Forest Research Branch

CANADIAN FOREST INVENTORY METHODS

by

H. E. SEELY

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ABSTRACT

The subject is introduced with a reference to the employment of forest inventories in Canada for the collection of important data on the forest resources, including information for use in forest management.

It is stated that from an operational point of view the most important development in forest inventories in Canada during recent years has been the Federal-Provincial Forestry Agreements entered into initially in 1951.

The special value of aerial photography, and advances made in its use in forestry, are emphasized.

An indication of the dependence of forest inventories on surveying and mapping and of the construction and use of forest maps is provided.

Photo interpretation for forestry purposes, including the determination of tree heights and the density of the forest stand, and the recognition of tree species, is mentioned. In this connection the possibilities for special aerial photography are recognized.

The approach to forest inventories through stratification and sampling is referred to, as are various sampling methods. Also, stand volume tables and tree volume tables, based on variables ascertainable from the aerial photographs, are mentioned. Reference is made to current investigations in the use of large-scale aerial photographs for sampling purposes.

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Canadian Forest Inventory Methods[1]

by H. E. Seely[2]

Canadian forest inventories are mainly characterized by the classification of the forests on aerial photographs, co-ordinated with field sampling. The degree of detail secured is largely related to the intensity of forest management requirements. No discussion of these inventories would be satisfactory without proper reference to the importance of aerial photography. Topographical mapping has progressed very greatly since the coming of the aerial photograph and the investigation of natural resources, including the forests, has been facilitated. The measurement of trees and forest stands in the aerial photographs for volume estimation is largely based on photogrammetric principles similar to those applied in topographical mapping. Closely related to the quantitative information is the qualitative information supplied through photograph interpretation of species, cover types, and site types. Changes in forest inventory methods have consequently taken place. At one time the forester found it necessary to proceed without a great deal of knowledge of what lay ahead of him on the "cruise line". With the arrival of aerial photographs and the use of the stereoscope small-scale models of the forest became available from which comprehensive information could be secured in advance of the field work.

From an operational point-of-view, the most important development in forest inventories in Canada during recent years has been the Federal-Provincial Forestry Agreements entered into initially in 1951. On the basis of these agreements the Federal Government is making financial contributions to the provinces to facilitate progress in forest inventories. The agreements have been largely on a provincial inventory basis and have had little or no application to intensive forest surveys as conducted by the provinces and the forest industry, particularly for detailed forest working plans or timber operating surveys. To a very large extent the initial provincial inventories have been completed but re-inventory or maintenance of inventory is being continued. The Federal Goverment is assisting in another way in that the Department of Forestry is engaged in research in forest inventory methods and in forest inventories on federally administered lands.

Aerial photography and forest mapping

Forest maps are usually based on topographical or planimetric maps prepared from surveys undertaken by the federal and provincial governments or by air survey companies under contract to them. In many cases, the forester must be content, temporarily, with less elaborate methods than are necessary in a comprehensive and systematic program of mapping. In territory where limited development has taken place he is often anxious to obtain a forest map immediately after the taking of the aerial photographs rather than wait for the

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[2] Head, Forest Inventories Section, Forest Research Branch, Department of Forestry, Canada.

extension of ground control by the surveyor. In these circumstances, provisional maps may be made from the photographs by simple methods and initial lack of information on the exact geographical location of the map and failure to adhere to the regular standards of accuracy may not be serious drawbacks. The forester may require maps at large scale, regardless of the lack of appropriate ground control, to secure sufficient space to show his forest symbols.

Aerial photography in Canada has been carried out under the authority of the Federal and provincial governments and by private industry including mining and forestry companies. Photographic operations of the Federal Government are directed by the Interdepartmental Committee on Air Surveys. The photography has been done by the Royal Canadian Air Force and private air survey companies.

The forest map may be of medium or smaller scales suitable for general forest inventory or may be of large scale for logging operations or special investigations where greater detail is required. Detailed forest maps are relatively expensive and may soon become obsolete as a result of logging, fire, wind, insects, and disease and other depleting factors on the one hand, and regeneration and growth on the other. Accordingly, it is generally desirable to restrict the preparation of detailed maps to areas on or near the scene of cutting operations.

