THE INVENTORY OF FOREST RESOURCES

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A knowledge of the forest resources of an individual country, and even of the whole world, may be considered important for many reasons. Only with reliable statistics gathered as far as possible simultaneously can a forest producing country summarize its forest balances. Only if such data are available, can the forest working industries of a country make their calculations of the existing supplies of raw materials, which is essential in planning operations that extend far into the future, and in organizing new industrial establishments or enlarging the existing ones. In addition to knowledge of the forest resources of a country and its separate districts generally, from the point of view of a country’s forest grower it is also important to know in what direction the forest production of the country is developing, and what advantages seem permanently to exist for carrying on forestry and for making it more efficient. From the economic point of view of an entire country, apart from a knowledge of its own forest resources, a familiarity with the forest resources of other forest producing countries is also essential. As the countries importing forest products partly meet their lumber demands from their own forests, it is important, both for the economics of such countries themselves as well as from the point of view of the countries exporting wood products to them, to be acquainted with their forest resources as well. It would, therefore, seem desirable from the economic point of view of each individual country, as well as from that of the whole world, that reliable, homogeneous, and as nearly as possible simultaneous forest statistics should be compiled of the whole world, or at least of those forest resources included in its economic sphere, together with data of wood consumption and of the forest balance.

Several countries, realizing the importance of their forest resources have already compiled such statistics, or are now preparing them. But many countries have no such statistics whatsoever, or they are
based on the results of rather uncertain calculations and estimates made at different periods. In most countries, and in the greater part of the world’s forests, in order to establish reliable, homogeneous and simultaneous statistics of forest resources and of the present condition of the forests, a general survey of forests equivalent to an inventory of the forest resources should be instituted.

The present time may be considered suitable for general inventories of forest resources on a large scale. The forest resources of the world have diminished to a great extent because of the increased consumption, and the value and uses of forests have thereby greatly increased. New uses for wood have constantly appeared, accelerating even its present rapid rate of consumption. In many countries, too, that export forest products, the annual consumption of the forests has already exceeded or will soon exceed the annual growth, so that the forest balances should quickly be ascertained, before cutting is increased and a return to an equilibrium becomes difficult. The fact is not without significance also, that the necessary labour for this kind of inventory work can at present be had easily, since men of the forestry profession in very many countries are suffering from lack of employment.

There are several methods for making inventories of the forest resources of a country, and different methods may be applicable in different countries. In countries where forestry is intensive and where the forest owners generally have working plans drafted for their forests, it may be possible, on the basis of these, to gather reliable and sufficiently homogeneous and simultaneous statistics on the condition of the country’s forests and on the forest resources in full. But on the other hand, this method is not applicable in countries where forestry is less intensive, and the summarizing of forest resources becomes possible only through a general, simultaneous survey. In the latter case, which is the case with the largest part of the world’s forests, a separate survey of all the forests of the country naturally is neither possible, nor even necessary, but recourse in this instance should be taken to some tried, representative method. This case only is referred to in the following, which describes the general outlines of a plan for a system that can be used in surveying a country’s forest resources.

The representative method of forest surveying generally presupposes the taking of so-called sample plots. There are, of course, many different ways of taking these sample plots. One of these methods,
Line forest surveying, which has been used in forest inventory for a long time in the northern countries, among others in Suomi for about half a century, has been demonstrated to be very suitable for the purpose in question by many previous investigations and at present on the largest scale by the recently completed simultaneous survey of the entire forests of Suomi, both in regard to the reliability of its results as well as its quickness and comparatively low costs.

Line surveying, in a way, comprises a large number of sample plots (lines) that are scattered evenly over all parts of the forest under survey. This, therefore, is a representative method in which, in order to obtain the most approximately correct results and the actual variation, the mutually parallel sample lines are always placed equidistantly from each other, and as perpendicularly as possible to the general longitudinal direction of the land figures (map figures). When lines are thus laid sufficiently close together, it is probable that they will correctly interpret the entire forest, if the district under survey consists of a collective whole.

It is obvious, that in line forest surveying the closer the lines are drawn to each other, the greater the accuracy which is obtained, for thus the greater percentage of the entire forest area is surveyed. By diminishing more and more the distance between the lines any accuracy desirable is reached, but this, of course, only by increasing the costs in a corresponding measure. Such a distance between the lines, or survey percentage, must therefore be chosen as gives the required accuracy at reasonable cost. Tests that have been made have shown that in order to obtain a satisfactory accuracy the survey percentage may be relatively so much smaller, i.e. the lines so much wider apart, as the area under survey is larger and more homogeneous. The accuracy of line surveying primarily depends on the distance between the lines, and not nearly to the same extent on the width of the lines themselves. By placing narrower lines closer together the variations are better accounted for, and generally in statistical work the accuracy of data increases as the square root of the number of observations.

