trees were less than 14 inches in diameter and could be bulldozed; less than a dozen in the cleared area were 18 to 20 inches and had to be blasted. The anticipated access routes were usable with minor improvements.

For the study, suggested sites for borrow pits and quarries had been picked almost entirely from published reports and maps. The field check indicated that a more detailed soils map could have been made 1) if good quality photos on a larger scale, preferably at least 1:10,000, had been available, and 2) if some spot ground check had been possible or if the interpreters had had previous field experience in the regional geology. The detailed soils map would doubtless have shown more suitable sites for construction materials.

## PHOTO INTERPRETATION IN FORESTRY*

*Kendall B. Wood, Consulting Forest Engineers, 436 Terminal Sales Bldg., Portland 5, Oregon*

SEVEN years ago, when I organized my private practice as a logging engineer and timber consultant in Portland, photogrammetry and aerial photographic interpretation as applied to timber problems was considered by practically all Northwest timber people to be only an interesting experiment. It is true that the aerial photographs had been used for some years in parts of the East and particularly in Eastern Canada. Stuart Moyer has provided information on some of the work the Fairchild Company had done in the early twenties in the pulp timber areas of Eastern Canada. Stephen Spurr had laid the foundation for scientific use of photogrammetry in timber appraisal work and had developed the techniques of using modified infra-red photography for distinguishing conifers from hardwoods. The Forest Experiment stations were using available photographs as an aid in preparation of Forest Survey type maps of the country. Nevertheless, in the West, where the bulk of the reserve timber in the country stands, very few, if any practical timber people expressed much interest in the use of aerial photography for map preparation or timber cruising work.

The change in seven years has been remarkable. In this time the timbered areas of the West experienced the greatest economic boom in their history. Stumpage rates have climbed greatly in excess of normal inflation and a pressing need has developed to get quick surveys of large undeveloped areas and to reassess areas hitherto surveyed and rejected because of low grade timber or inaccessibility.

Tremendous areas had to be covered rapidly in order to beat competitive buyers on a prospective timber buy. The forestry profession accepted this challenge and started applying photo-interpretation and photogrammetric map-making methods to meet the time requirement. Mistakes were made and are being made because of over-enthusiastic use of aerial photographs by foresters lacking in photogrammetric training, but on the whole a good job is being done.

The Society owes a debt of gratitude to the Forestry profession for "selling" photogrammetry to the timber industries, for today there are very few if any large timber owners in the West who do not utilize aerial photography in some phases of their work. There are already several large firms which employ staff photogrammetrists in addition to their forestry personnel. Practically all Forest schools now conduct courses in photogrammetry. We employ a number of young foresters during the summer and have been amazed to find that most of them

* Paper read at Nineteenth Annual Meeting of the Society, Hotel Shoreham, Washington, D. C., January 14 to 16, 1953. It was a part of the Report of the Photo Interpretation Committee.

have a working knowledge of photogrammetry. It is most gratifying to learn that Oregon has a larger Society membership than any other State excepting those which harbor large government mapping agencies. This is due to timber industries' acceptance of photogrammetry as a necessary part of the job of growing trees and producing logs.

There is also a good deal of subprofessional work going on. In one of our client's camps the Engineers' shack is a pretty popular place as both the side foreman and the Bull-Buck spend practically every evening—with a stereoscope, mind you!—studying the next day's work. On my next trip, I hope to tell you about the high climber who carries a pocket stereoscope with him. After he tops the tree he will sit down on top—250 feet in the air—and study out the next landing with aerial photographs!

Now, our plans for a full report on Forest Interpretation:

The following general outline will be followed:

### Part I—Forest Land Measurement

A. CONDUCTING A TOPOGRAPHICAL SURVEY FOR LOGGING DEVELOPMENT—Committee collaborator, S. B. Gross, Portland, Oregon.
   1. *Photographic specifications and methods of procedure.*
   2. *Control problems.*
   3. *Mapping requirements, purpose of maps, contouring problems, generalized type maps, training of personnel,* etc.
   4. *Conclusions and recommendations, probable accuracies.*

B. USE OF PHOTOGRAPHS FOR TOPOGRAPHICAL STUDY IN LOGGING ROAD AND LANDING LOCATION—Committee collaborator, Page Gilbert, Chief Engineer, Harbor Plywood Corporation.
   1. *Desirable types of photography.*
   2. *Methods for locating and correlating field work directly with photographs.*
   3. *Recommendations.*

C. A METHOD FOR DETERMINING CONTOUR LOCATION IN HEAVY TIMBER—Committee collaborator, Kendall B. Wood, Portland, Oregon.
   1. *Experinents in crown-diameter tree height estimates. How theory was developed.*
   2. *Field checks on accuracy of results.*
   3. *Recommendations.*

