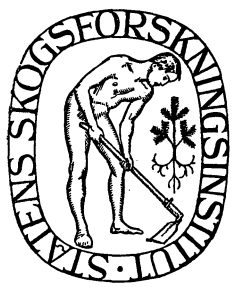

The Forest Research Institute of Sweden, Its Work and Organization

by

MANFRED NÄSLUND

REPORTS OF THE
FOREST RESEARCH INSTITUTE OF SWEDEN
VOL. 42 · NO. 3 B

The Forest Research Institute of Sweden

The Forest Research Institute of Sweden has gradually expanded in scope and organization from a modest beginning in 1902 to its present state. The years 1912 and 1944 were particularly important in this development. In 1912 the Institute, which till then had been under the supervision of the Board of Crown Lands and Forests, became an independent body. At the same time, funds were allotted for the erection of a special building at Experimentalfältet, which was brought into use in 1915. In 1944 a reorganization was made resulting in an important expansion and a wider range of activities, and a new Institute building, as well as an extension and rebuilding of the old one. The new building was completed in 1945 and the old one was ready by the spring of 1947. The organization was further expanded and completed in 1946—52.

It has been considered appropriate to give in this paper a review of the present state of the activities and organization of the Forest Research Institute. A detailed account of the development of the Institute over the period 1902—52 is available in the publication issued on the occasion of the celebration of its fifty-year jubilee.

Fields of Activity

The Forest Research Institute is the national centre for forest research. It has two main responsibilities. One, the scientific investigation of ways and means of tending the forests under different conditions: the other, the continuous record of the forest resources of the country together with estimates of the actual cut. Furthermore, it has the duty of assisting in the training given at the Royal School of Forestry.

These general prescriptions include numerous problems. To deal with these problems, the Institute is divided into six Departments which are, in chrono-o gical order:

1. *Forestry* under Professor LARS TIRÉN
2. *Botany and Soils* under Professor CARL MALMSTRÖM
3. *Zoology* under Professor VIKTOR BUTOVITSCH
4. *Forest Survey* under Professor ERIK HAGBERG
5. *Genetics* under Professor ÅKE GUSTAFSSON
6. *Work Study* under Professor ULF SUNDBERG.

Besides these six Departments there is for the Institute as a whole a Statistical Office and a Central Office, and also a laboratory for routine soil analyses.

The Director of the Institute is Professor MANFRED NÄSLUND.

In the following pages a short summary is given of the chief lines of the work of the Institute, prepared with the help of the Heads of the several Departments.

Department of Forestry

The research of this Department covers the fields of silviculture, forest mensuration and forest technology. The primary task of the Department is to make possible practical decisions on the main questions of silviculture. Silvicultural problems can be classified into two groups, of which one is the tending of stands for which production is the determining factor, and the other deals with regeneration. The scientific basis for the decisions will be obtained by production and regeneration studies. Linked with the production studies is research on forest products, and with the regeneration studies research on tools and their proper use. Most of the time and resources of the Department is directed to these two extensive fields of production and regeneration investigations.

Production Research: The task of this research is to provide guides as to how best to carry out practical silvicultural operations. The questions that have to be answered deal, for example, with choice of species and species mixtures, advantages and disadvantages of even-aged and uneven-aged stands, time of first thinning and thinning intervals, intensity of thinning and the method of thinning, high or low, etc., effects of thinning on timber quality, time and method of felling the stand, and so on. To answer these questions it is necessary to find out how the forest grows under different natural conditions and under different treatments. The importance of this branch of research is not, however, limited to providing directions for silviculture, as forest management plans and forest valuation are largely dependent on the results of such growth studies.

International research has been in progress for many years directed towards determining the growth and yield of stands on soils of different quality under a single method of treatment, or occasionally more than one treatment. The data have been derived from permanent sample plots which have been treated over a long period under the regime in question. The data were worked up by simple graphical comparisons of these long developmental histories.

On various grounds, which cannot be given here, Swedish forest research has given up this technique and set up as its general aim the determination of the course of growth of trees and stands under different natural conditions and different treatment. This broader aim involves problems which can only be solved by statistical methods. The new methods of observation and handling of such data make it possible to progress much faster than has hitherto been thought possible.

The work of *Production Studies* starts by establishing statistical equations on the basis of observations of development over short periods which express general relationship and so permit of the calculation of growth given the conditions that apply. Using such equations and certain subsidiary ones, yield tables can be prepared which give the growth and yield under different combinations of conditions. One is thus in a position to compare the results of different treatments under otherwise identical conditions. In this way, an unbiased choice between different methods of management is made possible.

For productive work in this field, the nature of the material is of the greatest importance. The material hitherto available has consisted of the permanent sample plots. The first of these was laid out at the start of the Institute 50 years ago and the rest have been laid out over the subsequent years. The data collected according to the old methods, with no consideration of statistical analysis, are very deficient in various respects, and this causes many difficulties in analysis. The chief result of this work has accordingly been to give provisional results for use in management pending the collection and working up of new data.

