ARMCHAIR FORESTRY THAT PAYS

At Harvard Forest, Modern Aerial Photography is Being Demonstrated as a Precise, Inexpensive and Time-Saving Instrument in Forest Management

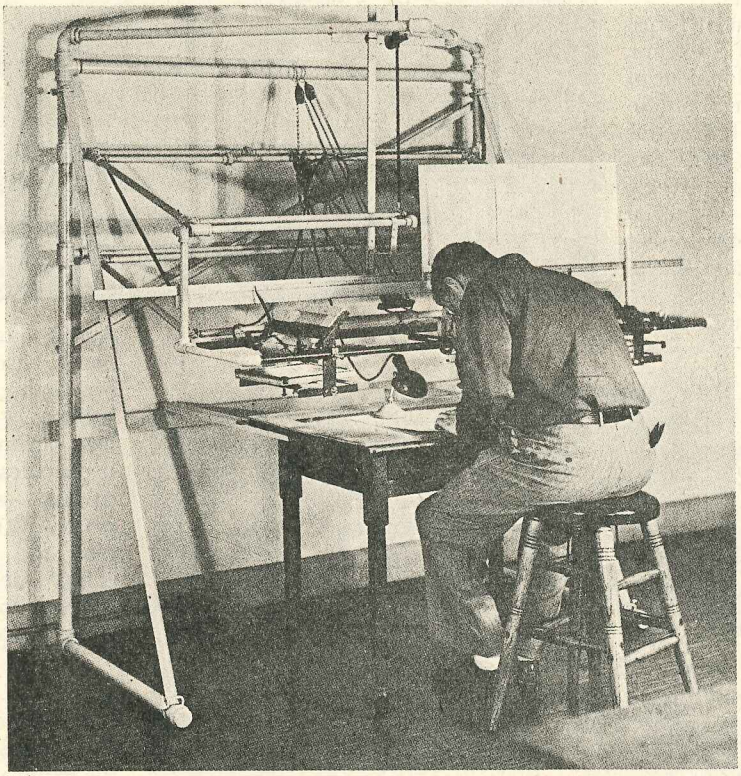
By STEPHEN H. SPURR

WITHIN a few years, armchair forestry may no longer be a term of derision, but rather one of admiration and envy —all because of the modern development of aerial photography. True, the forester will never have to forego the pleasure of getting out into the field, but he will be able to eliminate much tedious bushwacking and yet deliver the goods. With aerial photographs of the right type, a stereoscope and a few other instruments, he will be able to prepare type maps, cruise timber and control forest management operations with increased precision, less time, and at lower costs.

It all started with the first World War which gave impetus to the development of the airplane, aerial photography and photogrammetic techniques. As early as 1920, Canadian foresters began to use the airplane in type mapping, first depending upon sketching techniques, but soon switching to the aerial camera to bring back permanent records of the forest and terrain. Since then, aerial type mapping has been common practice in Canada, and more lately, in the U. S. and in other parts of the world.

Beginning in 1925, various German foresters carried out and published a number of studies dealing with the measurement of tree images on aerial photographs and the calculation of tree volume from these measurements. These studies involved the use of highly complex mapping instruments developed by German photogrammetrists, and, although they represented the first approach to aerial timber cruising, were never carried beyond experimental stages.

Timber cruises of North American timber were first made from aerial photographs in 1929 by the Canada Dominion Forest Service, using simplified techniques designed to cover large areas in a short time with moderate accuracy. In the Canadian method, areas were measured by a planimeter, tree heights by the length of their shadows, and stand volumes were determined from relatively crude stand volume tables. This method, with slight modifications, has been continuously used by the dominion Forest Service and several of the provincial services.



With the multiscope and good aerial photography the forester can accurately type map up to ten thousand acres a day

In 1940, the consulting firm of Mason and Bruce used aerial photographs to control and supplement a ground cruise of a tract of redwood timber. The number of trees on each forty acres were counted on the photographs and timber stands were segregated in three classes according to their average height as determined from parallax measurements, measurements of their apparent height, on stereoscopic pairs of photographs. This was the first extensive use of aerial photographs in this country in which tree images were accurately counted and measured.

Volumetric estimates from aerial photographs were first prepared east of the Mississippi by the Allegheny Forest Experiment Station of the U. S. Forest Service. In 1941, this station used a modification of the Canadian method to survey the timber resources of the Anthracite Region of northeastern Pennsylvania. The principal innovations were the use of dot-grids to determine area, a device previously developed elsewhere in the Forest Service, and the substitution of tree counts for the ocular estimate of stand density used by the Canadians. The project was highly successful, but the accuracy of the resulting estimates was lowered by the poor quality of available photographs and the inadequacy of available mensurational tables.