The scale of the aerial photographs, the scale of the forest map, and the intensity of the forest survey have varied from region to region in accordance with factors of accessibility or presence of agricultural land. A larger scale is usually required for forest mapping than for the compilation of the topographical map. Under the Federal-Provincial Agreements the scale of the photographs has commonly been 1:15,840, with smaller scales in remote areas and occasionally, for sampling purposes, a scale of 1:3,960 or larger. Forest maps have been made from these photographs, mainly by provincial forest services, and have been at scales of 1:15,840, 1:31,680, and 1:63,360.

Most Canadian forest inventories have been accompanied by detailed forest type maps but in some important instances these maps were not prepared, especially where the double sampling system, as referred to below, was employed.

Aerial photographs in Canada have been taken by the following methods:

(*a*) Vertical, in which the camera axis is pointed as nearly as possible in a vertical direction.

(*b*) Oblique, with the camera axis tilted in either a high-angle or low-angle direction.

(*c*) Trimetrogon, composed of a central vertical, with high-angle obliques to port and starboard, taken with 6-inch lenses.

(*d*) Forestry tri-camera, composed of a central vertical, with low-angle obliques to port and starboard, taken with 12-inch lenses.

The first three of these methods of photography were initially intended for use in topographical mapping but are also valuable for forestry. The last, which was developed for use in forestry, provides accuracy and speed in the measurement of tree heights, especially under winter conditions, and facilitates the identification of species. When taken at a scale equivalent to that of ordinary verticals the flight lines of the forestry tri-camera method may be spaced at intervals almost three times those of the verticals. Economy of coverage is secured but the rather expensive installation of the required three cameras is a considerable disadvantage unless extensive photographic operations are required.

In the initial photography of a forested area it is usual to compromise between the small photographic scale preferred by the mapper and a larger scale more acceptable to the forester. Sometimes two separate photographic operations may be desirable.

The Province of Ontario has adopted special techniques to secure maximum interpretability of photographs taken for forest inventory purposes at the scale of 1:15,840. Over-exposure and under-development, together with automatic "dodging" during the printing, provide superiority of sharpness in the negative and optimum densities in the positive. At the same time image motion, which is related to ground speed and scale, is limited to a fraction of resolvable distance on the photograph. Photo interpretation, especially the identification of tree species, is facilitated by these techniques.

Aerial photographs printed on semi-matte paper do not provide as much forest detail as those on glossy paper. However, on glossy prints special pens and pencils are required for the rapid marking of fine lines that will not smudge, are water resistant and are easily removable. Sometimes more of the detail in the negative may be reproduced in enlargements than on contact prints and enlargements provide more space for showing forest type lines and symbols. One disadvantage is that unless the negatives are of small size the enlargements may be bulky, expensive, and inconvenient for use and storage. Some of the advantages of enlargements may be secured by the use of magnifying stereoscopes on contact prints.

The principles of the stereoscope, with its three-dimensional qualities, have been employed in the construction of various instruments for the plotting of maps from aerial photographs. Elaborate stereo-plotting machines have been developed and are very valuable for the basic control of mapping but are of little direct interest to the forester. Simpler equipment based on the use of the stereoscopic projection of diapositives is employed extensively for mapping purposes and to some extent is superseding radial line plotting and the related slotted templates.

The radial line method provides a graphical solution based on the angle-true properties of lines drawn from the photo plumb-point and a suitable map may be made regardless of displacements produced in the photographs by differences of elevation in the ground. The slotted template method is based on the same principles as the radial line method, but employs equipment which facilitates an over-all adjustment and provides flexibility in conforming to control points. The use of perspective grids has been a very valuable method of mapping from oblique photographs.

The stereometer or parallax bar is of interest to the forester for the determination of tree heights and contours. His most commonly used equipment, however, may consist of simple mirror stereoscopes, lens stereoscopes, and photo overlays to facilitate photo interpretation. Useful instruments for the transferring to the map of the forest type lines from the photograph include those in which a semi-coated mirror is used to provide superimposed views of map and photograph, one image being obtained by reflection and the other by direct transmission of light. A more expensive transfer instrument which is sometimes preferred is the overhead reflecting projector, whereby an image of the photograph is cast on the map.

The Federal Government and some of the provincial governments have made use of photolithographed forest maps in varying degrees. The plates prepared for the publication of topographical map sheets may be used to facilitate the

preparation of the photolithographed forest maps, whose advantages lie in the facility with which great numbers of copies can be reproduced with forest types in full colour.