Line surveying is an advantageous method also in this way, viz.: — that the accuracy of the results can fairly easily be tested with the aid of methods based on mathematic-statistical calculation which are already developed on a firm foundation and which in Suomi, too, especially during very recent times, have been under most thorough investigation.
In commencing the surveying of an entire country's forests, a programme comprising the smallest details is necessary, for only in this way can the work of several survey parties be made similar throughout, so that all the results can be combined in due course without trouble into one group of statistics. For the same reason it is also important that the foremen in charge of the labourers engaged in the work, should be fully competent men, who have been thoroughly trained in line surveying on trial lines before the commencement of the work, and that the work of the surveying parties is continuously watched and directed.

When a homogeneous and a simultaneous statistical report of the forests of an entire country is the main object of the survey, in addition to the above, it is also desirable that the time of the survey shall not be spread over too long a period, but over as few successive years as possible in order that age-class, volume, growth, and other data can be adapted to some chosen epoch, without more or less inaccurate extraneous calculations. Thus, it would seem expedient for the linear distance to be chosen of such an extent, that while very accurate results (say within an accuracy of 1 %) are rapidly obtained for the most important questions with regard to the whole country, in some degree less exact results (say within 5 %) may be accepted for its smaller districts.

The survey lines are planned on the most accurate map of the country obtainable, and each surveying party receives a line map of its own territory for checking and other purposes.

The composition of the surveying party depends on the kind of work to be done on the line. When the line survey comprises in addition to regular surveying, also the counting and measuring of trees occurring within a chosen width along the line, the most suitably composed party should contain 8 persons: (1) a foreman (this position is filled best by a forester who has graduated from the highest course in forestry at college and who is especially skilled in forest mensuration), who supervises the work and does the estimating etc., filling in the survey form for every figure touched by the line; (2) a book-keeper (this position is filled best by a practical forest ranger who is a graduate of a lower course in forestry), who, among his other duties, records the gauger's announcements of the diameter measurements in the usual way; (3) a compass-man, who, travelling ahead of the rest of the party, determines the direction of the line with a dioptric-compass; (4, 5) two measurers, who measure the distances
travelled for the determination of the length of each land figure occurring on the line; (6, 7) 2 gaugers, who measure the diameters of the trees occurring on the respective sides of the line; (8) a porter, who assists in carrying instruments, tools, etc., and who measures with a staff the width of the line from its centre, whenever necessary to indicate to the gaugers which trees are included in the line. If growth investigations are constantly made in connection with the survey, then more assistants are needed.

In such territories where forestry is rather intensive and sufficient funds are available, the composition of the line surveying party, as outlined, is probably the most suitable. But where forestry is less intensive and costs have to be considered, the expenses can well be reduced without great detriment, especially by not counting the trees continuously nor taking growth data along the entire line, in which case these data are limited to sample plots that are measured at regular intervals along the line. (For sample plots in the survey of Finnish forests, for instance, the last 50 × 10 m² of every second kilometre of the survey line were chosen, and for the scarcer, but more important merchantable timbers [trees of at least 20 cm at breast-height] a gauging area of 100 × 10 m² taken also, at the end of every other kilometre). In addition to smaller expenses, this is advantageous, too, for the reason that on long survey lines there cannot be full assurance, even with constant supervision, of careful definition in counting or leaving out the many trees that occur just on the border of the line, which is likely to cause considerable errors, because each tree represents several hundred or even several thousand trees, depending on the size of the surveying percentage. The daily working results are about 2 km more, and the working expenses are reduced to about one-half of those described in the first instance, if the individual measuring is limited to the sample plots only.

In limiting the counting of trees to sample plots, the volume and the growth of the stands cannot be calculated separately for each land figure touching the line. But as it is necessary for statistical purposes to know the volume and growth of each stand touching the line, these are estimated ocularly, while travelling along the line through the woods with the help of growth and yield tables so far as they exist, and other subsidiary means. The estimating is done by the foreman of the party, who must be versed in this kind of work. But ocular estimates, by themselves, cannot, of course, be accepted as satisfactory, because with them might be combined, besides occasional
errors in a positive and negative direction which generally counter-
balance each other on a large scale, also systematic errors, which
make the estimator's results regularly too large or too small, etc.
This systematic faultiness must be absolutely eliminated from the
estimated results before they are used. For this reason the ocular
results of the estimator are checked and corrected, after completion
of the work, with the aid of the sample plots that he has taken, upon
which his ocular estimate is known and upon which the calculated,
or actual volume and growth is later obtained by calculations in
the office. In Suomi, where ocular estimation is used to a considerable
extent, this checking is generally accomplished with correlation
calculations and with the aid of regression lines, based on them. The
estimates of each estimator are checked in several sections, so that
possible variations at different times will also become apparent.
It is also often advantageous to check separately the estimates of
large and small volumes, as well as that of growths. By drawing
on the same co-ordinates (where the abscissa is the calculated and
the ordinate the ocularly estimated volume or growth), a normal
line and a smoothed line indicating the estimator's manner of ocular
estimating, which is obtained from the regression equation in checking
his estimates, the estimator's ability will be seen clearly, and whether
or not it contains systematic faultiness and of what kind the latter is.

