4) The efficiency of a plate camera is higher than that of a film camera of the same format and angular field.

In order to check the assumptions upon which the deduction of the area efficiency factors has been based, the well-known relative height error can be computed from the following expression:

$$\frac{dh}{H} = \frac{s}{f} \cdot \frac{0.566}{\sqrt{A_0}} \text{‰}^1 \qquad (13)$$

These relative height errors calculated from the area efficiency factors agree with the values well-known from practical measurements. It can therefore be concluded that the assumptions made are correct.

[1] The denotation ‰ means 1/1000—thus $1‰ = 0.1\%$.

ACKNOWLEDGMENTS

Finally the author would like to express his thanks to Mr. Don Kennedy for his help and patience in translating this paper.

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Forest Photogrammetry at a Small Regional College

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STEPHEN F. Austin State College is a small college[1] located in the piney woods of East Texas, celebrating its fortieth anniversary during this school year. Originally, it was a state teacher's college, but it has since broadened its scope to include other degrees in the liberal arts, science, business administration, forestry, agriculture, home economics, fine arts and music, as well as pre-professional training in medicine and related fields, and in pre-engineering. The original orientation of the college was to serve the regional needs of central East Texas, but during the past few years the basic region served by the College expanded to all of East Texas, with a sizeable enrollment from Texas' metropolitan areas, notably Houston and Dallas.

Stephen F. Austin State College has the only four-year degree granting forestry department in Texas. As a result, the forestry enrollment is statewide. A four-year forestry curriculum at a small college is somewhat unique in this country. However, Stephen F. Austin State College has offered forestry since 1946. Total forestry enrollment has steadily climbed, reaching 120 this year.

Photogrammetry was first taught at Stephen F. Austin State College in 1949 with an enrollment of four students. It was handled by six different instructors during its first seven offerings. Since 1955, however, the Department of Forestry has become more stabilized within the College. The author has instructed forest photogrammetry during its last eight offerings and has developed system and continuity to it. The time period for discussion in this paper will, therefore, include only the last eight years.

Eight years ago, in 1956, the Department of Forestry budget was only beginning to assume reasonable proportions, and photogrammetry equipment and photographs were in short supply. The photogrammetry inventory then consisted of a few photographs

[1] Fall semster, 1963, enrollment was 3335 students.

of the area immediately surrounding the College, several pocket stereoscopes, two mirror stereoscopes, a lazy daisy mechanical templet set, a parallax bar and a vertical sketchmaster. Since that time the Department has steadily built up its collection of photographs and equipment through market purchase and acquisition by way of the Texas Surplus Property Agency which sells equipment at handling cost to state colleges, independent school districts, and state hospitals. The area surplus depot is in northeast Texas and there is relatively little demand on its photogrammetry stock from other eligible institutions in East Texas. As a result, the Department of Forestry has obtained a number of pocket and mirror stereoscopes, a vertical and oblique sketchmaster, and several photo interpreter's kits from the Agency. Market purchases include height finders, parallax bars, a Kail plotter, point locators, and a large mechanical templet set.

The Department's aerial photograph collection includes coverage from every geographic region of the country, so that students may acquaint themselves with forest conditions in other regions. We have not been bashful in our requests for sample photographs from the domestic and foreign camera manufacturers and photo users. Examples of forest photography have been obtained from several foreign countries, principally Australia, New Zealand and Canada. The coverage of the city and county of Nacogdoches and the forestry summer camp area is as complete as we can make it. From it, student problems and departmental research projects have been instituted.

Forest photogrammetry is offered as a three semester-hour course, composed of two hour lectures and a three-hour laboratory session weekly during the fall semester. Since the course is senior-level, total enrollment is small —never having exceeded fifteen. Small class size has enabled the author to give close attention to each member of the class. A student assistant has been employed in the course during the past four years to offer even closer instruction for the laboratory sessions.

The photogrammetry course is devoted to both photo measurements and mapping and to photo interpretation, approximately half the semester being devoted to each segment of the material. Stress is given to solving practical problems which field foresters will encounter. These needs were made apparent from contacts with field foresters during short courses and research projects and were confirmed by returned questionnaires from graduates of the Department received prior to writing this paper.

