SOME DEVELOPMENTS IN THE USE OF AIR PHOTOGRAPHS FOR FOREST SURVEYS*

H. E. Seely

Chief, Forest Air Survey Division, Department of Mines and Resources, Ottawa

NO NATURAL resource is better adapted to detailed study by air photographs than the forest. Advantage is being taken of this fact to meet the current need for a national forest inventory or stocktaking of Canada's forest resources, distributed as they are over an enormous area.

Recognizing the potentialities of air photographs in the forestry field, studies and investigations were initiated by the Dominion Forest Service in 1929 which have led to the development of techniques, methods, and highly specialized instruments which have been widely adopted as standards. These developments have proved to have extensive practical application in the preparation of forest inventories, in management, and in forest protection planning. The Service is continuing and expanding its investigations in this field.

One of the most important advances achieved is the development of methods of volumetrically estimating standing timber from air photographs. The technique employs the height of the tree, supplemented in most cases by crown data, in place of the usual ground method of measuring diameter at breast height. The comprehensive view provided by the air photograph enables measurements to be made over a greater area of forest, and with less effort, as compared to the previous laborious and expensive method of ground cruising.

Together with the development of a technique of volumetric estimating, the shadow method of determining tree heights from air photographs has been developed, and grids have been devised for measuring tree heights in oblique photographs. The displacement method, whereby the image of the tree is measured on a single, vertical photograph, is also important. These methods in most cases render it unnecessary to apply the parallax method of obtaining tree heights, though the stereoscope is used to correlate the easily measurable trees with the rest of the stand and also to make slope corrections in the case of the shadow method.

The determination of tree heights from air photographs is affected by various conditions. Within dense stands individual height measurements cannot be made and furthermore the tree height methods apply with less accuracy to broad-crowned trees than to those having a narrower form. The shedding of the foliage of deciduous trees in the autumn makes possible a greatly augmented view of both trees and shadows, which lasts until the coming of the new leaves in the spring. Snow forms a smooth, bright surface upon which the shadows are sharply cast and by which the detail in the depths of the stands is accentuated. Failing a complete view of the tree or shadow, the visible portion may be measured and the unseen portion estimated. The inaccuracies which occur in individual measurements compensate each other to a large extent when the tree heights are averaged for the purposes of volumetric estimating, and very often an unobscured and accurately measurable tree may, particularly with the help of the stereoscope, be used as an index to the height of an adjacent group. While on the one hand very few individual measurements can be made in the case of dense, even-aged stands, on the other hand, if the average height is fairly constant, a com-

* Reprinted from *The Canadian Surveyor*, April 1947. (Editor's Note.) Mr. Seely's paper, presented at the 1947 annual meeting of The Canadian Institute of Surveying, was followed by very timely discussions, some of which are printed in part following the article.

paratively small number of actual measurements, such as may sometimes be readily obtained along roads or on the edges of clearings, burns, or cuts, may be sufficient.

In making a comparison of the various methods of determining tree heights, the above-mentioned conditions should be taken into account and no statement is complete unless the relevant factors are specified.

In the case of vertical air photographs, the shadow method produces the best results in mixtures of hardwoods and softwoods on level ground in winter photographs. This method is not as effective on hilly ground, as it is usually impossible to make accurate corrections for slope. In this case the displacement and parallax methods may be used to advantage unless the angular values have been weakened by the changed relationships that usually accompany the use of a lens of long focal length. The shadow method does not generally have its fullest application unless facilitated by the absence of deciduous foliage, and, accordingly, summer photographs in which hardwoods are plentiful, or photographs of softwoods taken at any season of the year, will often be dealt with to better advantage by means of the other methods. The displacement method has an advantage over the parallax method in that a longer basic measurement is utilized, but on the other hand the use of the floating mark under the stereoscope provides a convenience in measuring, particularly in the case of broad-crowned trees, that is not attainable by means of the displacement method.