The correlation between the ocularly estimated and the calculated
values of volume or growth is especially distinct; thus, in the survey
of Finnish forests the correlation coefficient, on the average, was
for volume $0.902 \pm 0.016$, and for growth $0.800 \pm 0.024$, so that
ocularly estimated values for volume and growth can be corrected
with great certainty to coincide with reality with the aid of such
smoothing calculations.

The facts to which attention should mainly be devoted in line
surveying and which therefore should be contained in the surveying
forms upon which they are marked at every figure touching the line
in order to give sufficiently illuminative statistical data on the different
aspects of the forests and the forest lands, may be mainly limited
to the following:

*Land owners*, differentiating between the most important groups,
such as the State, private owners, Joint Stock Companies, commu-
nities, etc.

*Superficial deposit*, as for example, moraine, sand, clay, etc.

*Kind of land*, as for example, forest land, field, etc.
Quality class of the locality (site), i.e., forest or moor type.

For the investigation of forest lands it can also be stated, whether the figure is for grazing purposes or not, whether it is considered fit for cultivation or not, and for the investigation of moors, the depth of the moor, the possibilities of drainage and of cultivation, etc.

In estimating stands, undergrowth and so-called hold-overs are distinguished from the dominant forest, whenever the stand is of such uneven age and of such uneven height that such successions are easily perceptible.

The species of trees are recorded by estimating what percentage of the volume of the stand belongs to each species of tree.

Age-class is determined in odd 10-year periods by boring (10 = age-class 1—20 years, 30 = age-class 21—40 years, etc.), and in uneven-aged stands both the mean age and the age limits are noted.

Density of the stand is estimated according to how many tenth parts of the area of the figure are covered by forest.

Quality class of the stand is best recorded by the aid of growth and yield tables by estimating how many tenth parts the volume of the stand forms of the volume of a corresponding normal stand.

The height is estimated for dominant height (Oberhöhe).

The growing stock is estimated with bark included, for instance, to full 10-cubic metre amounts per hectare.

The volume growth (current annual) is estimated unbarked by the aid of experience, growth-boring, and with the growth percentages of growth and yield tables, for instance, to one-half cubic metres.

When the line runs along the border of two estates, types, or stands, the length of the line is divided between them.

In order to show the present silvicultural condition it is important that for each figure and stand on the line, records pertaining to this phase are also taken, i.e., is the forest unthinned or thinned, or cut; what thinning or reproduction cutting method has been used; has the stand been spoiled or destroyed by cutting; artificial reproductions, etc.

A comprehensive statistical record of the forests can be arranged from the data on the above facts alone, which may be considered sufficient for taking an inventory of the forests of a country and for outlining plans for the forestry in the future. Since the survey, as it has been described here in some of its most important features, is comparatively inexpensive (the outdoor work of the Finnish survey cost — the linear distance being 26 kilometres — one dollar for each
Suomenkielinen selostus.

Maan metsävarojen arvioiminen.

Monista sekä metsätalousdellisista että yleisistä kansantaloudellisista syistä pidetään nykyisin hyvin toivottavana yhtenäisenä ja luotettavan tilaston aikaan saamista jokaisen maan ja koko maailmankin metsävaroista sekä puunkulutuksesta ja metsätaseesta kokonaisuudessaan. Useat maat ovatkin jo ryhtyneet toimenpiteisiin tällaisen tilaston laatimiseksi. Enimmässä maissa ovat tiedot maan metsävaroista niin epäluotettavina ja puuttueellisena, että tilaston aikaan saamiseksi on varta vasten suoritettava maan metsien yleinen arvioiminen.

Menettelytapoja maan metsävarojen selvittämisessä on useatakin valittavissa ja eri maissa lieneekin erilaisia menetelmiä sovellettava. Muutamissa maissa, missä metsille on luotettavasti ja suhteellisesti halpa, myöskään sinä suhteessa edullinen arvioimistapa, että sen tilaston luotettavuus voidaan verrata halvasti jo varmalle pohjalle kehitettyjen matemaattisetilastollisten laskelmien avulla.

Pohjoismaissa on sekä käytännön että tutkimusten perusteella parhaaksi menetelmäksi suuria metsääloja arvioitaessa osoittautunut n. s. linjaruoiminen. Tämä menetelmä on, paitsi yleensä tarkkoihin tuloksiin johtava ja suhteellisesti halpa, myöskään sinä suhteessa edullinen arvioimistapa, että sen tulosten luotettavuus voidaan verrata halvasti jo varmalle pohjalle kehitettyjen matemaattisetilastollisten laskelmien avulla.