The weekly laboratory exercises are the key to the forest photogrammetry course. Several of these are of special interest. One exercise concerns ordering photographs from different sources and from several different areas. Student crews are supplied sample order forms and ordering instructions from various government and private sources. The complete sequence of ordering photos is accomplished: writing the letter of inquiry describing a particular area of interest, ordering index mosaics, selecting and ordering individual photographs and re-ordering missing coverage. Prepared answers are furnished for letters of inquiry and the ordered photos are given to each crew based on the author's experience in procuring photographs for teaching and research.

Practice in determining standing timber volume by ground measurement, controlled by aerial photographs, and in estimating standing timber volume directly from photo measurements using aerial photo volume tables, are treated in separate laboratory exercises. Photos of an area near the Department's sophomore forestry summer camp are used for these exercises, since students have surveyed and cruised the area conventionally a year before.

During the last four course offerings a representative from Edgar Tobin Aerial Surveys of San Antonio has graciously visited the College to demonstrate first-hand the construction of a controlled mosaic. Each student then constructs his own mosaic from photographs furnished by Tobin. On two occasions the class has been flown to Tobin's San Antonio plant to see its mapping procedure first-hand.

Since the course is forest photogrammetry, forestry examples are stressed throughout. Work in parallax measurements on trees and other objects is particularly difficult to teach during one laboratory session. However, subsequent work with parallax measurements by students who have completed the course indicates that this short training plus approximately 24 man-hours for additional measurement and checking gives a man reasonable facility in tree height determination from aerial photographs.

Students construct a radial line-plot by the acetate method and check its control points by the use of mechanical templets in other

laboratory sessions. The photo interpretation portion of the course is initiated by a laboratory exercise in which each student examines approximately thirty stereo pairs of contact prints from throughout the nation, covering numerous types of man-made and natural ground and hydrographic features.

All seniors in the Department of Forestry are required to take a "special problems" course. Each student engages in a special research problem of his own choosing, or works on a project suggested by the instructor in the field he chooses. From one to two students per year have undertaken a special problem in forest photogrammetry. Two such projects called for design and construction of inexpensive substitutes for technical photogrammetric instruments, such as a mirror stereoscope and a parallax bar. In other projects students have estimated past growth of timber employing aerial photo cruises from old and new coverage of a forested area, have constructed photo coverage maps for the East Texas area, and have estimated the proportion of forest to non-forest land in the local country using index mosaics. Interested seniors thus gain additional practice using aerial photographs and provide the author with valuable material for teaching and research.

The Department of Forestry at Stephen F. Austin State College has offered a five-day short course for practicing foresters from Texas and nearby states since 1958. Since the forest photogrammetry house was in order and since foresters had expressed interest in the subject, a refresher course in forest photogrammetry was offered in 1958. This was simply a shortened version of the senior forest photogrammetry course with contemporary forest management examples; hence its preparation was not a considerable problem. Foresters gave the first course such a warm and enthusiastic reception that a second course, in more depth, followed the next year. This course stressed the time-saving use of aerial photographs in timber volume measurement as well as introduced foresters to a new quick field timber estimating method well paired with the photograph as modern forest inventory tools. Forest photogrammetry will be offered as the short course topic in the near future.

Short course material has been sent in response to each request for it. This material has been exchanged with other forestry schools and with forestry departments in foreign countries.

Since forest photogrammetry comprises just part of the author's field of interest, his research efforts have been limited in this field. Two research projects have been initiated. The first project has been a photo-use training manual for personnel of the Texas National Forests, U. S. Forest Service, with practical suggestions offered for getting aerial photographs 'on-the-ground' in forest management. Rather than containing small cutouts of aerial photographs or stereograms, the training manual uses whole photos to closely relate training to field practice.

