POSSIBILITIES OF STRATOSPHERE AND SUBSTRATOSPHERE PHOTOGRAPHY IN THE ADMINISTRATION OF FOREST LANDS*

F. R. Wilcox
Canadian International Paper Company

The use of aerial photography in connection with forest operations has developed rapidly during the past few years. It is now proposed to use stratosphere and substratosphere photography for the same purpose. The latter type of photography, although it presents certain technical difficulties, has many advantages which are discussed fully by the author.

THE use by foresters of aerial photographs has continued to develop during recent years. However, this valuable aid to forest management is not being used nearly as much as it might be, particularly by loggers. It is with reference to the latter group that these comments are written.

Any timber operator must expend an appreciable amount of money for the original photography before he can change his engineering procedure from the old and obsolete ground methods to the more economical aerial method. It is only natural that executives are reluctant to approve the expenditure of the necessary funds for photography.

The writer has appreciated this situation for a number of years and consequently has been endeavoring for some time to find ways and means of reducing this initial cost of photography.

In general it may be stated that the cost of photography varies directly with the scale. Furthermore, it has always been considered, for timber study purposes, that the larger the scale of the photography the more valuable the pictures are to the forester. This is only partially true and it is with this question of utilizing the smaller scale photographs that these remarks deal.

It is pertinent here to call attention to the fact that in this article "aerial photographs" means vertical photographs. Oblique photographs serve a definite purpose in forest management but they are a subject within themselves. In order to make clear the points desired, it is first necessary to summarize how aerial photographs serve the forester.

1. *As maps.*—Each aerial photograph is a map within itself. The science of assembling a number of photographs to form a compositemap at a true and common scale is known as photogrammetry. The methods of map compilation from photographs are many and vary from crude inexpensive procedure to precise, expensive methods. The forester is not concerned with the latter methods; in fact he should steer clear of them as involving inconsistent accuracy. Suffice it to say that photographs provide a means whereby the forester may make a planimetric map without going into the field. The writer makes this general statement since, in his opinion, there are few if any areas of forest land in the United States or Canada where there is not sufficient existing control to permit the preparation of a sufficiently accurate forest map to meet the forester's needs.

2. *In timber typing.*—After the photographs have been used to produce the map their next function is that of providing a medium for making a preliminary type map which is later checked in the field. This work of timber typing should always be done under the stereoscope. An individual properly skilled in the interpretation of photographs can make a remarkably accurate type map, though obviously he must be familiar with ground conditions in the region covered by the photography.

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Any forester will readily appreciate the advantages of such a preliminary type map. A few of these are:

(a) For inventory or valuation surveys of a large forest area when general figures only are required. A relatively few volume samples obtained on the ground and applied to the type areas will produce sufficiently accurate figures for this type of estimate. The writer has been associated with such surveys for the past ten years and surprisingly accurate results can be obtained.

(b) For planning a timber cruise no matter what its intensity, such a preliminary map is invaluable. In this connection it may be stated axiomatically that unmerchantable areas, such as recent burns, muskegs, marshes and areas of young forest, are the easiest types to interpret and recognize on the vertical photographs. In other words, one is always certain in one's knowledge of the unmerchantable areas that do not require immediate investigation.

3. *Operating data.*—If a woods organization invests money in photographs, they can be made to serve their greatest value to the logger in providing operating data, obtained from photographs by carefully studying them *under the stereoscope.* The consistent use of photographs in this way by an entire woods organization from manager down would materially affect its economic operation and be a step towards the ever elusive "cheap logs" that are familiar, by hearsay at least, to all operators; and once the investment is made every person in the organization who has to do with the planning of operations should always carry photographs when travelling in new country and should have a stereoscope available at his headquarters.

A few more remarks about stereoscopic study of photographs for executive use may be made. It is difficult to get a busy administrator to take the time to become even casually skilled in the use of a stereoscope. In such cases the use of stereograms (complementary colored prints) projected upon a screen has possibilities. The stereoscopic image can then be seen simultaneously by any number of observers by merely using spectacles containing glasses of the same complementary colors. This has obvious advantages over the stereoscope. The use of stereograms has not yet been exploited by foresters.

With practice the logger can determine from stereoscopic study of photographs (a) the accurate boundaries of each logging chance, (b) total miles of main and branch logging roads, (c) average skidding distances, and (d) location of cliffs and other obstacles to logging. In fact, all the elements of landed cost estimating are available.

It is well to point out here that it is not for a moment suggested that field work be entirely omitted. The operator must still see as much of his ground as time will allow. The average logging superintendent seldom has time to see every corner of his district.

4. *Volumetric data.*—The possibilities of determining timber volumes by aerial photographs have been only slightly exploited on this continent. There are unusual possibilities in this direction from tree counts on large scale photographs. Stand profiles have been very successfully made in Germany and other continental countries by means of the more elaborate compound stereoscopes (plotting machines). The volumetric study of vertical aerial photographs is a complete subject within itself and cannot be dealt with in detail here. Suffice it to say that it is worthy of consideration and must be considered in the deductions that follow.