Since then, in 1943, the Brown Company in northern New England has carried out the first extensive aerial timber cruise by an operating company. They used the anthracite survey method modified to suit their particular needs and the nature of their forests.

(The part aerial photography is playing in the Forest Resource Appraisal of The American Forestry Association is described in the article "Sampling America's Forest Wealth," by John B. Woods, in the December 1944 issue.—Editor.)

Thus, by 1944, aerial timber cruising had been successfully tried in a number of widely differing forest regions on various distinctly different types of problems. Its development, however, had been handicapped by the lack of basic knowledge concerning the relative value

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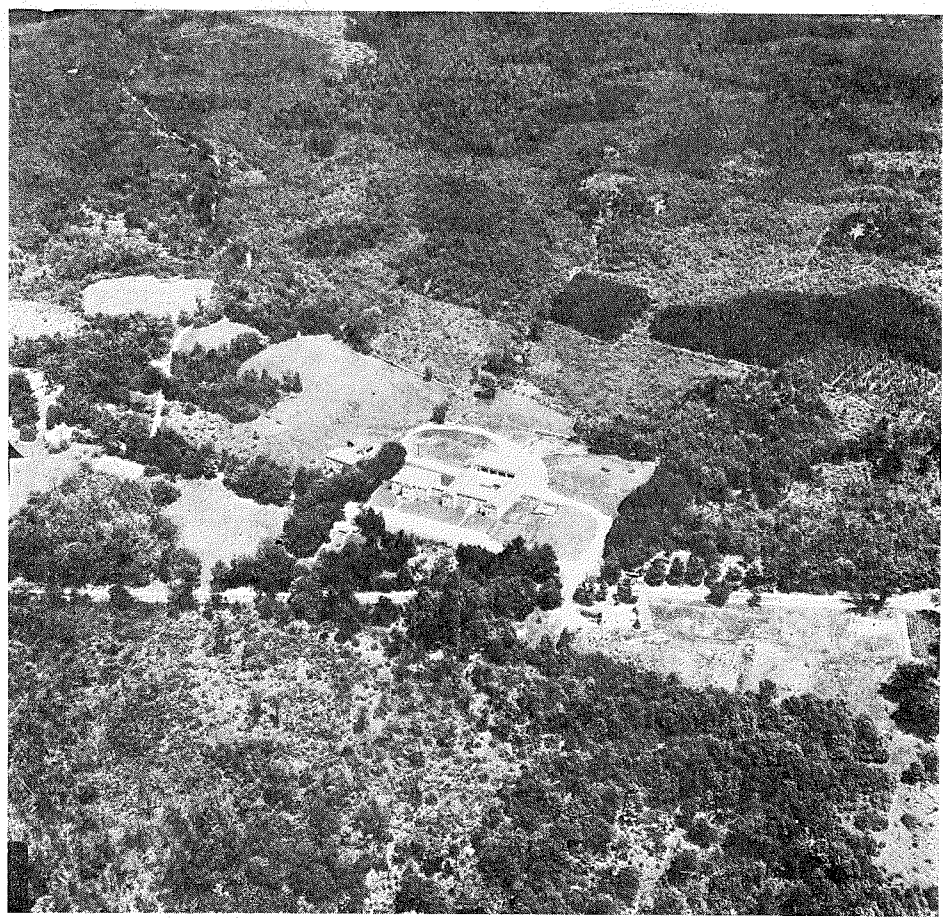
of various types and scales of photographs, their interpretation, their measurement, and the conversion of such measurements into stand volume.