As reported earlier to the Society, this photo training manual had a very specific purpose: (1) "to get photos in the field man's hands (both in the office and on the ground), (2) to have him gain confidence in their use, (3) to whet his appetite to learn more about them, (4) to have him use them in his regular work, (5) to let him devise new uses for them, and (6) to finally encourage him to leave a permanent record of his work for his successors."[2]

The second research project investigated methods for improving timber volume estimates at the county level for the forthcoming Southern Forest Resurvey in Texas. It was a cooperative project with the U. S. Forest Service's Southern Forest Experiment Station, New Orleans, correlating ground timber volume measurements with aerial photo timber volume estimates made at the same location. The study is essentially a replication of a similar cooperative project for an area in southern Alabama made by Gene Avery and the Southern Forest Experiment Station. Statistical evaluation of results still must be made, but preliminary indications are that a combination of photo-volume estimates and ground-volume measurements will show more reliable timber volume data at the county level compared to the previous method of employing only ground measurements.

A list of overlays and equipment available to foresters has been prepared and maintained. It was disseminated at the first photogrammetry short course in 1958 and revised for a training session in photogrammetry which the Texas National Forests presented at the College in the fall of 1962. The Department of Forestry has at least one copy of most transparent overlays available. Maps of available photography in East Texas are main-

[2] Baker, R. D. Getting aerial photographs 'on-the-ground' in forest management. PHOTOGRAMMETRIC ENGINEERING, March 1963, pp. 343–346.

tained to include all new coverage as its presence becomes known. The forest industry inquires about existing coverage from time-to-time; these maps have helped serve their needs quite well.

Upon request, assistance to solve photogrammetry problems is readily given. To date, assistance has been offered to foresters, surveyors and tax assessors. The Department maintains a comprehensive file of index mosaics for Nacogdoches and adjacent counties, receiving numerous requests for information about dates and types of coverage and directions on how to order it. As a case in point, a consulting tax-appraisal firm recently contacted the Department to find a forester to cruise timber. In the discussion that ensued, aerial photographs were demonstrated and their time-saving features for timber tax appraisal was pointed out.

The Department of Forestry has prepared exhibits for display at fairs, school science exhibits and professional forestry meetings. These have always attracted interest because the general public and even the professional forester is unaware of all the uses for aerial photographs. Young people are especially interested in seeing an area three-dimensionally and are more interested if the photographs have their house or school on them. Enlarged photographs attract much attention also. Several years ago the author prepared a talk on photo interpretation for local forestry groups, enlarging contact prints in an opaque projector for easy viewing by the audience.

In December, 1963, the Department of Forestry mailed a questionnaire to one hundred of its graduates, working in forest management or on jobs where aerial photos are probably used, concerning their use of photos since graduation. Of the first 50 responses received,[3] 21 graduates use the photos often, 20 use them some and nine do not use them at all. Of the photo-using group, 65 percent use photos obtained from government stock, 20 percent use photos purchased from private photographers from stock or by contract flying, and 15 percent obtain them from all possible sources.

Approximately half the photo users thought that photo clarity was either good or fair and only a very few thought that clarity was poor. Seventy-four percent of the respondents had received no further formal training in photogrammetry since graduation; of the remaining thirteen, two have completed a 6-month Civil Service approved cartographic training school, two have taken short courses at forestry schools and nine have received further formal training of short duration from the U. S. Forest Service. Industrial foresters apparently receive on-the-job training in aerial photo use.

Several forestry graduates furnished unsolicited praise for the course in forest photogrammetry since it provided them with procedures for using this time-saving forest management tool. Specific criticism was confined to one point—that the course as presently constituted applies too much to timber management and neglects the other multiple uses of forest land. Future offerings of the course will be reshaped to include examples of photo use in the other phases of forestry.

In conclusion, the experience at Stephen F. Austin shows that a small regional college can provide considerable training, research, and assistance in photogrammetry. This particular example has been forestry. It could just as easily have been agriculture, geology, geography, wildlife management, recreation, or other fields.

Photogrammetry can serve the educational needs of college students, the training needs of practicing professionals, the information desires of companies and individuals, and the thirst for general knowledge by the public. Small colleges, as well as large universities, satisfy these requirements.

[3] Deadline for the paper was January 15, 1964.