Considering the limitations of the old data, an extensive study of growth and yield was begun in 1941 along the new lines. As the big-scale fellings consequent on the fuel shortage threatened to destroy before long important research material in untouched forests, the investigation was at first applied to these stands.

This *new production study* is not based on permanent sample plots like the old one, but on single measurements of temporary plots in which diameter increment is determined by increment borings. Apart from the saving in time, which is a decisive factor, this method has other significant advantages which cannot be detailed here.

The new work deals with pine, spruce, and birch forests as well as with mixed coniferous and broadleaved crops. It aims in the first place at establishing general equations for growth, and yield tables. But as exact data of the site and of the trees on a large number of plots, for which increment is determined, are also recorded, it is possible to get a deeper insight into the conditions of growth. For this purpose investigations are carried out on the soil, as well as chemical analysis of samples of needles, etc. Furthermore, the botanical and other details which may characterize different tree races are noted on the felled sample trees. Through statistical analysis it should be possible to sort out in some measure the action of the different factors which influence the development of the trees. The data collected from the undisturbed forest also permit of a study of the effect of climatic changes on production. This collection of data is now completed for undisturbed stands and is continued in thinned stands. After analysing these new data, in which three or four thousand plots

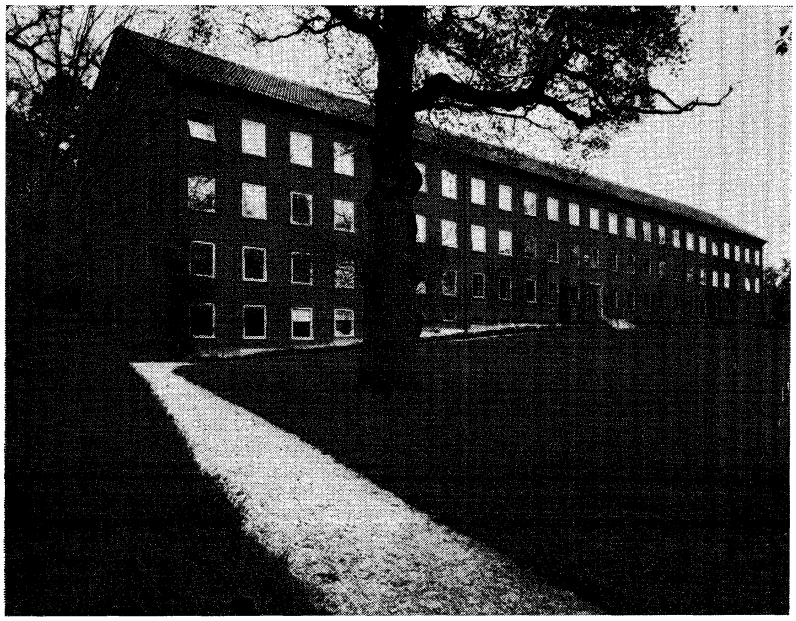

Fig. 1. The new Institute building, which houses the Administration, the Departments of Forestry, Forest Survey, Work Study, and Genetics.

will be involved, the Research Institute will be in a better position to give definite information about the yield problems of practical forest management.

The *technical properties* of forest products are given attention in this new study, including their dependence on natural site conditions and treatment. The Swedish Forest Products Research Laboratory co-operates in this work.

The new approach is only being used for pine, spruce, and birch. The *production of oak, birch, and ash* and other important species is dealt with in separate investigations.

The research undertaken under the programme of the Forestry Section in *Forest Mensuration* is directly linked with the production studies and consists of the further development of the technique of estimation of timber volume, converted yield and increment of single trees and stands. The object here is the development both of accurate methods for the special purpose of production studies and of simple methods suitable for practical estimation.

Investigations of *pruning* as a means of improving the quality of the growing wood are also included in the studies of production.

Regeneration Research: The task of regeneration research is to aid practice in the choice of methods of regeneration and to provide indications as to the appropriate application of the different methods of regeneration.