The use of aerial photographs or portions thereof put together in the form of a mosaic often appeals to the forester because it shows pictorial detail in assembled form. On the other hand it does not show "interpreted" information such as usually appears on a forest map. An ordinary forest map has superior clarity, especially when colour has been added to accentuate the various forest types. Often the forester may prefer the map to the mosaic, particularly because he can view the pictorial detail by examination of the loose photographs under the stereoscope. The construction of a mosaic becomes more difficult in hilly country because of displacements in the photographs, but when a mosaic can be assembled with ease it may serve as a ready mapping method because a rough map can be traced directly from it. On the other hand, the construction of a so-called controlled mosaic is dependent upon the prior compilation of a map, or on control data as required for map making. In the agricultural areas of southern Ontario most of the forest is found in woodlots. Aerial photographs of the scale of 1:15,840 and mosaics made therefrom have been used in these areas. Sampling, of an intensity of about one-tenth of one per cent, was by continuous lines in selected woodlots. The number of forest classes employed was much less than in the main forest belt.

Tree measurement, species, films and seasons

Information available from the aerial photograph on the nature and description of the forest has its main basis in the measurement and examination of the tree images either individually or in the aggregate within the forest stand. Investigation of environmental factors in the aerial photographs is sometimes quite important.

Measurement by stereoscopic parallax is the oldest and most commonly used of all photogrammetric methods of determining the heights of trees or stands. The *parallax method* was used in Germany as early as 1925 by means of highly developed stereoscopic plotting machines which had been built for topographical mapping. Present practice is largely based on the use of comparatively inexpensive stereoscopes, parallax bars, and parallax wedges, employed mainly with vertical photographs. In the *displacement method* the full length of the tree image is measured instead of merely the forward component of its length as in the parallax method. A disadvantage of the displacement method, however, is that it does not provide for the stereoscopic observation of the image measuring device. The *oblique method* is so called because it is used in the measurement of the tree image in oblique photographs. The *shadow method* differs from the other methods because it is based on the tree's shadow instead of on the tree itself. Various criteria for determining mean height of a stand have been employed, the chief of which is the average height of the dominants and codominants. Other measures of mean height are based on a few of the tallest trees, or on all trees, with weighting in relation to size.

Estimates of the percentage of canopy density (crown closure) shown by the aerial photographs are very important. Stereograms showing forest stands of known classification are valuable aids to the interpretation of canopy density but many would be required to represent all forest conditions at various seasons of the year, and at different scales, angles of view, and conditions of photography

with various cameras and films. Crown density scales or guides may be used to facilitate the photo interpretation of canopy density. A difficulty is encountered because of the variations which occur in the displacement of the tree crowns in relation to the distance of the tree from the plumb-point of the photograph. The establishment of correction factors to take account of these variations would be very helpful. The measurement of crown diameter has had only limited application in the past but may become more important if photographs of large scale come into general use.

Ordinary *panchromatic* films are used regularly in aerial photography but certain other films are of special value or interest. In *infra-red* photographs, the chlorophyll of the foliage produces highlights in contrast to the dark shadows of the trees and a variety of tones appear, particularly because of variation in the extent to which chlorophyll is present and because of the varying amount of shadow within the crowns of the trees. When a minus-blue filter is substituted for the normally used red filter, a photograph is produced which is intermediate in its characteristics between panchromatic and normal infra-red. The tones of infra-red are valuable in the identification of forest types and species in photographs taken in the summer months. In the province of Alberta, infra-red has been used since 1953 to distinguish between lodgepole pine and poplar. Comparable results may sometimes be secured, especially in view of the relative shortness of Canadian summers and the distinct tones of spring and autumn foliage, by photographing with ordinary panchromatic film in autumn, spring, or early summer. Sometimes panchromatic photographs taken during those seasons when the deciduous foliage is absent are preferable to infra-red or panchromatic photographs taken when the deciduous foliage is present. The height of the stand, the boundaries of forest types, and the extent of the understories of evergreen trees are often determined to better effect in the absence of deciduous foliage.

Colour photography offers advantages over black-and-white photography for the identification of tree species and insect-damaged trees but is adversely affected by haze in the atmosphere, especially at high altitudes. Colour prints on paper, which would be more convenient for use by the aerial photo interpreter than the usual colour transparencies, have been recently demonstrated in the use of Aero Ektacolor film. An advantage of such film is that extra prints may be secured readily from the negatives.