So much for procedure; now let us consider the photographic specifications, chiefly in respect to scale which will best serve the forester. It has been more or less accepted practice in the past for foresters to have their photographs taken with a combination of lens and altitude that would produce a scale of 800 feet to the inch.[1] There are many factors influencing the most desirable scale. However, for general conditions in the east at least, 800 feet to the inch is the desirable scale to serve all four divisions of use to which a forester puts his pictures. Unfortunately pictures of such a scale are expensive. It is not possible to quote prices because the cost factors vary widely with each project.

We now come to the question of stratosphere and substratosphere photographs.[2] It is obvious that the higher one goes to take one's photographs the larger will be the area covered by each photograph. For mapping purposes alone, then, the cost of compilation is greatly reduced because fewer units need to be compiled. It also follows that the cost of flying is at a minimum. For the quality of map required for forest management purposes one may go to almost any altitude and still obtain pictures with sufficient clearness of detail. Until very recently there have been few aeroplanes that had a ceiling of more than 20,000 feet. Another complication has been the need for oxygen equipment when flying over 18 or 20 thousand feet. The equipment is both cumbersome and annoying.

The problem of obtaining small-scale photographs has an alternate, partial solution, namely the use of short focal length lens. During the past several years there has been extensive experimentation with the so-called wide angle or short focal length lens. Some very interesting results have been obtained with focal lengths of about six inches. However, difficulties are introduced in that the margin of the photograph becomes blurred with the result of a reduced useful portion. There is also a loss of quality in the stereoscopic image. The standard specification established by the American Society of Photogrammetry still calls for nothing less than an eight-inch lens. The writer favors the use of the high altitude rather than the short focal length lens.

The expression of these opinions was prompted by the recent appearance at the 1938 Chicago air show of a new aeroplane designed and manufactured by Abrams Aircraft Corporation.[3] This ship has been designed for aerial photography and so far as is known it is the first civilian aeroplane to be designed solely for photographic work. The "bug bear" of photographic pilots has long been the lack of visibility for navigation, which is so important for the attainment of economy in photographic flying. The solution of this problem by an all glass nose is possibly the ship's most important feature. Secondly, it is provided with a supercharged cabin which eliminates the use of cumbersome and annoying oxygen equipment by the crew. The ship is reputed to have unusual flying performance.

The advent of this aeroplane should be welcomed by foresters interested in a more economical use of aerial photographs. There is no doubt that in the near future high altitude photographs will become of increasing importance and will have much to do with the wider use of photographs by foresters.

[1] The scale of any photograph in feet per inch is obtained by dividing the altitude of the aeroplane in feet by the focal length of the lens in inches.

[2] The space above the earth's surface is divided into two primary regions. The first is the troposphere, which is the dust-laden region of clouds, variable temperatures, and turbulent air currents. Beyond the troposphere is the stratosphere in which the temperature is found to be nearly constant and in which there are no rising and descending air currents. The height of the troposphere varies with season and latitude; it is usually encountered somewhere beyond 30,000 feet. The stratosphere flight of the balloon *Explorer II* encountered the stratosphere at 37,000 feet.

The lack of turbulent air currents has a favorable effect on high altitude photography insomuch as "tip" and "tilt" can be reduced to a minimum. It is obvious also that navigation should be at its best with resulting straight flight lines and therefore a minimum of photographs. With proper motor supercharging, maximum speed per horsepower is possible.

[3] For a description and specifications of this plane see Volume IV, Number 3 of PHOTOGRAMMETRIC ENGINEERING.

To return to the application of high altitude photographs to forest administration, there is no doubt that a good planimetric map can be made from photographs taken at any altitude no matter how high. The highest vertical photograph ever taken produced an excellent map. It is in the cost of the map that the forester effects his greatest cash saving through the use of aerial photographs. It is impossible to give detailed figures without a lengthy qualifying statement, but it can be said that the saving resulting from the use of normal verticals (say at 1,000 feet to the inch) over purely ground methods is somewhere between $12 and $20 per square mile. Stratosphere and substratosphere photography might well be expected to double this saving.

Timber typing can be executed satisfactorily for inventory purposes from high altitude photographs provided the photography is carried out during either spring or fall when contrasting foliage colors exist in the forest crown. If the work is done in midsummer, infrared photography can be relied upon to produce the same results.

To obtain operating and volumetric data from photographs, a detailed study must be made of relatively small areas. Here a very large scale photograph (600 to 800 feet to the inch) is required. It is seldom economical or desirable to photograph large areas at this scale. The forest as a whole should be photographed on a small scale, and annually the areas for the next year's operations should be photographed on a large scale. Such an annual program can also provide cut surveys and estimates for revision data.

For a number of years the writer has been advocating small scale, high altitude photographs supplemented by strips of large scale photographs placed in a similar manner to the usual cruise line layout to provide general estimates for inventory and appraisal work. The small scale photographs provide the planimetric and type map. After the photographs have been studied and "typed," the locations for the large scale strips may be determined. The strips will provide stem counts and height measurements (shadow measurement) to form a basis for volumetric data. Field work is carried out in the large scale strip areas.

Conclusion

Aerial photography offers unusual opportunities to the forester. The initial cost of the photographs can be greatly reduced by a greater appreciation and wider use of small scale photographs taken from the tranquil region of the stratosphere and substratosphere. The recent appearance of the Abrams "Stratoplane" will make available to the forester a new type of photograph.