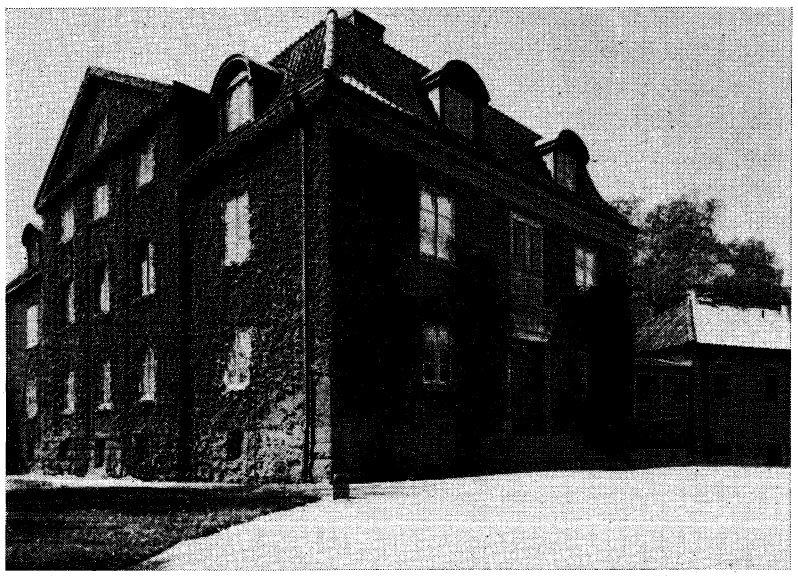

Fig. 2. The old Institute building with its extension, which appears on the right. These premises are at the disposal of the Departments of Botany and Soils, and Zoology.

As to *natural regeneration* there are problems concerning the most suitable way of carrying out the regeneration fellings and questions as to tending, time, procedure and costs of freeing the young growth, effects of quality and type on the secondary and final fellings, etc., and other measures involved in regeneration, such as mechanical or chemical soil preparation, burning, etc.

To solve the main problems of natural regeneration, it is necessary to find out how forests regenerate under different natural conditions and different treatments. At the Forest Research Institute attempts are being made to find the answers by statistical methods applied to observations on the condition of the regeneration at a given time, or over short periods of its development. In this way, with the help of equations or tables, it becomes possible to follow the progress of the natural regeneration from the commencement of the removal of the overwood to the establishment of the new crop on the ground. The results obtained by different kinds of regeneration fellings can then be compared under otherwise identical natural conditions, and an unbiased choice of a method is made possible. Combined, the results of Production and Regeneration research will cover the whole course of forest development. The importance of this for the forest manager in his choice of methods and the planning of practical silviculture, and for the control of woodland management throughout the country, can hardly be overestimated.

In working towards this important end the need for a more complete investi-

gation of the biological conditions of natural regeneration is kept in mind. Data are accordingly collected about the condition of the regeneration and the parent crop, the soil, climate, seed crop and so on.

In the field of *Artificial Regeneration* a large number of problems are involved, such as questions of nursery work, choice between sowing and planting methods with reference to biological and economic points of view, development of new methods of sowing and planting, manuring, condition and handling of plants, spacing, the best time and method of weeding, the cost of weedings, the best way of helping the individual plant, matters of race and provenance, disease. Only a few of these problems can be touched on here.

For clearing up the most important problems of artificial regeneration information is needed on the possibilities of sowing and planting in different ways and under different natural conditions. To this end, experimental plots are laid out in accordance with the principles of modern experimentation technique. The statistical analysis that is rendered possible in this way gives a wider application to the results. In the light of the considerable expansion of artificial regeneration of recent years, questions of costs and tools have become more important, and experiments in this field form a significant part of the programme. In this way new methods are being tried for bringing down costs by mechanization, especially by use of tractors.

The problems concerned with *cones and seeds* form another wide field for research, as the quality of the seed supply is of decisive importance for the results of plantation work and likewise also for future timber production. The necessity of storing large supplies of seed, the value of which may run into millions, still further accentuates the importance of thorough research in the field of seed storage. Moreover, in this matter of cones and seeds there is need for an information service linked with increased activity in seed collection.

In Sweden, developments during the last decade have led to an unsatisfactory situation with by far too many blanks and soils with unsatisfactory regeneration. Consequently, reforestation problems have arisen on a big scale. Since the young growth is the cradle of the mature forest, the problem of providing conditions for good regeneration at reasonable cost is a large and exceptionally important one. Its satisfactory solution is intimately bound up with research.

Department of Botany and Soils

This Department is mainly concerned with *fundamental research* aiming at an ecological analysis of the relations of forest yield to factors of site and of climate.

The problem is a complex one. Production in forestry depends on a biological chain of many links, including the tolerance and adaptation of trees to the

seasonal and accidental variation of factors occurring in a forest site, and all kinds of interactions between plants, between plants and soil, and between plants and animals. One reason for this is the fact that conditions first existing on a given site are modified in many ways under a forest cover. To a certain extent the forest creates its own environment.

One way of attack is the study of forest types, their distribution, historical development, and reactions to various treatments. Work along these lines in the Department has concentrated on types found in North Sweden. It has contributed information, for use in practical forestry, on conditions of growth and reproduction. Further studies of forest types are being made in Dalecarlia and elsewhere in the central and southern parts of the country.

Soil biology is another main line of study contributing to the understanding of conditions for growth and reproduction. The work of many years within the Department has supplemented P. E. MÜLLER's classical studies in Denmark on mull and mor, the two main types of the uppermost horizon of a forest soil.