Camouflage detection film combines some of the characteristics of infra-red and colour films. It responds strongly to infra-red rays, especially those received from the foliage of broad-leaved trees with their abundance of chlorophyll. Living trees vary in tone from purple to a vivid red while dead foliage, such as that of trees damaged by the spruce budworm, appears blue-green or gray-green. At the Petawawa Forest Experiment Station, which is situated near Ottawa, it was found that the tones of camouflage detection photographs taken in July were much brighter than those taken in September and spruce plantations in early summer appeared in a brighter red than pine plantations, presumably because of the slower development of foliage by the latter. It may be possible to distinguish species, to identify partially defoliated trees, and estimate the vigour of coniferous trees from variations in tone as related to chlorophyll activity in the foliage.

The recognition of tree species on aerial photographs of ordinary scale has generally been difficult, especially before field checks are made. The situation is changing, however, with improvements in photography and the preparation, by the provinces of Ontario and British Columbia, of guides to species identification,

together with the publishing by the Department of Forestry, of information on species identification. In a variety of ways distinctions between species or forest types become possible. Seasonal changes, particularly in foliage, sunlight, and snow, are important. Deciduous trees are easily distinguished from evergreens in late autumn, winter, and early spring. During the rest of the year similar distinctions may be apparent from differences in the tones of the foliage and broad forest types may be delineated. Crown characteristics and tone of foliage, including branching habit, shape and size of crown and arrangement, colour and degree of glossiness of the leaves may be important. Greater possibilities for the recognition of species will be found in photographs of large scale. A knowledge of site or ecological and phenological conditions may sometimes be useful. Infra-red, colour and camouflage detection films, as referred to above, provide special distinctions. Field sampling may often be applied very effectively to facilitate the photo interpretation of species, site, stand structure, defect, and related conditions.

In some regions an expert may recognize land forms in the aerial photographs and, from the topographical position, slope and vegetation may form an opinion of the soil parent material, soil texture and drainage in their relation to forest site types.

Stratification and sampling

The aerial photographs with their comprehensive and detailed view provide a unique opportunity for classification or "stratification" of the forest stands, with consequent economy in sampling. A single stratum may comprise all those stands which are of the same class in respect to such factors as height, cover type, and canopy density (crown closure). Site type, number of trees, width of crown, and degree of homogeneity of the stand have possible application in stratification. Stand volume tables may be used to establish a volume stratification from the interpreted factors. Stereograms may be helpful in determining the stratification. Typing and coding by visual observation from an aircraft may also be very helpful. The minimum area of stand delineation, which may vary from 5 to 100 acres, depends on the importance of the timber and the intensity of the forest survey.

Simple *random sampling* is a method in which the members of the sample are drawn independently with equal probabilities. In stratified sampling the population is divided into a number of parts, called strata, and a sample is drawn independently in each part. Stratified random sampling has been employed to some extent in Canada although costs have been high. A compromise has sometimes been introduced whereby the random method has been applied only in the selection of the forest stands for sampling or in the choice of field plots from sample areas selected systematically on the photographs.

Systematic sampling is characterized by the selection of sampling units at equal intervals, and may often provide more reliable results than random sampling. It may be necessary to guard against periodic variation in the population but systematic sampling, barring the effects of periodicity, provides an unbiased estimate of the mean. A disadvantage is that there is no valid method of estimating the standard error of the mean, although it may be possible in most cases of systematic sampling to find methods of estimating this error which are only moderately biased. Systematic sampling saves a considerable amount of time in collecting the field data, as compared with random sampling. Systematic

sampling has been used in Canada in the form of continuous lines, line-plots, and sample plots on aerial photographs.

In *"selected-line"* sampling, easily identifiable map features are selected at some distance from the stands and straight lines joining them are drawn through the stand or stands to be sampled. Sample plots may be selected at random on the lines or may be placed at regular intervals thereon. A great deal of bias will be avoided because neither the lines nor the plots are selected by personal judgment of the forest detail in the air photographs or on the ground. A prime consideration in locating the lines and spacing the plots is to secure good distribution. The number of plots depends on the requirements of the survey. The selected-line method has been employed extensively by private companies, provincial governments, and the Federal Government to expedite forest surveys, particularly in areas where travel is comparatively difficult.

