AERIAL PHOTO VOLUME TABLES*

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THIS paper presents a brief summary of progress made in aerial photo volume-table construction at the Pacific Northwest Forest and Range Experiment Station.

Under the present system of forest survey conducted by the Experiment Station, aerial photographs are used only for the purpose of delineating forest type boundaries. Volume data are obtained wholly from a random sample of ground plots. However, if it were possible to derive from the photographs estimates of volume, reasonably well correlated with ground-measured volumes, then these photo volume estimates could be substituted for a portion of the ground plots, resulting in a reduced cost for the same required accuracy. This is already being done in other sections of the country and in Canada, and the Experiment Station is now engaged in a small research program to see how well the system will work here in the Pacific Northwest.

The initial step was to collect the data for the preparation of aerial photo volume-tables. In this matter assistance has been requested from other public and private agencies interested. The present plan is to collect information on all of the factors which can be measured on photographs—total height, crown diameter, crown density and tree count; to determine which of these factors, or combination of factors, is best correlated with volume; to determine whether or not these factors can be measured with sufficient accuracy on aerial photographs; and to determine under which conditions these factors best apply. Since the collection of these data is a rather slow process, it has been necessary to confine the work for the time being to one species—young growth Douglas-fir.

After a few weeks of field work, data had been collected on a number of plots in Multnomah and Clackamas Counties in Oregon, and it seemed that a preliminary analysis was in order to see if further work appeared justified and, if so, along what lines. It has been impossible so far to cover the full ranges of site, and crown density, as is eventually hoped for. Most of the plots collected, up to the present time, have occurred in the higher crown density classes and on the better sites, so the preliminary analysis of necessity has been confined within these limits.

Using the data collected from 18⅕-acre plots, several aerial photo volume-tables were constructed in terms of both cubic feet and board feet. Individual tree tables employed the variables of total height and crown diameter. Stand volume tables were of two types—one employing average total height and crown density, and the other using these two factors plus average crown diameter.

Three tests have now been made on these preliminary volume-tables. In these tests the various factors of total height, crown density, crown diameter and tree count were estimated from aerial photographs. Volumes were determined from the various tables and then compared to volumes measured on the ground at the same points.

The first test was carried out on the same 18 plots from which the tables were made, using photographs with a scale of 1:23,000. The purpose was to answer this question: Given volume-tables well-fitted to the timber, can the

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necessary variables be determined accurately enough to provide a satisfactory estimate of volume? In addition, it was hoped to get some idea of which type of volume-table worked the best. Estimates of average volume of the 18 plots were made using seven different tables and all estimates were within 10% of the average volume as measured on the ground. Four of the seven estimates were within 3% of the true volume. These results indicate that the variables used in constructing the tables can be estimated with sufficient accuracy to provide a reliable volume estimate, provided the tables fit the timber. Best results were obtained from the stand volume-table employing total height, crown density and average crown diameter, while the poorest results were obtained from the individual tree approach. Differences, however, were slight and probably not significant.

The second test of the volume tables was performed on 48 plots which were taken in Clark County, Washington in the regular course of the timber survey. These plots were mostly in young Douglas-fir types on good sites similar to those from which the volume tables were constructed. However, some plots contained mixtures of hardwoods, and some were in density classes below those for which the tables were made. Photographs used were of a scale of 1:21,000. Again seven estimates of the average volume were made and most of them were 10 to 20 per cent higher than the ground measured volume. In spite of these differences, however, the correlation between photo-estimated volumes and ground-measured volumes was sufficiently high to be encouraging. Assuming similar correlation coefficients, a number of relatively cheap photo-volume estimations could be substituted for a portion of the expensive ground plots and still maintain the same sampling accuracy.

Again as in the first test, no really significant differences were found in the results from the various types of volume-tables.

