

NATIONWIDE SURVEYS OF  
FOREST RESOURCES AND WOOD  
UTILIZATION IN FINLAND

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### Historical data

In the nineteenth century the need of statistical information on the forests of this country was strongly felt in Finland. Data on the forest area were published in 1842 by a committee that had prepared statutes concerning the forests. In 1853 G y l d é n produced an estimate of the area under forest, the annual growth and the wood consumption, and of the utilization of wood for different purposes. A new estimate was made in 1863 by S o l d a n, using the results of the former investigator as his chief source of information. The forest committee of 1865, B l o m q v i s t (1880, 1893), S i v é n and S a l l m é n (1885, 1893, 1894), the committee appointed for the study of the presumed excessive cutting (1874), and the private forest committee of 1896 each produced a new estimate.

Some of the above-mentioned papers also contained a description of the forests. Of such chiefly verbal descriptions particular mention should, however, be made of the reports of the German v. B e r g (1859), the Scot B r o w n (1883), and H a n n i k a i n e n (1896), and of B l o m q v i s t's annotations from extensive journeys made in 1867—1869, which have been preserved.

The acquisition of forest statistics was eagerly debated at the meetings of the Finnish Forestry Association in the eighteen eighties and nineties and during the first two decades of this century. Statements and proposals were chiefly made by B l o m q v i s t, S a l l m é n and C a j a n d e r. The most noteworthy result was the report of the committee appointed in 1916 by the Association, in which the question of whether the Finnish forests were being excessively cut was put and the measures to be undertaken should the answer be in the affirmative were discussed. Several persons investigated or estimated the forests in various parts of the country or the possessions of some forest owner group, or tried to describe the forests of the whole country, or of the various owner groups, on the basis of the information available.

At the meeting of the above-mentioned association in 1907, C a j a n d e r produced a detailed program, which was used as a basis when in

1909 the Forestry Association Tapio instituted measures finally leading to the line survey, carried out in 1912, of the forests of two communes in central Finland. The purpose was to make a sample survey, in which methods could be elaborated for a future survey of the forests of the whole country. At approximately the same time, in 1907—1911, sample surveys of the forests were performed in the provinces of Åmot in Norway and Värmland in Sweden. The survey in the latter was carried out on a broad scale and influenced methods for a long time to come.

### The surveys of forest resources

In 1921 a survey of the forests of the whole country was commenced along entirely new lines. This is known as the first National Forest Survey. During the first year it was experimental in character, the proper survey being performed in 1922—1923. The survey was completed in 1924.

The method used consisted in mechanical measurement of sample plots in conjunction with ocular estimation of all the stands within the range of the lines to be surveyed. The intention was to achieve rapidly and at moderate expense a complete and adequate view of the forest resources and the condition of the forests both in the country as a whole and separately in the different provinces and main water system areas. Parallel survey lines were drawn through the country in the direction SW-NE, *i.e.* perpendicularly to the main longitudinal direction of the Finnish land compartments, as is usual in line surveys.

The method of ocular inspection, which is of long-standing use in this country, has in the course of time been brought to a high degree of perfection. In each bio-economic unit, or forest stand, touched by a line, the main characteristics of the tree stand are estimated with the aid of tables and measurements. These estimates relate to species and age, volume and growth per hectare, silvicultural condition, silvicultural measures that should be carried out, etc. Further the land compartments along the lines are classified according to the nature of the land utilization and the site type of forest or swamp. Thus statistical information is obtained.

The foresters acting as leaders of the survey groups had specialized in ocular estimation both as undergraduates and subsequently. Prior to surveying they were trained for this task in different types of stand on the measured sample plots and on the sample lines. Furthermore the

estimates of each leader were checked by the measurement of sample plots at fixed intervals along the survey lines of his group. Before measurement was begun he had to ocularly estimate the characteristics of the sample stand in the same way as in every other stand along the line. When the results from the sample plots had been calculated during the winter, the ocular estimates and the corresponding calculated results of each group leader were compared. This was often done separately for different lines or parts of lines.

Checking was performed by correlation analysis. The regression lines thus obtained proved a useful basis for correction of the ocular estimates. The correlation coefficients for volume per hectare, for instance, were as a rule over 0.9 and their mean errors were very small, *e.g.* in the second survey  $0.93 \pm 0.008$  on an average. As was to be expected, the correlation coefficient for growth was somewhat smaller, in the second survey  $0.84 \pm 0.017$ .