Ecological field experiments have been increasingly relied upon in the Department for the study both of soil biology and, directly, of the nutrition of the forest crop. They are supplemented by experiments, ecological in scope, made in the laboratory. The main results of this work are as follows.

Production in forestry depends more directly on available plant nutrients than was thought to be the case for several decades. Even on sites carrying lichen-pine forest, looking very dry, it has been found that the production is kept low less by a shortage of water than by a lack of nutrients.

Deep peat is often too poor in one or more *mineral* nutrients for supporting forest growth.

In average forests on mineral soil, *nitrogen* is the key nutrient, and indeed a key to forest production. In typical northern stands of old spruce, current increment was stepped up several-fold by experimental nitrogen fertilization. Mineral nutrients had little or no effect.

The characteristics of an incipient mor such as are seen even on good sites under old stands—under beech, for instance—are so many symptoms of initial nitrogen starvation. This explains the phenomenon in detail. Other explanations that have long been current do not fit the facts and must be discarded.

A typical undisturbed mor is a condition bound up with a shortage of available nitrogen. This can be relieved by violent disturbances disrupting natural connections or otherwise overthrowing the existing relative equilibrium. Such disturbances are clear-felling, burning, and other "activating" silvicultural measures. Mor is similarly "activated" by being disconnected from the trees, as on a trenched plot, and by mere sampling. The mechanism underlying this effect has been at the base of primitive agriculture since time immemorial.

It has been found to yield, in a year or two, a hundred kilogrammes or more of available nitrogen to the hectare, where the total store of nitrogen in the humus layer is a few hundreds of kilogrammes per hectare and the amount supplied annually with the litter is some 20 kg/ha (estimates for old spruce forest of an average northern type). Similar values have been obtained with beech mor and mor from a Danish heath. No increased supply of bases or nutrients is needed for this fertilizing effect to come about. Indeed, if carbonate of lime is added, this has been consistently found not to increase but to lower the rate of mobilization of nitrogen.

The nutrient status in Swedish forests is now being studied systematically in the Department by chemical analyses of leaves and needles ("leaf analysis").

Mycological research serving the purposes of *Forest Pathology* and of *Wood Technology* is another of the main activities of the Department. Part of this work is supported through a Wood Protection Committee by other State agencies (the State Railways Board, and the Board of Telegraphs, as well as the Water Power Board). The mycologist of the Department also serves on this Committee.

Snow Blight *(Phacidium infestans)* has been the object of a comprehensive study. It is a serious forest pest in North Sweden. Projects in forest pathology now being worked upon include the incidence and distribution of root rot caused by *Fomes annosus*, the varying resistance of Scots Pine to Pine Blister Rust *(Peridermium)*, and a similar variation in aspens and poplars with respect to attack by *Melampsora pinitorqua*.

The work done in wood mycology includes such projects as the control of rot in stored pulpwood and of blueing in logs. A study is being made of the interesting association of bark-beetles with blueing fungi.

Extensive series of tests have served to determine the resistance of wood, natural and impregnated, to the attack of wood-destroying fungi. Heartwood of pine and its protecting substance, pinosylvin, have been included in this work. Resistance to rot is being studied in part by exposing samples of wood in field experiments to the free attack of the natural population of organisms under various climatic and other conditions.

Department of Zoology

The fauna of the forest consists of a great number of different species, both helpful and harmful, insects forming the majority of both species and individuals. As from the economic aspect also the insects play a greater part than the other forest animals, the Department is mainly concerned with the biology, damage, and control of forest insects. Some of the injurious insects attack the needles or leaves of trees, *e. g.* the nun-moth, the pine

beauty, the pine sawfly, etc. These species may disappear completely for many years and then suddenly occur in great numbers over a wide area, only to disappear again a few years later. They have a marked periodicity in their occurrence, quite independently of human action. The connection between the mass outbreaks and climatic and other factors has long constituted one of the most difficult and, at the same time, most attractive problems in Forestry Entomology. Some studies, which for obvious reasons, must extend over a long period of years, are in progress in the Department and may in due course provide contributions to international discussion, now particularly active, of these topics.

Other injurious insects prefer sickly or dying trees and so are normally of minor importance. Such are notably the bark beetles, longicorns and some weevils. When these insects get chances of mass breeding through windbreak, fire, extensive snowbreak, or injudicious treatment of the woods, there is grave danger that they will also attack sound trees. The classic example of this is the spruce bark beetle, which under normal conditions attacks only sickly or fallen trees, but during epidemics will attack large stands of healthy well-grown trees. In the case of this insect, the connection between epidemic outbreak and external causes can easily be demonstrated: it is simply the presence of greater or smaller availability of breeding sites. The study of the life habits of injurious insects and their variation in different parts of Sweden is one of the chief occupations of the Department. An exact knowledge of the biology of pests is actually an essential basis of an effective campaign, for only with it can we decide in what stage of development the pest is least resistant and so can be attacked with greatest prospects of success. With the information thus collected it is often possible to reduce or even eliminate the damage of the pest in question without elaborate and costly measures.