A third test of the volume-tables was made on 16 plots taken by the Bureau of Land Management in Douglas County, Oregon. Most of the plots were on poor sites and in age classes older than those covered by the tables. Photos were at a scale of 1:12,000. Estimates of the average volume ranged from 25 to 45 per cent low. However, the correlation between estimated and actual plot volumes was high enough to indicate that, even under such conditions, some reduction in field work could be made by using a double sampling system. In this test, very poor results were obtained by the individual tree approach, but among the various stand volume methods no significant differences occurred.

In consideration of the very limited scope of the data from which the volume-tables were constructed, the results of these tests seem encouraging and indicate that more work on the problem is worth while. It seems evident that aerial photo volume-tables can be constructed which will provide volume estimates accurate enough to allow a substantial reduction in the amount of field work required for a timber inventory.

Although these tests did not provide conclusive proof of the superiority of any one method of volume estimation, there is evidence that the individual tree volume approach is less reliable than the stand volume approach. Because of this, and because data for the individual tree method is more difficult to collect, future work on the problem will be concentrated on the stand volume method including as variables, total height, crown density and average crown diameter.

The surface of this problem has scarcely been scratched. Considerably more data are required in order to build up tables covering the full range of sites and densities. Further checks are needed to determine the regional applicability of such tables. Data are required for the treatment of old-growth Douglas-fir and for other species. Although much work remains to be done the value of such work is definitely indicated, and if results continue to be encouraging, it won't be long before we will be using stereo work to replace a portion of the foot work required for timber inventory.

APPLICATION OF COLOR PHOTOGRAPHY*

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THE word "application" in the title of our panel discussion does not exactly pertain to the use of color photography by Region One of the Forest Service. To date, we have taken color photos with the idea of finding out how they could be applied. I shall attempt to present a few of the facts we have determined, relative to the use of color photography.

A comparison of the initial costs of different types of film is one of the first things which may be of interest. Using the 75′×9″ roll of film as a standard, color film is about five times more expensive than black and white or infra-red film. In round figures, the color film roll costs $125.00, the black and white $25.00 and the infra-red $30.00.

Developing color film requires about three times more time than is needed for processing black and white or infra-red; accordingly the development cost for labor is trebled. One man can process a roll of either of the latter types in about two hours, while six hours are required for processing color film. For making prints, the cost differential is even greater. Although Region One does not have equipment available for making color prints, we have had a number of 7″×9″ color prints made; the cost of each was about $8.00. Prints from infra-red or black and white negatives cost approximately 50 cents each.

Prior to our first attempt at taking color verticals or obliques on aerial film, available information and advice indicated that our chances of successful results were practically nil, particularly with only an $8\frac{1}{4}$-inch focal length camera. In fact we had about decided to postpone experimenting for a few years, when in the summer of 1946 we were asked to try some color shots of mountain-pine yellow pine killed by beetles. Using our Fairchild K-3-B camera (7″×9″ with $8\frac{1}{4}$″ focal-length lens), a number of high and low angle obliques were taken from an altitude of about 2,000 feet, and the negatives were processed in our own laboratory. The resulting transparencies were exceptionally good; definition and color was clear and strong; and the affected trees could be distinguished as far as three miles away. Those who had first-hand interest in the test were very favorably impressed. That same fall we borrowed a U. S. Army K-22, 9″×9″ camera with 12″ focal-length lens and made an additional test. Although conditions were not too favorable, the results were entirely satisfactory.

In the spring of 1947, we were called upon to take aerial color photos of "Tussock Moth" damaged timber on the St. Joe National Forest in north-central Idaho. As infestation was heavy and spreading rapidly, it was necessary to use an effective means of "selling" the need for controlling the moth. Vertical color shots from 10,000 feet were taken with our $8\frac{1}{4}$-inch lens, 7″×9″ Fairchild camera, as well as low and high angle obliques. The results, while not as good as our first or second attempts, were very effective. In the vertical photos, practically every tree that had been damaged could be detected, and the

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