### Part II—Measurement of Timber

A. SURVEYS OF STANDING TIMBER.
   1. *Conducting cooperative county aerial mapping project*—Committee collaborator, H. G. Chickering, Jr., Eugene, Oregon.
      (a) Project Planning.
         (1) Meeting of county and cooperating agencies and companies.
         (2) Determination of needs and requirements of maps and photos.
         (3) Projected costs.
         (4) Type of map and field examination required.
      (b) Aerial Photography.
         (1) Scales.
         (2) Area breakdown and reasons.
         (3) Specifications and contracts.
         (4) General conclusions regarding photos and enlargements.
      (c) Map Control.
         (1) Type of map control required.
         (2) Methods of obtaining control.
         (3) Accuracies.
         (4) Control extension methods.
      (d) Map Compilation.
         (1) Scales for urban and suburban areas.

(2) Pre-typing forested areas on photos.
(3) Pre-typing agricultural and developed areas on photos.
(4) Final compilation methods.

(e) Field Examination.
(1) Cruising and check cruising.
(2) Specifications for field work.
(3) Contract vs. county cruisers.
(4) Tax Roll checking in developed areas.
(5) The land grid and its importance.
(6) Large and small areas.

(f) Compilation of Basic Appraisal Data.
(1) Acreage counts.
(2) Building checking.
(3) Summary sheets.
(4) Final appraisal.

(g) Conclusions.
(1) The timber owner.
(2) The farmer.
(3) The County Assessor's office.
(4) The County Engineer.
(5) The County Court and Commissioners.
(6) Value received from an aerial mapping project on a county-wide scale.

2. *Cruising the Navajo Indian Lands*—Committee collaborator, John C. Dozier, Portland, Oregon.
(a) Purpose and requirements of the survey.
(b) Aerial photography scale, focal length, area covered.
(c) Preparation of control data, setting up type classifications, typing photographs.
(d) Preparation of base maps.
(e) Production of field copies.
(f) Planning and executing of field sampling work. Field edit of types.
(g) Use of IBM methods of reducing map and field data to complete timber cruise reports.
(h) Map completion.
(i) Conclusions and recommendations.

3. *Conducting a volumetric timber survey in the Redwood region of California.* The firm of Hammon, Jensen and Wallen of Berkeley will collaborate with the Committee on this subject. Detail outline not yet available.

4. *Resource survey of the El Peten compartment of Guatemala*—Committee collaborator will be Bertel Mason, Jr., of Portland. Detail outline not yet available. This section will cover some rather interesting procedures in locating Central American forest types by aerial photography.

5. *Timber survey methods in Lakes States Hardwoods, using photogrammetric methods*—Committee collaborator, Professor John Carow, University of Michigan, Ann Arbor, Michigan. Outline not yet available. This report will detail the generally accepted procedures and specifications for aerial photographs, type mapping and field sampling peculiar to the Northern hardwood timber types.

6 and 7. These two items which will cover *photographic timber surveys in Eastern Canada and Southern Pine regions* have not yet been assigned to collaborators.

B. STATISTICAL PROCEDURES FOR DETERMINING AREA OF SAMPLE ON PHOTOGRAPHIC TIMBER SURVEYS—Committee collaborator, Myron Savage, Rayonier Corporation, Hoquiam, Washington. Detail outline is not yet available.

C. TIMBER VOLUME TABLES BASED ON QUANTITIES MEASURED ON AN AERIAL PHOTOGRAPH—Committee collaborator, Robert Pope, Pacific Northwest Forest Experiment Station. Detail outline is not yet available.

D. CONDUCTING GROWTH AND YIELD SURVEYS IN IMMATURE TIMBER WITH AERIAL PHOTOGRAPHS—Committee collaborator, John Downer of the Weyerhaeuser Timber Company, Tacoma, Washington. Detail outline not yet available. This section will com-

pletely cover the procedures and methods used by the company on its vast holdings, for surveying and appraising stands of immature timber, types of photography desired, interpretation procedures, etc.

### Part III—Special Survey Problems

A. USE OF INFRA-RED PHOTOGRAPHY IN SELECTION OF TREE PLANTING SITES—Committee collaborator, John Wood, Assistant State Forester, Salem, Oregon.

B. USE OF AERIAL PHOTOGRAPHY IN ESTIMATING RIGHT OF WAY CLEARING COST.—Committee collaborator, Morris Boyd, Bonneville Power Administration.

C. AERIAL PHOTOGRAPHY IN FOREST INSECT INVESTIGATIONS—Committee collaborator, John Weir, Forest Insect Laboratory, Bureau of Entomology and Plant quarantine.