An important task is accordingly to work out suitable control measures based on the studies of the biology of the pest. These measures may be prophylactic or may have to provide for direct control.

Thanks to the modern insecticides D.D.T., B.H.C., Thiophosphates, etc., entomologists now have very effective weapons particularly suited for control of insects and their larvae, which live on leaves or needles. As the Department is not in a position to take an active part in the experimental development of these insecticides, its part consists chiefly in evaluating for Swedish conditions the experience obtained abroad. The injurious insects may be quite different from those in other countries, or their biology may differ significantly.

During the last few years a practice control technique has been developed with the use of helicopters, and has been tested in different parts of the country, mostly with good results, against pine moth, nun-moth, winter moths, pine looper, and spruce saw-fly. Experiments are also in progress for

finding out the effects of these measures on the forest fauna as a whole. The treatment of large areas with insecticides has, of course, very far-reaching effects on the biological equilibrium, but how far this disturbance goes and how quickly the equilibrium is restored is still uncertain.

Much more difficult to control are the insects which live under the bark and in timber. These are usually inaccessible to direct control by contact insecticides on account of their concealed mode of life. However, latterly, a quite new technique has been worked out which consists in essence in the transport of the poison in the sap-stream of the tree in the outer rings of wood. The results obtained so far have been very promising and the technique may now be tested on a big scale, both here and abroad.

Another very important problem, which has been studied for many years in close cooperation with the Mycological Section of the Department of Botany and Soils, is the connexion between certain injurious insects and fungi. Here we have two problems which have attracted the greatest attention in recent years, viz. the elm disease and the blue stain of softwood.

The universally feared elm disease was found in Sweden for the first time in 1950 and since then it has been reported in a considerable number of localities in the eastern part of the country. The disease is caused by a parasitic fungus which is carried by certain Scolytid beetles from tree to tree. The disease has, in all probability, been introduced with imported elm timber, and so the importation of elm plants, bark and elmwood is forbidden under an edict of 1951. To control the elm disease and prevent its further spread, methods have so far been recommended which have been tested abroad, but experiments have been started to find, if possible, new methods of dealing with this disease.

The connection between insects and blue stain has long been known. It has been shown that several insects can infect trees and timber with spores of injurious fungi: for example, certain bark beetles infect coniferous wood with the fungi which cause a more or less dark discoloration of the sapwood. Very significant losses are caused annually to forest and sawmill owners by this blue stain. The general connexion between insects and the blue stain has, as already mentioned, been demonstrated, but a number of important details are still unknown, particularly how the wood should best be stored and how unbarked logs, which for one reason or another, must be left lying in the forest for a season, can be protected. The main difficulty has been to obtain effective rain resistant sprays. However, suitable sprays of this kind are beginning to be found, and principles worked out in the Department are being tried out on an experimental scale. The experiments made so far have given satisfactory results and will now be repeated on a larger scale.

The expansion of planting work has increased the demand for suitable planting material, and so a number of new nurseries have been laid out, and

the old ones extended. At the same time, attention has been paid to the damage which is done by the cockchafer and allied species. Detailed investigations are being carried out in the Section on the biology of these insects and the most appropriate control measures. Good results have already been obtained regarding one of these species, the garden chafer; experiments are now in progress with the other species. Besides the problems which arise from the injurious insects of the forest, the programme of the Section also includes the soil fauna. These investigations aim at a fuller knowledge of the insects present in the soil and their importance for the breaking-down processes, and for the origin and development of regeneration.

As is evident from this review, the Zoological Section has a very extensive programme of work, which ranges from purely fundamental studies to the development of practical control measures.

Department of Forest Survey

This Department has taken over the responsibilities of the formerly independent *National Forest Survey*. Its chief task is to determine at appropriate intervals the extent and composition of the forest resources of Sweden. From 1953 onwards this work will be so organized as to cover the whole extent of the country every year and to record not only standing volume but also the annual cut as determined by the stumps left from the fellings of the previous season. Hitherto, the surveys have been made so as to cover each county at regular intervals of time, approximately 15 years: in this way, it was possible to follow the main changes which had taken place between successive inventories. With the help of these determinations it was possible to get a picture of the results of the treatment applied in the interval, i. e. whether the growing stock had increased or decreased, whether the extent of areas with unsatisfactory forest conditions had become larger or smaller, etc. From these figures everybody interested could obtain some check on the silviculture from county to county. The figures were used, for instance, for calculations showing the extent of the fellings in the intervals between estimates. Under the new plan we should get a continuous picture of the changes in growing stock and the forest condition year by year, as well as annual data on the increment and yield for the whole country.