The results from the sample plots thus give an opportunity for various comparisons. At the same time they serve another important purpose, namely the detailed analysis of the growing stock, *e.g.* with regard to its distribution in diameter classes, the quality of the trees and the distribution according to the different kinds of wood products. Furthermore trial markings on the sample plots serve as a basis for estimation of the felling quantity and its composition.

It has proved useful to proceed thus along two lines of investigation. Ample material for research is obtained in a relatively short time and at moderate expense.

The second National Forest Survey was carried out in the years 1936—1938. The method was essentially the same, but developed further in many respects so as to yield results satisfying modern requirements.

In most parts of the country survey lines and circular sample plots, 0.1 hectare in size, were distributed twice as closely as before. The funds available were greater, and the intention on this occasion was to calculate results of sufficient accuracy for all practical needs from smaller areas than previously.

The principal aim was to collect more detailed information regarding the number and quality of the large-sized trees of different species. In particular attention was paid to the silvicultural condition of the forests and to the measures to be undertaken for their improvement such as felling, artificial regeneration, etc., and to the felling quantity and its composition. It was regarded as essential to examine the results indicating

growth in the light of climatic variations. Hence some thousands of increment cores were taken at breast height from the surface to the pith of the trees in stands where no felling had been performed. These were measured with great accuracy by the measuring instrument developed by Bo Eklund. Noteworthy results were thus obtained, which served to eliminate false conclusions.

In the calculation of the results of the survey a punch card system was employed. For this purpose forms to be used in the field work in 1935 were made in such a way that the data recorded on them could easily be transferred to the punch cards. Thus the results from the whole country were ready some few months after the field work had been finished. Results were also calculated separately for all the main water system areas and forestry board districts.

When 3.2 million hectares of forest were ceded to the Soviet Union in the peace treaty of 1944, the results of the survey had to be recalculated for present-day Finland. These data had to suffice until a National Forest Survey was again carried out.

This was planned, and detailed instructions for the field work were drawn up, in 1950; in 1951—1953 it was performed.

The method was again essentially the same, but modified so as to meet the present requirements of forestry. The line survey and the measurement of sample plots were made in the field, except for some districts in the outer skerries and a small part of northernmost Lapland, which were examined by aerial photography, control plots measured in the field serving as a basis for the estimations.

Greater attention was attached to the number and quality of the large-sized trees. As far as these were concerned, the number of circular sample plots, 0.1 hectare in size, was doubled; the distance between them was 500 metres. The examination of the silvicultural condition of the forests and the planning of felling and other measures to be performed were also more thorough than before. The recovery of tree stands on drained swamps was studied, and the progress where such swamps were becoming covered with seedlings was followed. Furthermore observations were made on the racial peculiarities of the trees, etc. In connection with the survey an investigation of the occurrence of the different plant species and certain animal species was made, and the vegetational composition of various forest and swamp site types was studied. Hence a biologist trained for this purpose was attached to each survey group.

In all the national forest surveys it has been regarded as essential that

the results should be calculated separately for the different groups of owners: the State, private owners, companies, etc. Marks denoting the owner group were made prior to the survey on the maps to be used and local guides were employed to help in the classification.

When the results of a survey have been calculated, the main results are checked by statistical analysis. In 1921—1924 the standard error of the forest percentage, for instance, was  $73.5 \pm 0.66$ ; in 1936—1938, when the number of survey lines was twice as great, it was  $71.3 \pm 0.31$ ; a part of the forest land had been cleared to cultivated field, etc. The corresponding figures for the average volume, the northernmost forests included, were  $64.3 \pm 0.96$  and  $62.8 \pm 0.29$ , and for the average annual volume growth  $1.77 \pm 0.029$  and  $1.84 \pm 0.007$ . The calculation of these figures for the third survey is not yet concluded. The corresponding mean values are 71.7 per cent, 68.2 cub.m./hectare, and 2.0 cub.m./hectare.

The differences in the averages of the two first surveys are not great, and they fall within the limits of a threefold standard error. A detailed examination has, however, revealed considerable changes. Furthermore it should be borne in mind that the cession of forested areas to Soviet Union in 1944 reduced the forest resources of Finland by 11—13 per cent. There have been great variations in the annual consumption of raw material of the forest industry. In the nineteen-thirties a very promising start had been made in improving the woods. During the war and post-war periods this work came to a standstill, but in recent years the activity has again rapidly increased. The third National Forest Survey, carried out in 1951—1953, was felt to be an absolute necessity. It shows that the forest resources have improved since 1936—38.

