THE USE OF AERIAL PHOTOGRAMMETRY AND AIRCRAFT IN WOODS OPERATIONS*

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THE subject of the present and probable use of aircraft and air photography in woods operations is a broad one. Aircraft lend themselves to various phases of forest management and the aerial photograph is one of the most useful innovations of recent years in the logging industry.

From the ground an operator cannot see the forest for the trees while from the air a clear-cut picture of his ground problem may be obtained. The aerial photograph records more than the naked eye and records it permanently so that it can be filed for reference or studied in detail at leisure.

The enormous amount of time consumed in travel and transportation in the forest is a significant justification for the use of aircraft. Speed is one important factor that makes aircraft of such importance in woods work. If time saving is not important, then the use of aircraft is not ordinarily justified.

The use of aircraft in forest exploitation has developed slowly. The reasons for this are more or less obvious. The item of cost is the principal deterrent. Aerial photography or the direct use of aircraft in logging operations involves large expenditures; consequently it is not possible for the forest industries to experiment with their use and then become "air-minded" except at considerable cost.

The second deterrent to the use of aircraft in woods operations and forest management is the lack of elementary literature on the subject, particularly in relation to forestry. A glance at the bibliography published by the American Society of Photogrammetry would seem at first to make this statement a paradox, but while there are many books and professional papers dealing with allied or relative subjects there are comparatively few that treat the subject chronologically and completely in its relation to forest management. The available literature for the most part is in such inordinate technical detail that it is beyond the ready comprehension of the average woods operator.

A third deterrent is the fact that most of the commercial aircraft companies that make aerial photographs and supply aircraft services, do not fully appreciate the special photographic requirements for forestry purposes. Photographs which may be perfectly satisfactory for topographic mapping may, and often do, lack the necessary detail for forestry use. This situation, however, is gradually being corrected.

The use of aircraft and air photography in forestry is a fascinating study. To the forester, before he thoroughly understands the subject, the advantages of air photography are so apparent that he must guard against becoming too enthusiastic until he becomes familiar with all the important aspects of the problem.

Before considering further the use of air photography, some consideration must be given to the necessary ground work. Ground work is reduced, in some cases, but never completely eliminated by the use of aircraft in forest management. In fact an aerial map so reduces the cost of timber cruising (see Table 1) that it is possible actually to spend more time on timber sampling than was previously economically possible.

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The Use of Aircraft

The uses to which aircraft have been put commercially since the World War are numerous and are constantly increasing. Forest management covering as it does a diversity of activities includes practically all of the possible uses of aircraft operation. This is a desirable situation because it tends to permit a more effective use of aircraft than do other industries.

The uses to which aircraft may be put in forest management fall under seven main groups as follows: 1. map making, 2. timber estimating, 3. forest protection, 4. forest improvements, 5. logging cost estimating, 6. transportation, and 7. miscellaneous.

The Use of Aircraft in Map Making

It is through the medium of map making that aircraft serve their prime purpose to the forester. In its crudest form (visual) an observer may study a region

Table 1. Labor Comparison for Cruising with and without Aerial Photographs
(The values given are for each 1 per cent of estimate, per square mile)

Class of work	Man days required	
	With aerial photographs[1]	Without aerial photographs[2]
Preliminary office	.23	....
Cruising	1.33	2.15
Base lines	....	2.80
Exploring	.25	.19
Field office	1.02	.52
Miscellaneous	.72	2.21
Final office	.11	3.46
Man days for each 1 per cent of estimate	3.66	11.33
Labor cost (Average wages $3 per day)	10.98	33.99
Percentage of labor of total cost	68.2 per cent	74.6 per cent
Total cost per square mile per 1 per cent of estimate	$16.10	$45.43
Cost of aerial photography and map preparation	$20.00	....
	$36.10	$45.43
Saving per square mile per 1 per cent of estimate $9.33 or 26 per cent		

[1] Based on 290 square miles.
[2] Based on 540 square miles.

from an observation aircraft and record mentally a knowledge of the particular section. Although this can be considered a method of map making, the observer returns from such an observation flight with a mental map of what he has seen. This practice is not recommended. Its use is usually secondary to a flight serving another purpose. During the World War an "observer" was a definite part of a flight personnel, and while military organizations of the present day have photographers and gunners, there are no observers, the "photographic eye" has replaced the human eye.

Sketching consists of an aerial observer, transferring features and forest types as he sees them by ocularly measured distances, to a small scale map of the best available control. During the period of rapid expansion of the paper industry (1924 to 1929) sketching reached and passed its peak of usefulness. Forest organizations, anxious to obtain appraisal information in as short a time as possible, found in aerial sketching a solution to their problem, as the information

so obtained was of sufficient accuracy for the purpose in hand. During that period referred to the primary objective was usually a valuation survey to serve as a basis for acquisition. The aerial sketch map, supplemented by general ground exploration, gave results better and cheaper than the older method of ground reconnaissance. At the time sketch mapping was at its peak vertical aerial photographs cost from 4 to 5 times their cost today. The same circumstances that resulted in sketching in 1929 would today result in the use of high obliques or extreme high altitude verticals at about the same cost with far more accurate results.