From the data collected by the National Surveys various forecasts have been derived as to the quantities of timber which could be harvested under rational management. For the over-all planning of silviculture and the timber industry these forecasts are of decisive importance. The National Survey also provides the information concerning the quality of the soil as the basis for land tax, as well as data on the size and condition of the timber stock in the different taxation districts.

Areas and growing stock are recorded separately for the different categories of forest owners, so that the condition and management of the forest under each different group can be examined. Other notes of value for forest research in different regions are also made.

The method used is in principle that of systematic sampling. The areas used as samples are now plots laid out along parallel lines, called survey lines, running at regular distances from one another. In the First National Survey the trees were instead enumerated on a strip 10 m wide along the survey lines, and this strip served also to determine the distribution of the area in classes according to land use, etc. In the Second Survey, the method used differed between Norrland and the rest of the country. In Norrland the trees were enumerated within a 10 metres strip and also on sample plots laid out at regular intervals along the line. Sample trees for measuring the factors that determine volume and increment were only taken on the plots. In the South and Middle of Sweden the enumerations were limited to the sample plots, which were laid out more closely for this purpose. These served also for recording data on soil and stand. Only the land classification was based on records made on a continuous strip (20 metres wide) along the survey line. The sample plots formed small sections of the enumeration strip. In the Third Survey the procedure will again be different. Each year "sampling units" will be properly spaced along the old survey lines in sufficient numbers to give an aggregate line length of approximately one-tenth of the total for the whole country. These units will be squares and their sides (ranging in length from 1.2 to 2.2 km) will be treated as survey lines, using a combined line and plot survey method. This will enable a party to finish one unit a day (a line length of 4.8 to 8.8 km). This plan is designed so as to give in ten to fifteen years an estimate equivalent to the old one.

The accuracy attained is a matter of cost. It can be calculated on the basis of probability. In the Second National Survey, now completed, the total growing stock was estimated for the individual provinces with a standard error of 1.5 to 2 per cent. The spacing of lines required for this accuracy varied from 10 km in the northernmost part of the country down to 1 km in certain southern districts.

The new procedure aims in the first place at getting results for the whole country and each of five main regions. Every year about 900 sampling units with about 9,000 sample plots will be measured. For each of the five regions the growing stock will be estimated with a standard error not exceeding 2 %.

The First National Survey was carried out between 1923 and 1929. It followed an experimental forest inventory of the county of Värmland in 1911. This inventory served as a pattern not only for Sweden but also for Norway and Finland. The Second National Survey was made in 1938—52 and differed

in principle from the earlier one mainly in the introduction of the line-plot method. The further development of the technique has been in the direction of increased detail in the records and greater exactitude. The Third Survey is planned to begin in the summer of 1953. It is designed so as to give the results for growing stock, increment and yield continuously expressed year by year in the same units.

The detailed data collected in the National Survey are used for a variety of purposes in special investigations carried out for different authorities, commissions and institutes.

Department of Genetics

Research in this Department is concerned with heredity in forest trees and the principles of forest tree breeding, chiefly by the selection method. The Department was organized in July 1946 and began to work on the 1st January, 1948, when the present Head took up his post.

According to an investigation made at the Research Institute, the annual plantation requirements for Sweden over the next 20 years amount to about 100,000 hectares. Seed requirements can accordingly be estimated at about 60 tons annually. Evidently it is important to use satisfactory seed stock for such extensive operations. The better the stands we can raise, the better the production will be in the future: there is thus a great field for genetic research to develop improved seed stocks.

The breeding of forest trees can, and must, be carried out along several different lines. The methods to be considered are: selection, crossing, increase of chromosome number and induction of mutation.

The chief effort is concentrated on the problems concerned in the effect of the genetic constitution of forest trees on the production of the forest. The characters of forest trees and stands are always determined by both heredity and environment. There are various ways of distinguishing between one and the other of these factors. The genetic characters of the individual tree can be ascertained by vegetative propagation through cuttings or graftings which are planted out under a variety of conditions, *e. g.* with different spacings. The quality of the progeny can be tested by sowing the seed obtained either by open pollination or by artificial crossing, or by self-pollination. Only the last two methods are reliable from the genetic point of view. A test of the progeny is necessary, because a fine tree has not always a good genotype, and a good genotype may fail to give a good progeny.

Linked with these investigations dealing with the breeding value of individual trees and stands, a National Register is maintained of all the pine, spruce, birch and other trees which have been selected for future plant-breeding work by different institutes and investigators on account of exceptionally

striking properties, *e. g.* in growth, vigour, and good quality. The number of such trees amounts to about 3,000.