In oblique photographs the tree images are usually measured by means of the tree height grid and the wedge scale, which is referred to below. Excellent results are obtainable, though if the view is too greatly oblique, the tree may be obscured by its neighbours, and if too nearly vertical may not present sufficient length for good measurement. The use of the tree height grid on winter photographs holds the greatest promise for the successful measurement of the heights of hardwoods.

A paper entitled "Determination of Tree Heights from Shadows in Air Photographs" was published in 1942 and dealt with the technique that had been developed up to that time. More recently an adaption of a centuries-old device known as the "Mathematicall Jewell" has been used to expedite the calculations. For a description of this device see "Astrographics" by Frank Debenham, Professor of Geography at the University of Cambridge.

In volumetric estimating crown data are of possibly equal importance to tree heights. It was found impossible to obtain accurate results unless the crowns could be used in a dependable manner as a basic part of the procedure. With this in mind an instrument known as the "moose-horn" has been constructed for use on the ground to measure the per cent of crown cover, and a device based on the same principle is being developed for the purpose of making similar measurements on air photographs. A formula has been evolved for the determination of the diameter of the bole from measurements of crown diameter and height of tree.

Volumetric estimating is based on field data which show the relation between the quantity of wood per acre and the average height of the stand. Further data are being collected, but meanwhile it is assumed that the quantity per acre, by total volume, varies directly both with the height of the stand and with the percentage of crown cover. Except in the case of very intensive surveys it is expected that quantitative estimates of timber will in the future be obtained largely to better advantage from the air than from ground work. The degree of accuracy of air estimates, like that of ground estimates, is governed by the available data and is dependent largely on the degree of detail in the photograph.

Accordingly, the degree of accuracy with which the tree heights are being determined in each particular set of photographs provides an indication of the reliability of the air estimates. For broad forest inventory purposes a scale of 1,320 feet to the inch is usually sufficient, but for operating surveys or intensive working plans a scale of about 800 feet to the inch is to be recommended.

For use in measuring fine detail on the photographs as required for volumetric estimating, a device known as the wedge scale was designed some eight years ago. It consists of a strip of transparent material bearing a scale divided into tenths. From the zero point of this scale a line is drawn at such an angle that, by placing the scale line at right angles to the dimension to be measured, and moving the scale until the end points of the dimension coincide with the two lines on the scale, the dimension can be read off directly in tenths, hundredths, and thousandths of an inch.

Attempts to differentiate species in air photographs have not been as successful as volumetric estimating, and in many cases it is more practicable to depend on ground identification, particularly as field work is usually necessary in any case to secure information regarding age, defects, site, and other conditions. However, it will be found that if the quantitative information can be obtained from the photograph the necessary amount of field work will be very greatly reduced, as the qualitative data can be obtained with comparative ease on the ground.

While hardwoods can usually be distinguished from softwoods, except sometimes in midsummer photographs, a further differentiation of species presents difficulties. The desired distinctions may occasionally be obtained by a process of elimination in cases where very few species are present; by the aid of site classification from air photographs; by knowledge of the forest associations and successions; by shape and texture of crowns; by tone of foliage, particularly in the autumn; and by phenological changes.

Use of special films and filters may possibly provide a technique for identifying species, while colour photography offers another promising approach. The variation in glossiness of foliage in broad-leaved species may prove a valuable means of differentiation. In midsummer, infra-red photographs clearly distinguish softwoods and hardwoods; at other seasons the difference appears as well, if not better, in ordinary panchromatic film, in view of the absence of hardwood foliage in winter, and its very distinctive spring and autumn tones. While shadows are usually dark in infra-red photographs, the foliage appears unnaturally light, owing to the pronounced effect of chlorophyll on infra-red film. The result is a great variety of tones, ranging from black shadows to white foliage. These tones are governed by the degree of shadow between and within the crowns, and similar tones often occur with panchromatic film, notably in winter photographs. Variations in crown texture in individual species complicate the use of infra-red for softwood identification. During a series of experiments with a hand camera used on the ground, eight years ago, it was found that particularly distinct tones were obtained when a minus-blue filter was used with infra-red film.