The results of the surveys have been used for various purposes. In the first place they have served as a basis when measures for the development of forestry and other economy and of forest industry have been planned.

### The surveys of wood utilization

Many of the calculations mentioned in the part »Historical data» served for the approximately quantitative estimation of forest growth and consumption and their relation. Furthermore endeavours were made to estimate the utilization of wood. The data being, however, very inadequate, the results were unreliable. The first estimates made on a somewhat firmer basis were contained in the reports of the private forest committee of 1896

and of the committee appointed in 1916 by the Finnish Forestry Association. When in 1922 Strömberg and Krohn investigated the consumption of firewood, they also tried to estimate the consumption of wood in the whole country. On the basis of these and some other calculations Kovero made a new estimate for 1925.

Some other hesitant attempts were also made, in particular relating to less extensive areas. Mention may also be made of a calculation of the ratio between growth, growth capacity and consumption (Ilvessalo 1920), which was the first attempt in its kind. An investigation by Sari (1922) of the consumption of wood for home use in a certain province was carried out on a really scientific basis. This work has been of significance as a guide for later investigations.

The great expansion of the Finnish forest industries during the nineteen-twenties and the fact that the first National Forest Survey of 1921—1924 had provided the necessary data for one side of a forest balance expedited the realization of a thorough investigation of the factors relating to the other side of that balance, namely the removal of wood resulting from felling and natural destruction, and the utilization of the wood. Thus the first investigation of wood utilization in this country was undertaken.

It was carried out in 1927, and the purpose was to analyse in detail the various aspects of wood utilization and the other factors influencing the extent of removal of wood. It was also necessary to carry out auxiliary investigations for calculation of the volumes of saw and veneer logs and of hewn timber, and to determine the amount of logging waste and of waste resulting from floating and barking and the quantity of bark. Furthermore the solid cubic content of the cordwood and the shrinkage due to drying had to be considered. The investigation itself was based on direct measurements, official and other statistics, enquiries, and to some extent on estimates.

The most time-consuming and difficult part of the task was to determine the domestic wood consumption of the rural population. For this purpose all the wood felled during one year on 1337 sample farms was measured and entered by trained forest technicians, each working in a separate district. The sample farms were selected at random from agricultural statistical data from the different parts of the country. On calculation of the results, the districts were united to largely similar domestic wood consumption areas, in which the average consumption of wood per individual could be made out from the data entered and the population statistics. In the end, when calculations had been made on various levels, the domestic

wood consumption of the rural population of the whole country and of the different provinces was determined as a total, by species of tree, and according to utilization.

Official and other statistics and enquiries served as a basis for the determination of the export of unmanufactured wood, of the quantities used as raw material and firewood in the forest industries, and of the consumption of the railways and other means of communication, of the towns and various government offices in towns or elsewhere, and of municipal and other institutions.

The investigation yielded extensive and complete statistical data regarding the utilization of wood by species of tree, group of consumer and type of wood product, and regarding the volumes of wood used for different purposes.

In 1938 — which was the last year in which field work was carried out for the second National Forest Survey — a second investigation of the utilization of wood was commenced in order to ascertain the changes and the development that had perhaps occurred. This work was also done by the Forest Research Institute. The method was essentially the same as before, but brought up to date.

The number of sample farms chosen for the investigation of the domestic consumption of wood by the rural population was greater than before, 1900. The main concern of the investigation was again the stem wood, as in the investigation of the forest resources and growth at the forest survey. The utilization of all kinds of waste wood — branches, stumps and roots, laths, old wattled-fence stakes and building timber — and of chips and cones, etc., as firewood was, however, also considered.

The calculation of the results was much delayed by the war and the subsequent difficulties. In connection with the main investigation a number of secondary investigations were again performed, which throw light on various questions relating to the utilization of wood and the forests. The main investigation was carried out on the principle that the total consumption of wood during one year should be determined as accurately as possible. With regard to the kinds of wood subject to fluctuations in the market, the consumption was also determined for all the years from which reliable information was available. By making random investigations for a number of sample years attempts were also made to elucidate the rather small annual variations in the consumption of the kinds of wood largely independent of these fluctuations.

Today the results of this investigation of wood utilization are no longer



regarded as valid owing to the great changes that have subsequently occurred, mainly as a result of the cession of extensive territories to Soviet Union in 1944. The population of these, almost half a million in number, moved to present-day Finland, whose forests have to suffice for their needs also. The field work of the third National Forest Survey having been completed in 1953, the Forest Research Institute has therefore commenced a third investigation of wood utilization in Finland in 1954.