As mentioned above, the Swedish demand for coniferous seed is estimated to be about 60 tons annually, not even half of which can be produced at present. To meet this demand, and also to improve the quality, several investigators have recommended that special "seed plantations", or seed orchards, should be established. In these plantations valuable trees should be multiplied vegetatively, brought to early flowering and crossed with one another. This idea may, if correctly carried out, be of inestimable value to Swedish forestry. In the discussions on this question the genetic side has to some extent been inadequately considered. There is reason to believe that some of the trees now listed as 'plus'-trees will give an unsatisfactory progeny, or in some other way be unsuited as parent trees in a "seed plantation", *e. g.* owing to a high degree of self-fertility. This question and related ones are being studied in experimental "seed plantations".

In progeny tests, as in other planting investigations with progenies of different trees and types of trees, the relative resistance of the progeny to attacks of fungi and insects will be studied, partly in cooperation with the entomologists and mycologists of the Institute, in the hope of finding types with inherited resistance. It is not impossible that crossing will result in improved stocks possessing an increased power of resistance to attacks of several kinds.

The importance of the provenance of seed is an expression of the hereditary geographical variation in forest trees. This question, studied in other Departments ever since the early years of the Institute, is now assigned to the Department of Genetics. The present work aims at a genetical analysis of the problem. On the practical side an effort is made to fix more definitely the ranges within which seed can be used without risk. Attention is also given to the advantages that may possibly be gained by using stock adapted to a climate in some way differing from the local one.

Department of Work Study

In forest production the work involved is always one of the most important items of expense. In order to compare any two different alternative methods of operation it is accordingly necessary to know the features in which these alternative methods differ from one another and thus affect the amount of work involved. It is one of the tasks of the Department to study relationships of this order so that the costs can be correctly introduced into such calculations, in the field of production research as should prove useful for the development of suitable methods of managing and for establishing sound programmes of forest management.

Systematic Work Studies should increase the knowledge of operational processes and speed up the rationalization of forest work.

The main field of Work Study is in the felling and transport of timber. Considerable work in this field has already been carried out for 15 years by research groups financed from private sources. The Department of Work Study recently set up at the Research Institute will work in close contact with these groups.

With the wide variation of methods of felling and transportation throughout the country, not only methods of work but also tools and machines must be adapted to local conditions. Great importance is attached to investigations into methods of work as they are fundamental to the generally recognized need for the occupational training of forest workers. Careful study of the physiological aspects of work is also needed. Important here, too, is the co-ordination of the different stages by which the timber is transported from the stump to the factories. Among the external features which affect the work, the size of the timber plays a leading part. In work that is as pronouncedly manual as forest work is it is particularly important that the manual tools should be just right. This applies not only to the appropriate action of the cutting and splitting tools but also to the suitability of the tools, their strength, convenient handling, and adequacy for the normal power output of the men.

The use of machines for forest work is also important on many grounds, but it is necessary both that the machines should be capable of carrying out the work at a reasonable cost and that the mechanization, from the point of view of organization, should gear in with the normal work without excessive cost. Repeated handling of timber between the different stages of transport calls for particular attention, especially for wood of small dimensions.

Although the work involved in purely silvicultural operations such as sowing, planting, cleaning, and draining is small compared with that required for felling and transport, all possibilities must be examined for increasing the efficiency even of these operations. Their cost falls at the beginning of the rotation and a long period—often many decades—passes before the invested capital is repaid by fellings, so that even small savings in cost can make a considerable difference in the profitableness of the silvicultural measures.

Statistical Office

On July 1st, 1949, a Statistical Office was opened at the Research Institute. The staff consists of a research leader and a number of clerks. The Office is provided with calculating machines of standard type and punched card machines. The punched card equipment at present consists of a tabulator, a reproducer, and two sorters, as well as punching machines.

The Office will undertake calculations which demand more advanced

statistical methods, and calculations which are advantageously carried out by the use of punched cards. The Office also has the task of giving advice to the different sections of the Institute on the design of experiments and the analysis of data.

From this account of the tasks of the several Departments it will be seen that three Departments, *viz.*, Botany and Soils, Zoology, and Genetics, can be grouped as the *scientific departments*, tackling their problems in much the same way as problems of natural science. The other Departments, Forestry, Forest Survey, and Work Study, are concerned mainly with work of a forestry technical and statistical character and can be described as the *forestry departments*.

Besides the natural common interest in the several Departments of the Institute, which binds them together into a single organization, there is important co-operation between the Institute and other scientific institutes, such as the Royal School of Forestry, the Swedish Forest Products Research Laboratory, the Swedish Forest Tree Breeding Association, the Society for Practical Forest Improvement, the several research units for Work Study, the Swedish State Seed Testing Station, the Government Plant Protection Institute, the Royal Agricultural College with the National Agricultural Research Centre, the Royal Institute of Technology and the Universities of Stockholm, Uppsala and Lund.

The research work of the Institute maintains close contact with different activities of practical forestry.