The use of air photographs for the classification of forest sites has been investigated, and it has been found that stereoscopic examination makes it possible to extend accurately over wide areas sample ground classifications involving the conventional investigations of geological and soil conditions; study of tree growth in the photographs frequently provides in itself a sufficient indication of the nature of the site.

A development of considerable significance concerns the reproduction by photolithographic process of forest inventory maps based on air photographs and requiring a minimum of ground work; this development is of importance, particularly because it enables quantity production of maps in full colour at a very cheap rate.[1] The process has been made possible by the co-operation of the Geographical Section, General Staff, Department of National Defence.

The maps, as resently standardized, show the forest classified according to type, crown cover, and height, these being the factors most readily derived from air photographs. The maps are printed on a scale of one mile to the inch. Broad estimates of timber quantities can be derived from such maps as indicated above If supplemented by field data covering species, quality, age, and site, the maps will provide a very comprehensive picture of the forest conditions obtaining. While it is yet too early to determine costs precisely, it seems probable that such maps can be produced at a cost ofa bout $2 per square mile mile. In view of the constant changes occurring in the forest, because of cutting, fire, insect attack, and other depleting agencies, or of regeneration and growth, inventory maps require periodic revision. Such revision can be accomplished cheaply and expeditiously by air photography, at an annual cost estimated to run from twenty to forty cents per square mile.

The rather rigid requirements of air photography for topographic work do not obtain in the field of forest mapping; this circumstance has made possible the development of a technique at once economical (possibly at one-quarter of the cost of vertical photographs of equivalent scale) and informative, and particularly useful for purposes of re-photography. The chief feature of this method is the low-angle, or steep oblique photograph. It was tested in 1937 on Riding Mountain National Park, and the results were published eight years ago in a pamphlet entitled "Air Photographs as Used by the Dominion Forest Service." In this report a tri-camera arrangement was suggested as a means of covering a wider strip of territory. Quite recently a new tri-camera set-up was devised, in which the centre camera points vertically downward, and the other two point right and left so as to take steep oblique shots.[2] Experience indicates that all three cameras should be equipped with lenses of twelve-inch focal length. For general forest inventory purposes, such an arrangement of cameras, operating at an altitude of 10,500 feet, will give an average scale of 1,320 feet to the inch, taking the average of the vertical and the obliques. For forest operating surveys, of course, a lower altitude is desirable. A tree-height grid specially adapted to this system of photography has been prepared.

Except possibly in the case of certain softwood forests, the winter is the best season for forest photography in Canada. This is because of the absence of the deciduous foliage, the bright background provided by the snow, and the lengthy period during which a high percentage of good photographic days may be expected. The latter part of the winter affords better exposure conditions because of stronger sunlight, and sometimes winter conditions extend into April. Type distinctions and tree heights are obtained to best advantage during the winter, and the low-angle or steep oblique view in the winter holds the greatest promise for the successful measurement of the heights of hardwoods; it is also advantageous in the case of softwoods. For these reasons the use of winter photographs for forestry purposes has been advocated for many years.

A difficult photographic problem is presented by the pronounced contrasts

[1] An excellent forest map, "Bonnechere Ontario Map," which accompanied the original article is available from the Hydrographic and Map Service, Department of Mines and Resources, 105 George Street, Ottawa, at a price of 25 cents.

[2] The method follows in detail suggestions by D. N. Kendall, of the Photographic Survey Co., Toronto.

that are found in the winter landscape, but for forest photography it is unnecessary to record the detail of the snow-covered topographical features. Good results may be expected if the photographic technique is concentrated on the registering of definition in the trees.