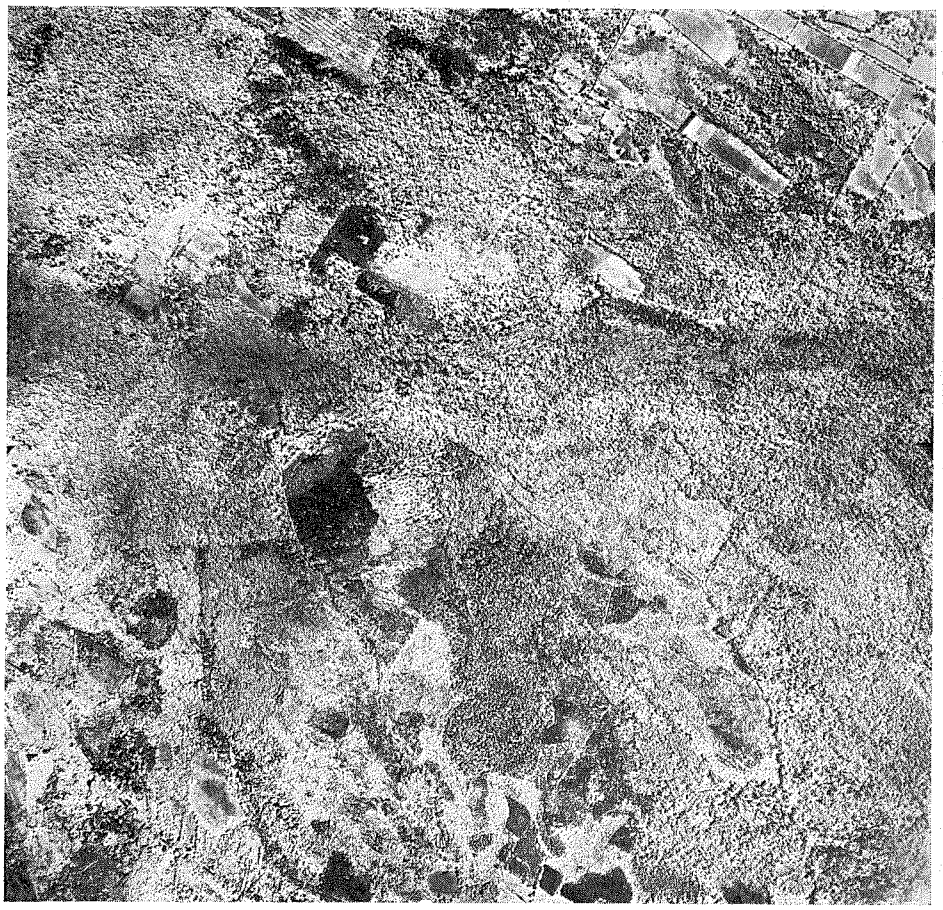
To supply this information, the Harvard Forest has organized and is actively carrying on controlled experimental work in various aspects of forest aerial photography. Cooperating in this venture have been the Fairchild Aerial Surveys, Inc., Polaroid Corporation, Eastman Kodak Company, U. S. Forest Service, Canada Dominion Forest Service and Royal Canadian Air Force. In its first year, this cooperative experimental program has pioneered in the use of infrared and color film in forest type mapping, in the development of a simplified instrument for type mapping from aerial photographs directly onto a base map of a different scale, and in the development of an extremely simple and accurate device for measuring tree heights.

Considering the development of forest aerial photography in the past 25 years, and the extensive use and development of aerial photogrammetry and aerial photointerpretation in World War II, it seems apparent that we are today at the dawn of an era in which much of forestry will be based upon the use of aerial photographs. Their value, both present and future, to forestry is real and sharply defined.

The most obvious—and the most highly developed—use is in mapping. Modern photogrammetric techniques permit the rapid production of both planimetric and topographic maps from aerial photographs at a low cost and with a high degree of accuracy. In the United States government alone, aerial techniques have become the rule in the mapping work of the Army Air Forces, Army Engineers, Geological Survey, Coast and Geodetic Survey, Hydrographic Office of the Navy, Soil Conservation Service, Forest Service, and others.

Practically every practising forester has had some experience using aerial photographs in type mapping. Even the casual observer can frequently delineate stand boundaries on aerial photos and prepare an accurate stand map merely by visiting each stand to classify it, relying upon the photographic information





An oblique view of the Harvard Forest, above, useful for illustration but not for timber cruising from the air. The infrared vertical of the same area at left, however, reveals softwoods in varying shades of gray—red pine being the darkest—while hardwoods appear nearly white. With aerial photographs of this type and the proper instruments, foresters are able to cruise timber and control forest management operations with increased precision at lower cost

as a basis for determining shapes and areas.

Such use, however, barely skims the surface of the possibilities of type mapping. In the first place, photographs examined stereoscopically will reveal in the third dimension a wealth of detail undiscernible on a single print. Type lines, age-class lines, cutting boundaries, property lines, and many other features stand out under the stereoscope, but are frequently difficult to see on the individual photograph. No forester, once accustomed to the use of the stereoscope, will depend upon any other technique.