In *subjective* sampling the sample plots are selected by the air photo interpreter to represent average or typical portions of the population but although economies in sampling may be secured, the selection is subject to bias.

In the *double sampling* system, used in the nation wide Forest Survey of the United States Forest Service and under certain conditions in Canada, the aerial photo stratification, instead of covering the stands fully, is often confined to systematically located circular photo plots of usually one acre in area. Accordingly, the system does not provide for the preparation of ordinary forest maps. Circular field plots of $\frac{1}{5}$-acre are located within some of the photo plots to provide tree measurements and a check of the photo interpretation of the acre plots. The photo interpretation of $\frac{1}{5}$-acre plots is difficult because the true position of trees near the perimeters of the plots cannot always be determined and because the amount of interpretive information on $\frac{1}{5}$-acre is often limited. Forest surveys in some Canadian provinces have been conducted by a modified double sampling system, especially where an inventory of a rather generalized character has been required.

In an investigation made by the Department of Forestry it was found that in comparison with random sampling there was no evidence that bias existed in systematic line-plot and selected line samples. The lack of bias may be ascribed to the absence of definite patterns or trends, in spite of considerable variability in the forest, *within the air photo stratification.* Thus the systematic line-plot and selected line sampling methods appeared to be as reliable as the random method when applied to strata determined from the air photographs, at least under the conditions investigated.

In pulp wood forests, sample plot sizes of $\frac{1}{5}$-acre or less are commonly used in field work. Plots of larger size are used in saw timber, the plot size increasing in a general way with decrease in the number of trees per acre. With the employment of air photo stratification, the sampling intensity is generally reduced, becoming a fraction of one per cent in broad forest inventories.

Point sampling with the relascope or wedge prism has been applied by various organizations, notably the Province of Ontario. This province employs point sampling with the wedge prism in conjunction with yield tables to secure rapid volume determination.

Volume summaries are commonly made in cubic feet of wood by species and by diameter classes divided into two groups consisting of 4 to 9 inches and 10 inches and greater. Volumes in board feet are usually shown for large diameter classes. Cull factors are applied to secure estimates of the quantity of sound wood. The data are variously classified to take account of cover type, age class,

stocking, and related conditions. Punched cards and machine compilation and tabulation are employed to facilitate the computing and summarizing of the classified volume data. The dot grid, the polar planimeter, and a method in which map segments are weighed, have been used to determine the areas of forest stands. Periodic aerial photography, yield tables, and permanent sample plots are employed for revision of forest inventories.

Volume tables for photograph interpretation

Stand volume tables and tree volume tables, based on variables ascertainable from the aerial photographs have been constructed or are being constructed to provide a direct approach to volume estimation. Procedures used by the Department of Forestry in the field measurement of sample plots for stand volume tables include the recording of all trees, the measurement of canopy density, and the securing of information on cover type and site type. Also, crown diameter, height and age have been determined for a few trees in each sample plot and a variety of information, particularly on stand history, has been noted. In the place of the determination of canopy density in the aerial photographs or its ocular estimation on the ground, an instrument known as the "moosehorn" has been developed and used for the measurement of canopy density on the ground. In this instrument, evenly spaced marks resembling those of the "dot grid", which is employed in the planimetering of map areas, are incorporated in a small viewing box.

It may be desirable, when trees can be readily counted and measured in the aerial photographs, to use volume tables based on the average crown diameter and height of individual trees. Two such tables have been constructed for use in saw timber and a table for application in the photo interpretation of large-scale 70 mm. photographs, in which individual trees of all sizes are visible, is under construction.

Large-scale photography for sampling purposes

When large-scale photography is taken under suitable conditions it provides intimate detail of each tree. Because it is too expensive for application to the whole forest, it must be looked on as a sampling procedure which will be a supplement to, or a substitute for, field sampling. The Department of Forestry has been investigating the use of large-scale photographs taken with the Vinten 70 mm. air camera. A current project is being conducted on Vinten photographs taken in the winter with a shutter speed of $\frac{1}{2,000}$-second and at a scale of 100 feet to one inch. The photographs have been enlarged to 25 feet to one inch and trees have been counted by species, measured, and numbered on $\frac{1}{5}$-acre sample plots laid out on these photographs. Field checks have been made and a report is being prepared. (In practice no field work of any kind would be necessary in the use of 70 mm. photographs for forest surveys of limited intensity.) Scale was controlled by the radial line method supplemented by distances measured locally during the field checks. It is indicative of the amount of detail secured that the snow-covered ground is occasionally visible near the centres of Vinten photographs even under dense canopies of evergreens, permitting the measurement of individual tree heights and a good estimate of mean height of stand. In countries where snow is rare or absent, large-scale photography might be applied to advantage under overcast conditions when lack of shadow permits a good view of the ground.