It is becoming practicable to have two photographic operations, one for basic mapping and the other for forestry information, and the demand for forestry photography is hastening the issue. It appears probable that the two operations can be conducted at about the same cost as a single compromise operation, and at the same time there will be undoubted economy in mapping together with better forestry information. The explanation is that the requirements of the mappers would be satisfied by comparatively small-scale photographs, while the above-mentioned tri-camera forestry photography would fill the needs of the foresters. Thus if both the forester and the mapper were freed of the necessity of comprising to suit the other's requirements each would be able to obtain photographs with sufficient savings in cost to compensate for the expense of separating the photographic operations.

Two instruments have been originated, namely, the duoscope and the monoscope, for the transfer of detail from the photograph to the map, and are being employed successfully. From experimental modifications of these instruments the first working model of the multiscope, which later underwent considerable development at the Harvard Forest, Petersham, Massachusetts, was constructed.

The tedium involved in prolonged use of the conventional planimeter is a potential source of errors. The Dominion Forest Service has for some time past been working on a photo-electric planimeter which will measure irregular areas by the aid of photo-electric cells and an ammeter; this instrument should make possible measurements on maps, etc., with infinitely less labour, and with greatly increased speed and accuracy. In cases where it is unnecessary to find the areas of the individual sub-divisions and where a total for each class of sub-division is sufficient, the so-called dot system is employed. This is based on the use of a transparent sheet having dots spaced at regular intervals so that, when it is super-imposed on the map, a count of the total number of dots falling upon the various sub-divisions enables the areas to be determined.

Forest maps have been prepared for a total of more than 100,000 square miles, over 20,000 square miles of which have been accompanied by volumetric estimating. In the remainder, much of which was done before volumetric estimating was developed, the forest has merely been divided into the more obvious classes.

In conclusion it cannot be too strongly emphasized that the air survey efforts of the Dominion Forest Service are dependent upon the work of the other Government organizations, including the Royal Canadian Air Force; the Topographical Survey Division, Bureau of Geology and Topography; the Hydrographic and Map Service; the Geographical Section, General Staff, Department of National Defence; and the National Research Council.

Discussion by Mr. J. A. Brodie, Department of Lands and Forests, Toronto

I think we all know that the primary requirement in resources development in this country, as well as in any other country, is adequate and accurate maps. I think probably the surveyor is just as much responsible for the condition of our resources development, and the difficulties which the forester and others have in controlling and preparing reports of these resources, as those who are directly responsible for the administration of the resources themselves. We cannot do anything unless we have adequate maps. It is not the job of the forester to prepare these maps; that is the job of the surveyor, and we cannot proceed in forestry until that basic work has been undertaken.

The administrative duties of the Department of Lands and Forests in Ontario include timber management in all its phases, the administration of Crown lands involving land settlement for agricultural purposes, summer resort lands and the tourist trade, and in addition the administration of inland fisheries, game and wild-life. In short, the Department is more or less involved in all phase of the development and use of the natural resources in the forested area of the province. The total forested area of the province presently accessible and on which the natural resources are being developed is approximately one hundred million acres. The interest of the forester is in the multiple use of forest land and not infrequently, forest management policy must be adjusted to accommodate other than the interests of timber production and management.

Aerial photographs were first used for forestry purposes in Ontario in 1922. Since that time the Aerial Surveys Section of the Department has covered an area of 65,659 square miles by vertical photography. In addition to this, 10,780 square miles were covered by oblique photography in the period 1922 to 1927; much of this earlier photography is now of little value for resources mapping.

In 1946 the Department undertook a complete aerial survey of the forest area of the province comprising 140,000 square miles. The contract for the aerial photography and planimetric mapping of 125,000 square miles was let to the Photographic Survey Co. Ltd., in March 1946. An area of 15,000 square miles is being photographed and mapped by the Aerial Surveys Section of the Department. Up to December 1946, a total area of 33,000 square miles of photography was completed on this program, and work is proceeding on the production of planimetric maps.

Specifications call for vertical photography, 9″×9″ plate size camera, 6″ focal length, Ross f5.5 lens or equivalent with between the lens shutter. Photography is at an elevation of 7,920 ft., above mean ground level giving a scale of twenty chains to the inch (1–15840).