This is an entirely new field of use of photography in timber work and promises to be a useful contribution. The following preliminary notes from John Weir have been received:

"Aerial photographic research for the detection and evaluation of forest insect outbreaks in timbered areas is being carried on by forest insect laboratories located at Portland, Oregon, and Beltsville, Maryland. Each laboratory has conducted various photographic experiments in their respective regions to determine the most practical film and filter combination and the best scale of photography which can be relied upon to give accurate tree mortality figures. It is hoped that a high degree of accuracy may be attained through photo interpretation and limited ground sampling.

"Aerial photo tests to date have been limited to a few major timber types which have insect damage characteristics readily discernible from the air. As soon as aerial photographic techniques can be satisfactorily determined (the tests) will provide accurate insect mortality information for these few timber types which have insect damage and tree mortality more difficult to recognize and to evaluate from aerial photographs.

"On the West Coast the ponderosa pine type and the Douglas-fir type have received aerial photographic study by the Portland Forest Insect Laboratory. Panchromatic, infra-red, and color films with different filters have been tested at various scales ranging from 1:2,500 to 1:7,500. Color and several panchromatic combinations have given results superior to infra-red photography. Further experimentation is needed to determine the most satisfactory panchromatic combination and to compare the interpretation accuracy of black and white to color photographs.

"Large scale photography is basic to accurate forest insect damage evaluation. In the case of interpreting photographs of ponderosa pine and Douglas-fir stands for insect killed timber a scale of approximately 1:4,000 shows great promise. Additional photographic experiments are required to ascertain the best interpreting scale for evaluating insect losses in each timber types. A statistical and cost analyses of ground and aerial photographic methods will prove the value and practicality of more extensive aerial operations in the future."

### Part IV. Reference Bibliography on Subject of Use of Aerial Photographs in Forest Survey Work

Professor Stephen Spurt has kindly permitted reproduction of his extensive bibliography on aerial photography in Forest work.

The foregoing pattern will, of course, be modified and amended somewhat before the Committee's work is done. There will be no pretense of covering the entire field as the science is too young and advancing far too rapidly for anyone to do this. Each species and each forest type is a problem of its own. The forester-photogrammetrist, who day after day works between the forest and the photograph in his particular locality, will develop many valuable techniques of identification which the interpreter in the office will never find. I strongly feel that no strict procedures for any particular photographic timber survey project

should be set up by following techniques on other jobs. Ideally, the project should be photographed and a reconnaissance ground survey should be made before the type mapping specifications are set up. This in most cases will make possible simplification of type specifications and more accuracy.

In all, the final report will contain approximately 250 pages of material by approximately 20 collaborators. We hope to have the maximum possible illustration by actual photographs. The present schedule calls for all detail outlines to be in by March 1. Unedited copy should be ready by September 1 and the final draft by December.

I have attempted in this study to place emphasis on as many new applications of photogrammetry in forest work as I can find, such as the work by John Weir in insect investigations and by Bonneville Power in making right of way estimates.

I will welcome letters about new applications of photogrammetry in forest work and I will try to incorporate such information in the final report should it merit comment.

# AIR-PHOTO INTERPRETATION IN NATURAL RESOURCES INVENTORIES*

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## Introduction

EARLY last year the author was asked to head the Natural Resources Section of the Photo Interpretation Committee. Owing to circumstances beyond his control, the section has remained very much a skeleton. This is not due to lack of activity in the field of natural resources inventories, both in the United States and Canada, where a large number of projects are underway with a view to evaluating one or another natural resource. For example, in Canada, the provinces of Ontario, New Brunswick, Nova Scotia and British Columbia are all in the process of assessing their forest resources under a joint Federal-Provincial scheme. The basis of this is a rapid general inventory by aerial photography, interpretation and key ground surveys. A similar effort is going forward in the field of soil surveys in all of the ten Provinces. In the United States the U. S. Department of Agriculture, Division of Soil Surveys, has been using air-photographs since the 1920's and since 1930 has made use of photo interpretation as a regular part of its work.[1] The well known Forest Survey of the United States[2] is designed to give a nation wide forest resources inventory. In both countries the techniques of air-photo interpretation have been advancing, and new methods, such as the Forestry Tri-Camera, are being introduced from time to time. However, the main progress has been in the volume of work being done, which speaks well for the growing acceptance by the various controlling agencies, both private and governmental, of the value of the methods.

As the methods of forestry and soil surveys are quite well known, it occurred to the writer that, as a substitute for describing those methods, an inventory of some other or related natural resource might prove of greater interest to the group assembled here. It so happens that his native Nova Scotia, through its Research Foundation, has been conducting inventories on such unusual re-

* Paper read at Nineteenth Annual Meeting of the Society, Hotel Shoreham, Washington, D. C., January 14 to 16, 1953. It was a part of the Report of the Photo Interpretation Committee. Published with the permission of the Nova Scotia Research Foundation.