Going a step further, tree heights may be accurately measured upon photographs, and the number of trees an acre or other estimates of stand density can easily be obtained, thus permitting more precise type mapping on the photographs, and reducing the amount of checking which must be done in the field. Finally, the use of infrared and color films now permits the identification of many individual species. Experiments recently carried out by the Harvard Forest indicate that practically all softwood species may be identified on infrared photographs, and that hardwoods can be segregated to some extent under favorable conditions. The use of the proper film and filter combination will greatly increase the value of aerial photographs in type mapping.

Identifying forest types under the stereoscope is one problem. Transferring stand boundaries to a map is quite another. Up until recently, the forester has had only crude techniques at his disposal unless he had access to one of the very few complex photogrammetric instruments, highly accurate, highly expensive, highly time-consuming, and highly unsuited to forestry use. Lately, however, simple instruments have been developed which simplify and accelerate this task. Two of these were built by foresters specifically to transfer data from photographs viewed stereoscopically directly onto a map of a different scale. These are the multiscope, developed jointly by the Harvard Forest and the Canadian Forest Service, and the KEK plotter, a product of the Division of Engineering of the U. S. Forest Service.

So much for mapping from aerial photographs. That use alone will ordinarily justify the cost of flying an area. But above that, aerial photographs are being increasingly used in timber cruising. This use is based upon the fact that stand and tree images can be accurately measured, especially when viewed stereoscopically. Measurements of area, whether by means of planimeter, rotometer, transects, or area grids, constitute the most obvious type of measurement which can be quickly and accurately made on photographs. Stand density, too, can be easily determined, either by counting the number of crowns visible in a given known area, or by estimating crown closure in a given stand. On individual trees, crown diameters can be measured with a simple wedge scale, and tree heights can be determined by either the shadow length or the parallax method. With the recently developed Harvard parallax wedge, a very simple device, tree heights can be measured to an accuracy of 5 percent on photographs with a scale of a thousand feet to the inch.

The accuracy of a photocruise depends not only upon the accuracy with which the above four measurements can be made, but also upon the correlation of these measurements with stand volume and timber quality. This is a question upon which research is being actively undertaken, and which will require a great deal of attention in the future. The mensurational aspects of aerial timber cruises constitute the least understood and the least studied portion of the field of forest aerial photography. Experience with emprical photocruises which have already been undertaken, however, indicate that estimates accurate within at least 10 percent, and frequently within less than 5 percent, can be obtained if the photographic work is controlled by careful ground checking.

The third great field of usefulness of aerial photographs in forestry is in management, and here the implications and possibilities are great. At the Harvard Forest, for instance, aerial photographs are currently used to locate roads and trails, to delineate cutting operations, to determine the priority of silvicultural operations in various stands, to plan silvicultural treatments, to locate property lines, to evaluate defoliation by the gypsy moth and, in general, to save many time-consuming trips into the forest. They can be used and are used to locate logging railroads, to evaluate site, to map erosion, to survey damage by many types of insects and diseases, and to plan and administer fire control operations.

The above enumeration may sound very inclusive. It is. Aerial photographs seem destined to become just as much of a forester's tool as the calipers, the volume table, or the Abney level. A word of caution, however, is advisable. Too often, the forester becomes so enthusiastic with aerial photography that he loses his sense of perspective to his own detriment and to that of his work. Aerial photographs have definite limitations and these should be thoroughly and fully understood.

Most important, the value of an aerial photograph is limited by its age, scale, and other photographic characteristics. Old photographs taken at a high altitude and with ordinary film can supply much information of value. But they are surprisingly inadequate when compared with modern photographs taken with increased photographic control, with the proper film and filter combination, and at a scale suited to the needs of the forester. Full values can only be obtained by the forester equipped with up-to-date, high quality photographs designed for forestry use.

Furthermore, it should be realized that the accuracy of photocruises is strictly limited by the few measurements which can be made on aerial photographs. More precisely, their accuracy is limited by the precision with which tree heights, crown diameters, stand density and stand area can be measured and the correlation of these measurements with stand volume. Greater accuracy can be achieved only through careful supplementary sampling on the ground. It is highly improbable that aerial techniques can ever be successfully used independent of ground checking. Rather, they will change the amount and kind of ground work needed. The most efficient timber cruise—that is, the cruise giving the greatest precision for the least expenditure of time and money—will undoubtedly be one in which both photographic and ground techniques are scientifically developed and carefully correlated.

All in all, the future of forest aerial photography is very bright. Its scientific use will permit inexpensive and precise forest mapping, timber cruising and control of forest management operations. What is needed at the present time, however, is objective research to evaluate statistically just what can be done in forestry with aerial photographs, and to find out how they may be most efficiently utilized.