Planimetric maps are on a scale of 20 chains to 1 inch, the same scale as the photography. The whole program is scheduled to be carried through at the rate of 28,000 square miles per year to be completed in a five-year period.

The features worthy of note in this program are the use of the wide angle lens and the plotting of the base maps on a scale of four inches to the mile.

Photographs made with the wide angle lens have an exaggerated vertical dimension when viewed under the stereoscope. The tree cover in which the forester is mainly interested has height and with the vertical dimension accentuated the trees stand out and can be viewed and identified more readily. The height measurement is one of the main factors to be measured on aerial photographs in volumetric methods.

The inventory phase of the development of forestry was completed, in Ontario, in 1932. This phase required general information only as to volume of timer mainly giving the location of timber and the roughest idea of the volume on individual small areas but giving relatively reliable figures for the province as a whole. Maps on a scale of one inch to the mile were quite suitable and were in keeping with the general nature of the other data.

The present phase of development of forestry in Ontario is the placing of most of the forest area of the province under a sound system of forest management. Accurate maps with much additional detail are required and volumetric measurements of timber must be somewhere within a plus or minus error of ten per cent. The present and projected ultimate use of land is of very great importance and the relative important of other uses of forested land such as tourist trade, summer resort uses, agricultural uses, values for wild life, mining and hydro-electric power development come into consideration in various locations throughout the province. If forests are to be managed all of these competitive or complementary uses of land must come into consideration and be recorded on maps and plans. From the standpoint of forest management any map on a scale of less than 4 inches to the mile is of little value in presenting the information that must be at the disposal of the administrative officers.

For the preparation of maps of this kind, aerial photography is about the only practical method at our disposal. Planimetric maps are first prepared which are supplied to the forester. Forest types are taken from the photograph and plotted on the plans after which the whole map sheet is taken to the field for checking.

Mr. Seely has dealt very completely in his paper with the making of volumetric estimates of timber from aerial photographs. Practically all of our knowledge on this phase of the work is due to the research carried on over a period of years by the Dominion Forest Service under the direction of Mr. Seely. Scarcely a year passes but new contributions to the technique of timber estimating by the use of aerial photography arises from Mr. Seely's work.

As Mr. Seely points out, there are three measurements or conditions identifiable from aerial photographs—(1) species, (2) height, (3) density. By a process of very logical reasoning and the use of a well-planned mechanical process, volumetric estimates are produced from the photographic methods alone. All this is clearly and concisely set forth in Mr. Seely's paper and I can add very little to it.

Mr. Seely has stressed and strongly recommends the use of winter photography for forestry purposes and very ably supports these views. It should be pointed out that planimetric detail is poorly defined on winter photographs and correction of planimetric maps by use of winter photographs will be difficult. Adherence of snow to coniferous trees may confuse tree identification and measurements. It also appears to me that Mr. Seely has placed this method in an unduly favourable light by estimating the cost at one-quarter the cost of vertical photography on the same average scale. Possibly one-half to two thirds the cost would be a safe all round estimate until such time as actual large scale use of the method has given an accurate basis for estimating costs.

At the present stage of development of mapping and timber estimating I do not favour the suggestion of separating the function of mapping and timber estimating by the use of two systems of photography. We must have maps and timber estimates both to be prepared at the same time. Photography even for mapping should be on approximately the same scale as the final map. For resources development the scale is 4 inches to the mile and it would appear inadvisable to attempt to prepare maps on a scale of 4 inches to the mile from photography on a scale of 2 inches or one inch to the mile. This is a matter, however, on which I have had no experience and will stand for correction.

The use of the aerial photograph has opened new horizons in resources development by making possible the making of accurate, detailed maps and measurements cheaply and speedily over large areas. Now for the first time those administering our national resources can have at their disposal the necessary information for sound administration. In this work the surveyor will always occupy the key position as the map maker. Without accurate maps, planning of resources development is impossible.

