AERIAL PHOTOGRAPHY IN QUEBEC¹

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QUITE recently, *Louis Bourgoin*, civil engineer, one of the learned professors of the Montreal Polytechnic School, in an article entitled "*Le Rôle de L'Ingenieur Après la Guerre*" (see *Recueil* of April 1945—pages 31-34), asked the following question: "Is the engineer professionally prepared to occupy a prominent place in the perturbed world of the post-war period?" And he further wrote: "First of all, the engineer must be a realizer who builds, extracts or manufactures."

As forest engineers, we have the conservation of our forests at heart and it is our concern to see that the products derived therefrom be used in such a way as to keep the economic machinery of our country in motion. In the words of *Louis Bourgoin* we mean to build, extract and manufacture.

But is it possible to consider a forestry problem of any sort without the aid of a detailed and accurate forest type map of the particular area where forest operations are contemplated? How is it possible, without this indispensable tool, to make a reliable plan of such items of a forestry undertaking as—

- 1—Construction (silviculture, management, reforestation, etc.);
- 2—Extraction (exploitation, transportation, including driving, etc.);
- 3—Manufacture (inventories, calculation of the probable economic needs of the country, etc.).

It is an admitted fact that aerial photographs are indispensable to the forest engineer for they will solve a great many of the problems which he is likely to encounter in the planning of the above items. Indeed aerial photography provides, amongst other advantages, the appropriate cartographic material for the engineer and he should endeavour to use it to the best advantage.

You may wonder what is meant by the term "appropriate". That is what I propose to discuss to-day, namely, the main factors which make up the basis of efficient forest mapping:

- 1—The choice of the most suitable scale for the work.
- 2—The exact and sufficiently complete description of the forest conditions of the area.
- 3—The determination of reference points in sufficient number and marked in such a way as to be easily detected when carrying out complementary measurements.
- 4—The scale, the characteristics of the contour lines, i.e. their exact horizontal and vertical ordinates, as well as the exact location of all reference points (to ensure a given average degree of accuracy to a forest operation).

¹ Paper read at a meeting of the Province of Quebec Section, C.S.F.E., Quebec, June 4, 1945.

Oblique Aerial Photography

5—The economic necessity of carrying out mapping work in a given time with a minimum of personnel and material and, at the same time, without prejudice to the accuracy of the work.

Having in mind these five elementary requirements is it possible, with the aerial photographs now available for the Province of Quebec, to prepare a forest type map corresponding to our needs?—If not, what should be done? As an answer to the first question, the following table speaks for itself:

Total area photographed (by Ottawa)	95,000 sq. m.
Total area photographed (by Quebec)	54,000 sq. m.
Oblique photographs (Ottawa)	31,000 sq. m.
Vertical photographs (Ottawa)	64,000 sq. m.
Vertical photographs, serviceable (Quebec)	23,000 sq. m.
Vertical photographs, obsolete (Quebec)	31,000 sq. m.

This table indicates that our actual supply of serviceable photographs covers an area of 87,000 square miles, i.e. 64,000 square miles photographed by Ottawa and 23,000 square miles by Quebec. However, this total should be further reduced to 75,000 square miles, because about 5 per cent of the photographs taken by Quebec which are not obsolete have no overlap or very little of it. Overlap, indeed, is essential for stereoscopic observations and mapping work of reasonable accuracy. At the same time these figures do not include the areas photographed by companies carrying on forest operations, nor the vertical photographs taken by Ottawa covering areas along the North Shore and Anticosti Island.

SCALE

The scales of most of these photographs vary from 16 to 20 chains to one inch. Thus we only have an area of 500 square miles covered by photographs at an approximate scale of 10 chains to an inch.

It follows that, in order to meet immediate requirements, all forest land in Quebec should be either photographed or re-photographed. At first this might seem impossible because too expensive, but, on the other hand, can we afford as forest engineers to permit the establishment of a forest industry in a given region when we cannot tell whether the commercial raw material is sufficient in quantity to feed such industry permanently?

The practice of waiting for events to force action (a practice which has been followed to date) should be discarded. Forest industry should be given a fair deal; and we should at all times be prepared to supply accurate information.

PHOTOGRAPHING

The factors which affect the cost of vertical aerial photography are the temperature, the scale, the altitude of flight and the areas photographed. (size, shape, etc.)

In the Province of Quebec there are only 4.4 days per month favourable for photography, i.e. 53 days per year. From a forest point of view the most favourable period for this work is between the 15th of May and the 15th of October, i.e. 22 days or 132 hours of flight in five months per

year. Consequently, when it is intended to carry on extensive photographing this factor should be considered because, if the negatives must be completed at a given time, the contractor must use several planes and perhaps also establish victualling points if the region to be covered is remote from a permanent landing station.

The second factor is the scale. Photographs at a scale of 20 chains to the inch seem to meet the requirements of all governmental services. With this scale the altitude of flight above the mean level of the ground to be photographed (with a lens of a focal distance of 8.26 chains), will be 10,890 feet. With the necessary overlap for stereoscopic observations, i.e. 60 per cent longitudinally and 40 per cent laterally, each negative will comprise a net area of 24 per cent or 0.945 square miles. It is known that the altitude of flight for a given scale is in direct proportion to the focal distance of the lens in use. Before selecting one lens in preference to another it should be ascertained that this lens does not deform the picture or exaggerate the parallax distances. It should also be ascertained whether it produces a perfect and clear picture and a satisfactory overlap without affecting the quality of the negative. The lens used should, therefore, be one of large angular field but with a minimum focal distance.