### The forest balance

The investigations relating to the utilization of wood have as far as possible been carried out simultaneously with the National Forest Surveys in order to obtain comparable information on the two aspects of the forest balance.

By determining the consumption of wood and, in connection with this, the cutting waste, floating losses, etc., and with the aid of tables elaborated for the conversion of the quantities of different kinds of wood products into volume of stem wood it has been possible to calculate the annual felling quantity. The annual total removal of wood from the forests has been calculated by adding to this the quantities of wood rotting on the spot as a result of self-thinning or natural damage. The annual total removal has been calculated not only for the year of investigation, but also, using the aforesaid method for each year of the period between two forest surveys. The results have been calculated both for the whole country and for the main water system areas, the forestry board districts and, in part, for the different owner groups.

By comparing the annual removal with the annual growth it has been possible to make a so-called growth balance. For the sake of comparison a growing stock balance is made by considering separately the changes occurring in the volume of the growing stock. It is, however, only under certain conditions that either of these balances shows whether felling has been excessive, or whether it would be possible or even desirable to fell more, considering the maintenance and profitable development of the forests.

The establishment of growth as an index for felling is, of course, based on the assumption that the forest area is evenly distributed over the different age classes until the rotation time of the species of tree and the site, and that the volumes of wood in the different age classes are up to

expectation. In order to make a balance based on the growing stock it is also necessary to make comparisons relating to structure and not only to total volume.

Endeavours have been made to calculate the so-called silvicultural felling quantity by examining the felling that ought to be carried out during the next period of, for instance, ten years in each forest stand touched by a forest survey line, by estimating the quantity of wood to be removed in the felling — considering the growth still due — and by checking the estimates on the basis of sample markings carried out on the circular-sample plots measured on the survey lines. A comparison of this with the real felling quantity and with the annual volume growth gives another kind of balance. The last, and apparently most adequate method used in this country is the so-called rental cut calculation (L i h t o n e n 1946), by which a felling quantity is calculated which is compared with the real felling quantity and with the volume growth.

A forest balance is an essential condition of judicious forestry, and therefore different methods have been tried for its determination. In order to make a reliable balance it is necessary to estimate the forest resources, and to investigate the removal of wood and analyse the composition of both the resources and the removal. — The forest and wood balances have been examined in a special paper by S a a r i (1953).

## List of the main publications in chronological order

(In these publications are to be found the titles of the other publications referred to in this paper)

- Ilvessalo, Yrjö, The forests of Finland. The forest resources and the condition of the forests. A paper discussing the main results of the General Forest Survey. (Communicationes Instituti Forestalis Fenniae 9. Helsinki 1924). Published in English.
- »— The forests of Finland. Results of the General Survey of the Forests of the Country carried out during the years 1921–24. (Ibid. 11. Helsinki 1927). Finnish with English summary.
- Saari, Eino, Wood utilization in Finland. With appendixes of Paavo Aron, Eino Hartikainen and V. Pöntynen. (Ibid. 14. Helsinki 1934). Finnish with English summary.
- Ilvessalo, Yrjö, The forest resources and the condition of the forests of Finland. The second National Forest Survey. (Ibid. 30. Helsinki 1942). Finnish with German and English summaries.
- Erkkilä, E. E., The total wood utilization of the rural population and its development. (Ibid. 32. 1. Helsinki 1943). Finnish with German summary.
- Lihtonen, V., Regulation of Finnish forestry in the light of removal and rental cut. (Acta forestalia fennica 53.3, Helsinki 1946). Finnish with English summary.
- Osaara, N. A., Pöntynen V. and Erkkilä E. E., Wood utilization and forest balance in Finland. (Comm. Inst. Forest. Fenniae 36.4. Helsinki 1948). Finnish with English summary.
- Ilvessalo, Yrjö, The forests of present-day Finland. A description based on the National Forest Surveys. (Ibid. 35.8. Helsinki 1949). English.
- »— Third National Forest Survey of Finland. Plan and instructions for field work. (Ibid. 39.8. Helsinki 1950). Finnish with English summary.
- Saari, Eino, Wald- und Holzbilanzen. (Acta forestalia fennica 60.2. Helsinki 1953). German.
- Ilvessalo, Yrjö, The forest resources of Finland in the light of three National Forest Surveys. (Comm. Inst. Forest. Fenniae 43.4. Helsinki 1954). Finnish, Swedish, English.

## Selostus

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