Discussion by Mr. Laframboise

A careful study of Mr. Seely's paper indicates that much progress has been made toward this end, and though I do not think we can ever eliminate ground work entirely, except perhaps for general estimates of the quantity of wood on a large area, the methods described in his paper should eliminate a very large part of the expensive ground work, and certainly more than enough to pay for the air survey, the mapping, and the technical work, involved in estimating the volume of wood from air photographs. Certain data, which Mr. Seely has mentioned, such as the distinction of species, quality, age, and site will probably always require some ground sampling, but with fully developed air photographic technique, this part of the work can be done cheaply, if controlled by thoroughly trained men, not only in the science of forestry, but in the science of photogrammetry as applied to forestry.

The technique of using photographs for forestry purposes, as described by Mr. Seely, requires considerable training, if the full benefits are to be derived from photographs. The methods described must be used discreetly by men who know the forest on the ground, the variations in stand per acre, and in species, caused by change of site or exposure. In other words, a high degree of skill is required if mistakes are to be avoided in making a volumetric estimate from photographs of forest areas. A good deal must be done by deduction. Certain topographical data showing in a photograph may indicate to the trained man, familiar with ground forest conditions in the district, the kind of type, the stand per acre and even the composition by species which might be expected. Such knowledge would naturally aid him, and act as a check when making a volumetric estimate by physical examination of the details in the photograph. Unfortunately there is not a sufficient number of trained foresters versed in forest photogrammetry to make full use of the photographs now available. The photographs and technique have advanced more rapidly than the training of foresters to use them. However, foresters are now fully alive to their shortcomings in this respect, and photogrammetry is now a part of forestry courses in the leading universities. In a few years this gap will be filled when a large crop of young foresters, with some photogrammetric training, will be ready to take full advantage of the work which Mr. Seely and others have done.

Referring to the detailed discussions of the various factors involved in volumetric estimates, I think Mr. Seely has described these quite thoroughly in his paper, and that his arguments are well founded. He appears to be reaching towards the ultimate goal of estimating volumes without any ground work. This calls for a revision of the whole approach to volume tables, so that they will conform to measurements from above rather than below. I see no reason why this cannot be done though it will require a good deal of basic ground work, just as is the case when building volume tables in the conventional manner.

In the matter of scales for forestry purposes I personally prefer a scale about 800 feet to one inch, where detailed estimates and type classifications, are required, but there is no doubt that a great deal of information may be obtained from photographs at scale of 1,320 feet to one inch and this scale is probably not too small for estimating larger areas.

In the commercial field, where estimates of watersheds or working units as small as four or five square miles are often called for, the practice has generally been to use the photographs for the planimetric map or mosaic, and for carefully segregating the forest type areas. These forest types are often graded into three or more classes, based on probable cordage per acre, without making any attempt to measure trees on photographs. The measurement of tree heights and diameters are obtained by running sample cruise lines where, in the judgment of the forester, they will obtain an average tally in the various types and grades. The average cords per acre are then applied to the respective type areas. At the same time valuable data in regard to age classes, tree heights, defects and data required for the adjustment of volume tables are obtained. In other words, the photographs are used as a valuable aid, but the ground work is still a substantial part of the whole operation. The extent to which the ground work is eliminated depends on the skill and experience of the forester is using photographs.

Several companies, using photographs, scale 800 feet to one inch, in the above manner have reported surprisingly accurate estimates, with very little ground sampling. These estimates have checked out with the subsequent cuts.