Many photographic essays of ten chains to an inch (1:660 or 1:7920) have given excellent results. These essays were made with a 9.38 inch lens at a theoretical altitude of 6487.8 feet above the mean level of the ground. Both resinous and mixed stands are discernible on such photographs and it is my belief that this scale would be more practical in general forest practice than the scale of 20 chains to an inch. The cost, however, would be 2 or 3 times greater. As our films will be of far superior quality in the near future, it would be possible to obtain almost perfect enlargements.

If this scale were used each negative would cover a net surface of 0.236 square miles only, assuming a longitudinal overlap of 60 per cent and a lateral overlap of 40 per cent. Consequently, for a given area with a scale of 20 chains, four times as many negatives and probably three times as much time would have to be spent on mapping.

Would the results be more satisfactory? From a planimetry point of view meticulous attention would be essential in the construction of the basic plan and the localization and transfer of primary control points on the photographs. As far as altimetry is concerned the relief of the ground could be easily followed and its interpretation would be much simpler. If we consider the forest point of view the forest types would be more discernible. For stereoscopic studies of the forest types and for the laying out of forest roadways and of contour lines the 10 chain scale would, therefore, give results which would more than compensate for the difference in cost.

The cost per square mile of preparing aerial negatives is also influenced by the area to be photographed. If a firm or agency were allotted annually a certain area for photographing it could afford to do the work on better terms.

Contours on mosaic and line maps

At the present time the cost of aerial vertical photography is from \$8 to \$12 per square mile at a scale of 20 chains, and approximately \$15 to \$25 per square mile at a scale of 10 chains, depending on whether the area to be photographed is 100 to 1,000 square miles. These figures are only approximate estimates.

In the United States photography at a scale of 1:20,000—8.25 inches costs approximately \$2.50 per square mile, but it should be taken into consideration that our neighbours are able to carry on this kind of work during the greater part of the year. Indeed, they count on at least one hundred favourable flying days per year.

MAPPING

In the practice of cartography the following point should be borne in mind:

1. Preparation of the control map at the average scale of the photographs (horizontal, vertical and forestry data);
2. Preparation of photographs (transfer of the principal points, localization and transfer of secondary control points);
3. Application of radial-triangulation methods for the control of photographs (Slotted Templet Method or Floore Radial Intersector);

4. Interpretation of photographs (forest types, sites, infestation, morphology of the ground, etc.);
5. Restitution of planimetric details (lakes, waterways, roadways, etc.);
6. Restitution of forestry details (forest types, windfalls, blow-downs, burnt-over or cut-over areas, etc.);
7. Topography (laying out of contour or form lines, determination of the heights of land, forest roadways, improvements to waterways, choice of prominent points for the establishment of towers, stations, etc.);
8. Revision of the manuscript;
9. Publication.

CONCLUSIONS

When I. F. Fogh on behalf of the Province of Quebec Section of the C.S.F.E. invited me to read this paper he asked me to express my views of the possibilities of aerial photography during the post-war period as an aid to the industrial development of this province.

Personally, I am convinced that vertical aerial photography is indispensable to the forest engineer who wishes to construct, extract or manufacture. Photography will render very valuable service so long as it is used in its own sphere. We should not lose sight of the fact that there are possibilities of errors in the practical application of aerial photography and that these errors must be reduced to a minimum by means of indispensable data gathered in the field. To proceed otherwise would expose the operator to serious disappointments which might prove costly and would probably cause a lack of confidence in the method itself.

The most urgent immediate need is a combined program under which a certain section of our vast forest domain would be annually photographed or re-photographed at a scale acceptable to all parties co-operating in the project. Knowing the area to be photographed annually it would be possible to obtain interesting offers from firms specializing in aerial photography work. In addition appropriate premises should be made ready for the study of photographs and the preparation of maps. These premises should contain a laboratory for the impression of prints and a central library where members of the public would be allowed to examine and purchase any photographs in which they might be interested. A vault should also be maintained at a temperature suitable for the preservation of films.

Have we the necessary personnel?—The answer to this question is in the affirmative. We have a number of young engineers who possess the required scientific knowledge and who are qualified to supervise this work.

What is lacking?—We need proper premises and the necessary modern instruments to carry out this program. Photographs should not be taken uselessly for the simple pleasure of taking them, and all photographic material on hand should be used to the best and fullest advantage.

The drawing up of plans could also be done by commercial agencies but under the direct control of government technicians.

Contact prints 400 ft. to the inch.

Moreover, whenever photographs are taken by any agency, all parties who might be interested should be advised of this contemplated work. If this were done much duplication and unnecessary expense could be avoided.

An investigation should also be made to ascertain the number of primary control points (planimetry, altimetry and forestry) required to yield reliable information as to a given region.

A thorough study should be made of the interpretation of negatives from the forest point of view in order to find a formula or process which would permit reasonably accurate estimates to be made of the wood volumes of different forest types.

In the United States they are looking forward with much interest to the results of our experiments in the application of vertical aerial photography to forestry. We should take the lead and develop and adopt methods of our own. Our forests offer a vast field of action and wide spaces for research of all kinds. We should endeavour to use the talents of our youth to the best advantage and make the maximum use of our forest wealth.