SUMMARY

Canadian forest inventories are mainly characterized by the classification of the forests on aerial photographs, co-ordinated with field sampling. The degree of detail secured is largely related to the intensity of the forest management requirements. No discussion of these inventories would be satisfactory without proper reference to the importance of aerial photography. Topographical mapping has progressed very greatly since the coming of the aerial photograph and the investigation of natural resources, including the forests, has been facilitated. With aerial photographs and the stereoscope a small-scale model of the forest becomes available from which comprehensive information can be secured in advance of field work.

From an operational point-of-view, the most important development in forest inventories in Canada during recent years has been the Federal-Provincial Forestry Agreements entered into initially in 1951. On the basis of these agreements the Federal Government is making financial contributions to the provinces to facilitate progress in forest inventories. The agreements have been largely on a provincial inventory level and have not applied to forest surveys at the more intensive level of detailed forest working plans or operating surveys. Initial provincial inventories have been largely completed but re-inventory or maintenance of inventory is proceeding. The Federal Government is assisting in another way in that the Department of Forestry is engaged in research in forest inventory methods and in forest inventories on federally administered lands.

Forest maps are usually based on topographical or planimetric maps prepared from surveys undertaken by the federal and provincial governments or by air survey companies under contract to them.

Aerial photography in Canada has been conducted by vertical, oblique, trimetrogon, and forestry tri-camera methods.

In the initial photography of an area it is usual to compromise between the small photographic scale preferred by the mapper and a larger scale more acceptable to the forester. Sometimes two separate photographic operations may be desirable.

To secure maximum interpretability of aerial photographs taken for forestry purposes the Province of Ontario has used image motion control, over-exposure, under-development, and automatic "dodging" of the prints.

The principles of the stereoscope, with its three-dimensional qualities, have been employed in the construction and use of photogrammetric instruments, both simple and complex. Aerial photographs may be assembled in the form of a mosaic, which is sometimes valuable for forestry purposes but does not show "interpreted" information such as usually appears on a forest map.

Various photogrammetric methods of determining the heights of trees have been used. Estimates of the per cent of canopy density shown by the photographs are important. The measurement of crown diameters may come into considerable use in the future.

Ordinary panchromatic film is generally used in aerial photography but special films, including infra-red, colour, and camouflage detection, are of value and interest.

The recognition of tree species is being facilitated by improvements in aerial photography and by the preparation of guides to species identification. An expert may recognize land forms in the aerial photographs and may appraise the soil and drainage in relation to forest site types.

The aerial photographs with their comprehensive view provide a unique opportunity for classification or "stratification" of the forest stands. Sample plots are selected by random and systematic methods and occasionally by special methods of easy application and quite limited bias.

Stand volume tables and tree volume tables, based on variables ascertainable from the air photographs, provide a direct approach to volume estimation.

Large-scale photographs provide valuable detail for each tree, especially when taken at fast shutter speeds. In such photographs trees have been counted by species, measured, and numbered on $\frac{1}{5}$-acre sample plots. Field checks have been made and a report is being prepared.

SOMMAIRE

Au Canada, les inventaires forestiers se font surtout par deux moyens coordonnés, la classification des forêts par photographie aérienne et l'échantillonage au sol. La précision des détails est subordonnée en grande partie aux besoins de l'aménagement forestier, et pour bien étudier ces inventaires, il est nécessaire d'accorder toute l'importance voulue aux photographies aériennes. La cartographie topographique a fait de grands progrès depuis l'avènement de la photographie aérienne, laquelle facilite de beaucoup le relevé des ressources naturelles, qui comprennent évidemment les forêts. Les photographies aériennes et le stéréoscope permettent de voir la forêt en relief et en modèle réduit, et de recueillir des renseignements détaillés avant d'entreprendre le travail sur place.