Recently a paper company interested in the timber on an area of 100,000 square miles, not previously mapped, was faced with the problem of its development. The country was quite rough, and consequently a topographical map was desirable. It was decided to have a contour map made by the multiplex system. This called for photographs taken with a 6 inch lens from about 18,000 feet above sea level. The scale was, however, too small for forest details, but the photographs were enlarged to 1,320 feet to one inch. While these enlargements, and even the contacts, showed the forest types adequately, the details in regard to individual trees were probably not quite sharp enough for measurement by Mr. Seely's methods. However, adequate forest detail could be obtained on such a survey by running a second camera with a 20 inch cone or a 12 inch cone to obtain scales of 800 feet to the inch or about 1,320 feet to the inch with very little extra cost. By this method both needs could be served namely, economy in ground control and in mapping of topography and waterways, and economy in providing forest photographs. If the 20 inch cone were used about 43% of the total area would be covered by photographs about 800 feet to the inch, and if a 12 inch cone were used over 60% of the total area would be covered by photographs at about 1,320 feet to the inch. Either of these strips should provide a very wide sample strip through the central portion of the small scale basic strip, and certainly an adequate basis for preliminary volumetric estimating.

For later more detailed forest surveys, vertical rephotography at a large scale, or steep obliques, may be carried out from time to time on parts of the limits where such information is required. Since the maps would already have been made, the steep oblique method could be applied if desirable.

In the latter part of his address, Mr. Seely has mentioned the development, by the Dominion Forest Service, of a photo-electric planimeter. This device, when completed, will be a great boon to foresters, by eliminating the measurement of the thousands of small forest types by the hand planimeter. I understand that the completion of this device has been delayed because of the pressure of other work, but I sincerely hope that the Dominion Forest Service can soon complete the final details.

Discussion by Mr. Simpson

Anyone who has listened to this paper and the discussion must appreciate that an aerial map for forestry inventory is the solution to timber sizes and quantities and putting them in a quantitative analysis basis, and since timber varies in height and size, with soil conditions, terrain, and other factors, it becomes a real problem for forest engineers.

In the initial stages photography is obviouly important, and I think the photographic business has reached the stage where trees may be shown sharply and accurately, and the heights can be obtained accurately enough, if we have a combination scale which will suit the planimetry and also the study of the individual trees. The solution to the problem of low and high altitude photography, without running a second strip for forestry, is the combination scale.

Mr. Brodie brought out the point about obtaining tree heights and that the use of the wide angle lens was advantageous. Mr. Laframboise has mentioned that using a 20 inch cone to obtain a large scale might have advantages. There might be some difficulty in getting the tree heights as accurately as in photographs taken at a lower altitude with a wide angle lens. There is a great deal of food for thought on the subject of the ultimate combination of an economical scale for mapping and for forestry, and this is one of the major problems which, I think with further thought, will result in getting something satisfactory to all concerned.

As PHOTOGRAMMETRIC ENGINEERING goes to press, a local meeting is announced for 8:00 P.M., Thursday September 18, 1947, Department of Interior Auditorium, Washington, D.C., in accordance with the following program:

THE AIRBORNE MAGNETOMETER AND ITS RELATION TO PHOTOGRAMMETRY

MR. EDMUND S. MASSIE, JR., *Moderator*

Field Operations and Compilation Procedure Incidental to the Preparation of Isomagnetic Maps.—Mr. Fred Keller, Jr., Geophysics Division, Geological Survey.

The Practical Operation of the Airborne Magnetometer since 1943. (Followed by color motion picture.)—Mr. Virgil Kauffman, Aero Service Corporation.

The Cartographic Aspects of the Airborne Magnetometer.—Mr. M. A. Phillips, Fairchild Aerial Surveys, Inc.

The Future Use of the Airborne Magnetometer in General Magnetic Mapping.—Lieutenant Commander E. B. Roberts, U. S. Coast & Geodetic Survey.

Audience Participation

On Exhibit—Magnetometer Apparatus and Illustrations of Map Compilation Technique—Courtesy of U. S. Geological Survey.

It is anticipated that a large attendance will be on hand to learn of this fascinating development from these speakers, all of whom are outstanding pioneers in the recently developed field of Airborne Magnetometer Surveying. No device perfected in recent years has enjoyed the wide acclaim and universal acceptance which has been accorded the airborne magnetometer. It is another case of a development, born in the exigency of war, being put to put to profitable peacetime use.

For the benefit of all members, it is hoped that the papers are available for publication in an early issue of PHOTOGRAMMETRIC ENGINEERING.