With regard to *Education* at the Royal School of Forestry, the Institute has the following responsibilities: the Head of the Department of Work Study and the holder of a personal Professorship in this subject at the Institute both teach at the Royal School of Forestry. The Head is assisted in this by one of the chief research workers and an assistant of the Department. The Head of the Zoological Department gives lectures on advanced Forest Entomology. Anybody on the staff of the Research Institute may be asked by the Supervisory Board, common to the Institute and the School of Forestry, to lecture on his work and its results. Lectures are indeed frequently given in the Royal School of Forestry by the research members of the Institute. By special appointment the present Head of the Statistical Office has been teaching Statistics and Mathematics at the Royal School of Forestry since 1951.

Organization

The Forest Research Institute is under the same supervisory Board as the Royal School of Forestry.

This Board is composed of the Head of the Board of Crown Lands and Forests, the Head of the Royal Board of Private Forests, the Principal of the

School of Forestry, and the Head of the Research Institute, *ex officio*, together with six members appointed by the Government for three-year periods.

The Institute is in charge of a Head with the title of Professor. His duties are to co-ordinate work within the Institute and to maintain contacts with the other branches of forest research and forest practice. For answering questions on practical forest management research workers of the different Departments may work together in teams whenever needed. For administration and office business the Head has a First Secretary, who also serves as Secretary to the Supervisory Board.

Heads of Department are entitled "Professor", and each is assisted by "Research Leaders" in charge of Sections or special research. There is a varying number of assistants, foresters, forest helpers, laboratory assistants, and others, in the different Departments.

The Statistical Office is under a Research Leader, who has a clerk. The Central Office is under the First Secretary. Questions of more general or wider

Personnel

	F	BS	Z	FS	G	W	SO	A	Total
Head	—	—	—	—	—	—	—	1	1
Heads of Departments	1	1	1	1	1	1	—	—	6
Research Leaders	4	2	1	1	1	1	1	—	11
First Secretary	—	—	—	—	—	—	—	1	1
Librarian[1]	—	—	—	—	—	—	—	1	1
Assistants	3	3	2	4	3	1	—	—	16
Head Clerk	—	—	—	—	—	—	1	—	1
Head Foresters	1	—	—	1	1	—	—	3	6
Storekeeper	—	—	—	1	—	—	—	—	1
Forest Assistants	6	—	—	4	1	1	—	—	12
Cashier	—	—	—	—	—	—	—	1	1
Registrar	—	—	—	—	—	—	—	1	1
Head Laboratory Assistants	—	2	2	—	1	—	—	—	5
Clerks	1	—	—	1	—	—	—	—	2
Commissionaire	—	—	—	—	—	—	—	1	1
Office Assistants	4	—	—	4	—	1	1	3	13
Institute Servants	—	—	—	—	—	—	—	2	2
Other Laboratory Helpers	—	11	—	1	2	—	—	—	14
Other Office Helpers	17	—	—	9	—	1	1	3	31
Total	37	19	6	27	10	6	4	17	126

[1] Serves also Royal School of Forestry.

F = Department of Forestry.
BS = Department of Botany and Soils.
Z = Department of Zoology.
FS = Department of Forest Survey.
G = Department of Genetics.
W = Department of Work Study.
SO = Statistical Office.
A = Administration and Records, including the Head Foresters in charge of the Research Forests.

importance concerning forest research are first discussed by a committee, consisting of the Head of the Institute and the Heads of Departments, before they are brought before the Supervisory Board.

On January 1st, 1953, the personnel of the Institute, with the exception of probationary employees, was as shown above.

There is also the personal Professorship of Work Study. Of the 126 posts shown in the schedule, 90 are on the permanent staff. Not shown in the schedule are some 70 persons temporarily engaged during the working season May—October.

For the budget year 1952—53 the Government has made the following financial provision for the Forest Research Institute: —

	Swedish Crowns
Salaries	997,000: —
Running costs	250,700: —
Special investigations	204,000 :—
Forest products investigations	60,000: —
Forest inventory	388,000: —
Total	1,899,700: —

Besides these sums, the Institute also had in 1952 a sum of 346,000: — Swedish Crowns from the Price Stabilization Fund. The Institute is moreover entitled to collect a refund of the actual cost of any investigations they carry out for State industrial undertakings, Municipal Authorities, Institutions or private individuals.

The research of the Institute is mainly based on analysis and compilation of data collected in the field. Field work is accordingly very extensive. The Institute has thousands of permanent sample plots and temporary plots scattered over the whole of the country. Besides these, it has, as mentioned above, three research forests with a total area of 3,400 hectares, *viz.* Tönnersjöheden in the province of Halland, Siljansfors in the province of Dalecarlia, and Svartberget-Kulbäcksliden in the province of Västerbotten. There is also the experimental area of Bogesund near Stockholm. The Research Forests and the experimental area are supervised by the Head Foresters stationed in them.

The results of the activities of the Institute are printed in periodicals and in three special series published by the Institute, or they are communicated in lectures and practical demonstrations.