Ryhdyttäessä kokonaisen maan metsävarojen arvioimiseen on yksityiskohtaisesti pieniäkin seikkoja selvitelevän suunnitelman laatiminen ja arvioimistöissä toimivien henkilöiden harjoittaminen koelinoilla välttämätöntä. Vain siten on tekevä lukuisien arvioimisjoukkojen hyvän yhdenmukaisuudesta.

Milloin yhtenäisen ja yhtäaikaisen tilaston aikaan saaminen koko maan metsistä on arvioimisen päättäytyksensä, on edullista, että arvioimistö ei jakaamattakaan pitkälle ajanjaksoille, vaan mahdollisimman harvoihin peräkkäisiin vuosiin, niin että tilastot voidaan ilman epävarmoja lisäskelmiä keskittää johonkin määrättyyn aikavaiheen. Tällöin voidaan tarkoituksenmuokaiselta määrätä arvioimisjoukkojen välineen etäisyys niin suureksi, että koko maahan nähden saadaan tarkat tilokset mahdollisimman nopeasti, kun taas maan pienempiin osiin nähden tyydytään jonkun verran vähemmän tarkkoihin tuloksiin.
Laajoja alueita käsitettävässä linja-arvioimisessa ei suurien kustannusten takia useiminkaan kannattaa suorittaa puiden lukua ja mittausta, kasvututkimuksia j.n.e. yhtämittaisesti pitkin matkaa koko linjalla, vaan ne rajoitetaan linjoilla määritettyjen säännöllisten välimatkojen päässä toisista oteuhille koeloihelle. Päivitystakin vastaaminen supistamiseksi tänä on edullista siitäkin syystä, että pitkällä arvioimislinjoilla ei voi olla aliteisesti silmälläpidosta huolimatta riittäviä takeita juuri linjakäytäleen rajoille sattuvien sangen lukuisien puiden joko mukaan lukemien tähän pois jättämisen houlellisesta tarkastamisesta, mistä taas voidaan aiheuttaa virheellisyyksiä, kun arvioimisprosentti pakastakin on hyvin pieni.

Rajoitettaessa metsikköön kohdistuvat suoranaiset mittaukset koeloihin, toimitetaan arvioiminen koelojen välisillä linjanosilla jokaiselle metsäkuivilla silmämääräisesti. Arvioimisen toimittaa arvioimisjoukkoon johdava, jonka siis tulee olla tällaiseen työhön hyvin harjaantunut. Silmämääräisen arvioimisen tuloksiin sellaisista ei lainkaan tyydytä, vaan ne ovat tarkistettavat ja oikaistavat sitä varten kehitettyjä, yleensä korrelatiolaskelmia ja niiden avulla saataviin regressiokuvioihin perustuvia menettelyjä käyttäen. On osiittautunut, että arvioimisen perhehtyeillä henkilöillä on silmämääräisen arvioimisen tuotteita tähän kasvuvarojen ja laskettujen elli todellisten kuutiomääärä- tähän kasvuvarojen välillä erittäin selvä riippuvaisuus. Nämä tätä riippuvaisuutta osottava korrelatiokerroin oli Suomen metsien yleisessä arvioimisessa toimineilla arvostelijoilla keskimääräinen riippuvaisuus nähden 0.902 ± 0.016 ja kasvuun nähden 0.800 ± 0.024, joten silmämääräiset arvot voitiin sangen suurella varmuudella oikaista täysin todellisuutta vastaaviksi.

Ne seikat, joihin arvioimisessa ensi sijassa on huomioita kiinnitetävää ovat: maanomistaja, maalaji, tiluslaji ja metsätäyppi, metsikön puulaji-, ikäluokka-, tuheys- ja hyvyyssuhteet, metsikön kuutiomäärä ja vuotuinen kuutiokasvu ha kohden, n.s. arvopuiden lukumäärä sekä metsikön nykyinen metsänhoitollinen tila. Jo näitä seikoja käsitettävien muistiinpanojen perusteella saadaan metsitä riittävä tilasto maan metsävarojen selvittämiseksi. Kun arvioimistyö sellaisena kuin se tänään muutaminiä tärkiempiin piirteteisiin nähden on kuvattu vaatii suhteellisuutta vähän-kustannuksia — esim. Suomessa 26 km linjaväline suoritettuna keskimäärin 1.7 penniä valtakunnan maalaalan jokaista hehtaaria kohden ja 2.4 penniä metsähehtaaria kohden — ei liene voitettavatnimia esteitä olemassa yli useampiin maiden metsävarojen arvioimiselle lähtökohtina.