Sketching will always have some usefulness in small forestry projects, e.g., sketching the progress of a fire, making a preliminary survey of damage following a fire, insect damage, etc.

Photographic mapping is the only accurate and complete method of map making from an operating point of view. The progressive timber operator of today is as familiar with the aerial photograph as he is with a pair of calipers or a hand compass. In the near future all operators will follow the progressive operator of today. This is not a prediction but rather a statement of fact.

Timber Estimating

A complete detailed timber estimate can not be made from aerial photographs[1] but as the use of compound stereoscopes becomes more practical it will be possible to make such estimates. The essential value of photographs in timber crusing is still to produce a map. In this connection it is important to point out that there are few if any sections in the commercial timber regions of this continent where existing sufficient control (government traverses, township, and county lines, etc.) do not exist to produce a map of sufficient accuracy for forest purposes. With an accurate planimetric map of an area it is then possible to make a timber type interpretation from the photographs, providing they have been taken at any season other than midsummer[2] and by transferring this information to the map. The accuracy of such a type map, prepared by a trained individual, is far greater than that of a type map prepared by ground methods. It is significant that the types affecting the accuracy of the estimate most profoundly (unmerchantable) are the easiest to distinguish on aerial photographs. The larger the scale of the photograph the greater the degree of accuracy obtainable.

For reconnaissance purposes for areas larger than 100 square miles inventory estimates of a fair degree of accuracy may be made by applying a personal estimate of the volume on the average acre in each type classification. Such an estimate should not be confused with the detailed operating estimate previously referred to. On large scale pictures stem counts can be made but the d.b.h. dimension is still lacking. Studies are being made in Europe attempting to relate crown diameters to d.b.h. This procedure, coupled with stand profiles will undoubtedly produce the first solution to the problem of obtaining reliable detailed volumetric studies from aerial photographs.

Forest Protection

The operation of aircraft in protection against fire (detection) was the first use to which aircraft was put by foresters. Possibly the outstanding example of the utilization of aircraft in both fire detection and suppression is in the Forest

[1] European foresters have made volumetric studies with the uses of excessively expensive plotting machines. Such methods are not economically practical on this continent at present.

[2] If infrared film is used midsummer pictures are quite satisfactory.

Service of the Province of Ontario. The extensive areas of forest in this province do not allow for a complete system of fire towers. Aircraft cannot compete with properly located fire towers, as far as cost is concerned. Aircraft are also used for forest protection purposes in the western part of both Canada and the United States.

From a suppression point of view the aeroplane can not be surpassed. The more inaccessible the fire the more valuable it becomes for transportation and observation. Aircraft have been used successfully for the past ten years in fire suppression work by the writer.

Dusting of large areas of insect infested forest was effectively carried out in 1929 and 1930 during the hemlock looper epidemic on the north shore of the St. Lawrence. This operation was executed by the Dominion government. Dusting is dangerous and expensive flying; dangerous because the ship must skim over the tree tops. Since these earlier dusting operations there have been big developments in this phase of work. At the present time the auto-giro is the most practical ship for dusting. There are several organizations in the United States equipped to undertake dusting with auto-giros. As aircraft become more efficient in performance and economical in flight, these dusting operations will become more important as an insect control method. Insect infested areas are particularly apparent from the air both visually and photographically.

So far as the writer knows, aircraft have not as yet had any direct value to the forest pathologist in control work. Photographs, of course, are a valuable aid to the pathologist. These would be used just as a type map would be used in analyzing forest composition in relation to fungous diseases.

Improvement

As any method of surveying serves a definite purpose in planning and executing a forest improvement program, so does the aerial photograph serve the same purpose at a lower cost. Road location especially is facilitated by the use of aerial maps. As in the case of timber estimates, the location can not be completed without some ground work. However, much preliminary work can be carried out before going into the field. A proven method of using aerial photographs in road location work will be briefly outlined.

If aerial photographs are already available, so much the better. If they must be taken for the particular purpose in hand, they should be taken in the general direction of the proposed road route and include a strip wide enough to cover all possible routes. In most cases a strip from one to two miles wide should be ample. A scale of approximately 1,000 feet to the inch will serve, although there are certain factors which determine the most desirable scale. These do not require discussion here.

Starting at the road's point of origin, the photographs are studied stereoscopically. About three possible locations are made on the photographs using different colored pencils to differentiate the locations. The different colors indicate, in sequence, which is the most desirable route, and serve the additional purpose of making it easy to follow each route from one overlap to another. It naturally follows that in "easy country" it may not be necessary to lay out more than one.

