency. It is still obscure to what extent lesser damage to spruce forests is connected with a decrease in the number of mooses. In the past 15 years their number has continuously decreased, but during the period above in some places the intensity of damages to spruces was even higher.

The dynamics of the number of tetraonids and the structure of forests in the leking area of capercaillies (*Tetrao urogallus*) were studied. In 1978-1994 the density of capercaillie population has varied from 1.4 to 3.9 individuals/km<sup>2</sup> (on average 2.4 indiv./km<sup>2</sup>), that of black grouse (*Lyrurus tetrix*) 2.9-4.9 indiv./km<sup>2</sup> (on average 4.0 indiv./km<sup>2</sup>). On the whole the population density of both species above has been rather stable in the last years. But in that period the number of hazel grouse (*Tetrastes bonasia*) was decreased.

In the case of capercaillies the existence and number of the population primarily depend on the quality of habitations. Of the prime habitations the pine stands amount about 50%, whereby the leking areas are only in old pine forests, the coniferous forests in total account for 80 - 95%.

## RESEARCH CENTRE OF NATURE CONSERVATION

A research into the distribution, state and ecology of rare plant and animal species and populations under protection is being conducted.

In Estonia the list of plant species under protection includes 185 items. Of them 143 plant species belong to the 1st and 2nd categories of protection, i.e. reserves are needed for maintaining of their habitats. The inventory of the natural habitats of the plants showed that a lot of species could provoke specific interest for nature conservation. Among them there are all these 22 plant species which have only one or some few localities in Estonia, and upward of 40 species taken under protection only a short time ago. The list of the species include: *Nuphar pumilum*, *Cruciata glabra*, *Dracocephalum Ruyschiana*, *Pulsatilla patens*, *Gymnocarpium robertianum*, *Anthyllis coccinea*, *Saxifraga hirculus*, *Ajuga reptans* and others.

The land reform also causes some changes in the ownership and utilization of the areas reserved. For that reason in 6 Estonian reserved areas the species composition of unique plants and probable degradation in the state of their populations brought about by changes in the ownership of the land were ascertained. At present it is known that 127 protected plant species have one or more habitats on the territories of investigated nature reserves. The researches will be continued next year as a great number of protected areas are not botanically investigated up to now.

Studies about the populations of four very unique plant species exposed to danger in Estonia were continued. The conservation of these species - *Aconitum laxiostomum*, *Astragalus arenarius*, *Pulmonaris angustifolia* and *Cerastium alpinum* ssp. *lanatum* - under the stable or improving conditions is becoming problematic. People's consciousness is of great

importance to the species conservation and to the improvement in their growing conditions. This requires sound knowledge of species ecology and population dynamics. The main reasons for changes in their population dynamics were also analysed.

Studies about the migration ecology of waterfowl in East, Central and West Estonia were done. Greylag geese (*Anser anser*) in their autumn migration stop mainly on the islands and in the area of Matsalu Bay in West Estonia. In 1991-1994, 9,830-14,850 greylag geese were counted there. Bean geese (*Anser fabalis*) and white-fronted geese (*Anser albifrons*) stay primarily in the continental part of Estonia. In 1994 a total of 11,210 bean geese and 6,240 white-fronted geese were counted in 13 places.

During their spring migration more than 100,000 barnacle geese (*Branta leucopsis*) make a stay on the islands of Saaremaa, Hiiumaa, Muhu and in the area of the Matsalu Nature Reserve. In the past 30 years an approximate tenfold increase in the number of barnacle geese in their spring migration has taken place and it seems to be on further increase. Their breeding places have been on 13 islands. By 1994 the local population was increased up to 89 breeding pairs and this process continues to show an upward tendency. At the same time an average number of full clutch has decreased. To improve on the nature conservation on the Endla and Hiiumaa islets a research into the bird fauna in their sanctuaries there was carried out.

The occurrence and potential inhabitation of flying squirrels (*Pteromys volans*) in South-East of Estonia were studied. Flying squirrels are now rare in Estonia and the inhabitation of each individual should be protected. Unfortunately the number of their living places has declined due to the fellings in forests.

Of the amphibians and reptiles the new data about the spread of green toad (*Bufo viridis*), common spadefoot (*Pelobates fuscus*) and sand lizard (*Lacerta agilis*) were obtained. The distribution map of the natterjack (*Bufo calamita*) was drawn up. The findings of an interest also included pool frogs (*Rana lessonae*) and Laxmann's shrew (*Sorex caecutiens*).

The bats inhabiting in the Piusa and Älgase caves were counted. In different years the 6 caves in Piusa (in South-East of Estonia) were inhabited by 1,000-2,000 bats. The caves form their largest hibernation colony in the Baltic countries. The Älgase cave (in the northern part of Estonia) was hibernated by 300-1,000 bats.

The researchers also investigated the structural dynamics of land use in Estonia. Data about the land balance (1900-1993) were gathered, organized and sorted. The reasons for changes in the structure of land use were analysed. The map about the distribution of ornithological fauna in the areas which will be compensated has been completed.

In 1994 national environmental monitoring programme was initiated. The work on its subprogramme "The monitoring of rare species and associations" is co-ordinated and partly performed by the Research Centre of Nature Conservation. In 1994 the methods of monitoring were worked out, the areas of monitoring were selected and monitoring programs of the first selection were accomplished.