Au point de vue exploitation, le perfectionnement le plus notable qui ait été apporté au travail d'inventaire forestier au Canada, ces dernières années, est sans doute la conclusion des accords fédéraux-provinciaux en 1951. En vertu de ces accords, le gouvernement fédéral accorde des subventions aux provinces, afin d'accélérer le travail d'inventaire forestier. Les accords ont surtout trait aux inventaires forestiers au niveau provincial, et ne sont pas applicables aux relevés forestiers détaillés qui ont trait au travail en forêt proprement dit ou au relevé aux fins d'exploitation. Les provinces ont presque terminé leurs premiers inventaires, et certaines d'entre elles ont même déjà entrepris de nouveaux inventaires ou remis les premiers au point. Le gouvernement fédéral leur vient aussi en aide par l'entremise du ministère des Forêts qui s'occupe de recherches en vue de perfectionner les méthodes d'inventaire et qui se charge de faire l'inventaire des forêts dont la gestion relève du gouvernement fédéral.

Les cartes forestières sont ordinairement dressées à l'aide de cartes topographiques ou planimétriques obtenues soit du gouvernement fédéral et des provinces, soit des sociétés privées qui travaillent à forfait pour le compte de ces gouvernements.

Au Canada, la photographie aérienne des forêts se fait selon des méthodes de la prise de photographies à la verticale, en oblique, trimétrogones, et à l'aide d'appareils à trois prises de vues simultanées adaptés à la foresterie.

D'ordinaire, lorsqu'on veut photographier une forêt du haut des airs, on prend des photos à une échelle qui se situe entre la petite échelle qui convient aux cartographes et la grande échelle qui convient aux forestiers. Il est parfois nécessaire de faire le travail de photographie aérienne en deux opérations distinctes.

Afin de s'assurer la meilleure interprétation possible des photographies aériennes prises à des fins d'inventaire forestier, la province d'Ontario tire parti

de la suppression du flou par déplacement, de la surexposition, du sous-développement et du tremblement automatique durant l'impression.

Les principes fondamentaux de la stéréoscopie, notamment celui de la vue en relief, ont été mis à profit pour la fabrication et l'emploi d'instruments photogrammétriques, simples ou complexes. Les photographies aériennes sont parfois assemblées en forme de mosaïque, ce qui convient dans certains cas pour effectuer des travaux d'inventaire forestier, bien que les données qui y figurent n'aient pas la précision de celles qui figurent sur les cartes forestières.

Diverses méthodes sont en usage pour mesurer la hauteur des arbres sur photo, à l'aide d'appareils photogrammétriques. Les estimations de la densité de la voûte foliacée d'après des photos ont beaucoup d'importance. Il se peut qu'à l'avenir on mesure le diamètre de la ramure des arbres d'après des photos aériennes.

En photographie aérienne, on se sert généralement de films panchromatiques ordinaires, mais on se sert aussi avec intérêt et profit de films de fabrication spéciale, notamment les films sensibles à l'infra-rouge, les films en couleurs et les films qui servent à déceler le camouflage.

Les progrès réalisés dans la photographie aérienne ont abouti à l'identification des essences et à la création de clefs pour faciliter cette identification. L'expert peut parfaitement déceler le relief du terrain à l'aide de photographies aériennes, et il peut même interpréter le rapport entre la topographie et l'hydrographie, d'une part, et les divers types forestiers, d'autre part.

Les photographies aériennes, grâce aux détails qu'elles révèlent, offrent un moyen insurpassable de classer ou d'établir la stratification des peuplements forestiers. Des places-échantillons sont choisies soit au hasard soit selon certaines méthodes systématiques soit selon des méthodes faciles d'application et dont les risques d'erreurs sont très limités.

Des tables de volume des peuplements et des tables du volume des arbres, fondées sur des facteurs variables vérifiés à l'aide de photographies aériennes, constitutent des moyens directs d'évaluation des volumes.

Les photographies à grande échelle fournissent des détails précieux sur chaque arbre en particulier, surtout si elles sont prises en ultra-instantanés. Grâce à ces photographies, on est parvenu à compter le nombre exact d'arbres de chaque essence et même à calculer les mesures dendrométriques d'un peuplement-échantillon de $\frac{1}{5}$ d'acre. Ces mesures ont été vérifiées sur place et le compte rendu de ces travaux est en préparation.