The next step is to explore in the field all of the possible routes and determine the most desirable one. This work should be carried out by the person responsible for the location. One assistant and one or two packers to move camp when necessary is all the party requires. The photographs are used constantly during the field work and a portable stereoscope is indispensable.

With this work done, the next step is to lay out the entire road as a series of tangents, on the photographs. This layout is accomplished under the stereoscope. The point of origin and termination of each tangent are carefully located with respect to features which can be identified on the photographs and on the ground. By features are meant creek crossings, marshes, small clearings, definite changes of timber types, etc., which are not difficult to recognize.

The bearing and distance is computed on the photographs for each course. A field party is now organized to run and blaze the tangents in the field. This location of the tangents also provides a final map of the road.

Excessive grades are measured with hand level while bridge locations are measured for length and span, and all this information is recorded on the margin of the photograph. There are obvious advantages in having information relative to the location on the photographs so as to be readily available whether the pictures are functioning as a map or being studied under the stereoscope.

The final location work consists of picketing the center line of the road. It is absolutely unnecessary to do any transit work, as tangents are kept straight by lining up three pickets. It has been found convenient to complete the final location about three or four miles ahead of construction. Changes that are made in the blazed tangent location are never great if the work previous to the final picket line has been carefully done. Before the location is finally accepted as the best, the route must be travelled and retravelled to make absolutely certain that there is no better location.

In the actual construction of the many dams[3] required for branch stream driving engineering other than that type known as "haywire engineering" need not be resorted to. On the other hand, the usefulness and efficiency of many a dam has been lost after the first year of its existence because of the lack of a "cut-off-dam" in some low area. A cursory examination of the photographs under a simple stereoscope will immediately tell the observer the definite spots that must be checked on the ground for "cut-offs." In this manner, any operator can eliminate an excessive amount of arduous and expensive field work.

Logging Cost Estimating

Outside of stand per acre and total volume the important factors affecting logging cost are: total miles of branch and main haul road, skidding distance, and topographic features. These factors are readily determinable from a stereoscopic study of photographs and when carried out in connection with ground work provide the best possible data for estimating costs.

As the compilation of statistics affecting logging costs becomes more and more essential, so will the use of aerial photographs become more important in logging control. The cut survey, giving the area cut and showing total miles of branch and main road constructed, is indispensable for proper compilation of logging cost statistics. The aerial photograph makes available a ready solution of these survey problems. With the necessary instruments, complete profiles of all logging roads can be made cheaply when required in the office. This is out of the question, economically, with ground methods. The use of the motor truck in winter hauling of logs makes a stronger demand for more qualitative data relevant to winter haul roads.

The extensive use of photographs in logging control will be universal just as soon as their cost is reduced sufficiently. Roughly these costs have decreased from $50 per square mile in 1927 to $15 in 1935. In fact, when no money has

[3] It is of passing interest here to point out that in certain parts of eastern Canada roughly two dams are required for each million feet of wood handled on branch streams.

been spent previously on maps and surveys the cost is already well within the necessary limits.

Transportation

Aerial transportation as used in forest administration falls under two main heads, *viz*: freighting and supervision or taxi service.

The element of speed is the controlling factor. Aerial freighting cannot compete with motor or rail transport. It only becomes practical in emergency operations such as fire suppression, fire detection, etc. However, aerial transport has been used economically in sections of eastern Canada to log timber limits that were being "cleaned up," and where the remaining stand was not sufficiently large to justify the building of roads. On at least one such operation aircraft were used to transport all logging supplies including hay and oats. The ship used had a pay load capacity of 1,600 pounds and made a round trip in one hour. The same weight by portage road required two teams and five days to make the round trip.

The value of aircraft in forest freighting then is essentially an emergency operation. It is not likely that aircraft will ever be an important factor in transportation on the well managed forests of the future as far as logging operations are concerned.

Turning now to supervision, the picture is entirely different. Here there are big possibilities and aircraft will be much more extensively used for this purpose. The high-salaried executive can well afford to use aircraft to inspect logging operations. The reference here is to woods managers and their superiors, men who think nothing of making periodic mill inspections, but who entirely neglect the stepchild in the form of inaccessible woodlands. Aircraft will permit the busy executive to come in closer contact with his woods operations and thus permit him to properly supervise them.

Miscellaneous

Aircraft have numerous other uses in forestry and woods operations. The volume of pulpwood piles can be accurately determined from photographs. Both range and game managers can utilize aerial type maps as they now do the ordinary ground type map. For example, in about 1930 the Canadian government made a successful inventory of buffalo by photographing the heads and making image counts. At times they can also be used to advantage in recreation and general forest travel.

These are but a few of the miscellaneous uses of aircraft in forestry work. There are many others, but lack of time does not permit their consideration.