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Measurement of Vegetation and Terrain Characteristics On Small Scale Vertical Aerial Photographs [1]

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Introduction: Few events in recent years have stirred public imagination and interest to the degree occasioned by the uses made of aerial photographs in the Cuban affair. The average earth scientist, however, was not taken by surprise since the basic methods, materials and principles involved were not new to him. As a matter of fact, since World War II, aerial photography has become an everyday, virtually indispensable tool to most earth feature and natural resource analysts. In order better to understand the application of aerial photographs to such civil pursuits, it would be well at this point to differentiate the two basic levels of use:

(1). *Photogrammetry* involves use of highly precise measurements and complicated instrument systems. Among the products of photogrammetry, to list a very few, are highway design, topographic maps, bridge and dam site surveys.

(2). *Photo Interpretation* involves the extraction of both subjective information and the performance of measurements at a lower level of precision than that essential to the photogrammetrist. Photo interpretation work is usually done by the skilled professional (e.g., archeologist, forester, geographer, geologist) who utilizes this information to formulate decisions pertinent to his professional activity.

Admittedly, this a gross over-simplification of the distinction between the two levels of activity and precision since there is a certain degree of overlap between the two. As a matter of fact, there are some individuals who are fully qualified to perform both functions. Nevertheless, these basic categories must be recognized in order to indicate to the average subject matter specialist the photo interpretation applications which are available to him directly.

Although the photo interpretation process is basically subjective, both in nature and by definition, a useful degree of quantification is possible. Crude though these measurements and controlled estimates may appear to be to the photogrammetric engineer, they are still suitable and often fully adequate for the purposes of the interpreter. It is doubtful, however, whether these techniques are being put to sufficient use since it is generally estimated that not more than 60% of the useful capabilities of currently-available photo interpretation systems are being realized. It is the purpose of this paper, therefore, to briefly describe some of these measurement techniques, give a few examples in current use and suggest some possibilities for the future.

Types of Measurements: In general, photo measurements can be considered as being either "direct" or "indirect." In the former category, one measures on the photo and equates such photo features as horizontal distance, area, ground or object elevation, slope and object counts in terms of the same features on the ground. So-called indirect measurements, on the other hand, can be used to assess ground population features which are not the same as those measured on the photos. For example, the density of forest stand tree crowns as estimated or measured on aerial photos is not necessarily significantly correlated with the ground-measured crown density of the same stand. As a matter of fact, the ground measurement of the latter is slow, tedious, unreliable and has little practical value to the inventory forester. But it can be shown that (Figures 1 and 2) a very strong relationship exists between photo crown densities and forest stand volume (1, 5). It has also been shown, in cases of large scale photography and open stands such as Ponderosa Pine, that photo measurements of crown diameter can sometimes be used to predict tree stem diameters at breast height (6). Similar relationships also exist between photo stand height and such stand properties as volume and stand diameter (Figures 3 and 4).

Measurement Limitations: Serious errors are sometimes made when direct measurements of length and/or area are made from photography of mountainous country. As

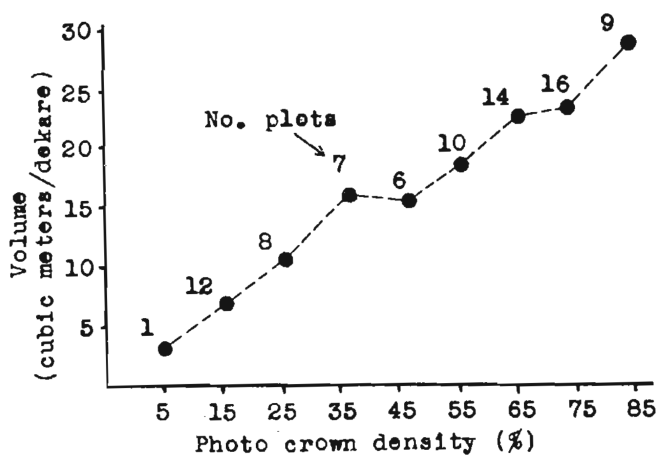

FIGURE 1. Relationship of mean photo crown density estimates of 3 interpreters and the volumes of 83 test plots in the Elverum and Konitgsberg areas of Norway.

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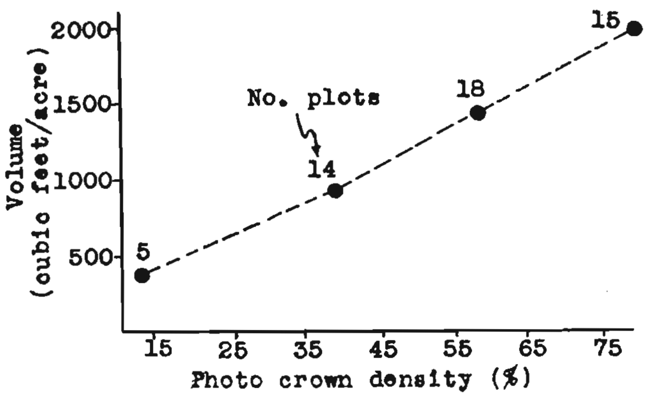

FIGURE 2. Relationship of mean photo crown density estimates of 8 interpreters and the volumes of 52 1/7-acre plots in Koochiching County, Minnesota. Fall pan 1/20,000 scale photography.

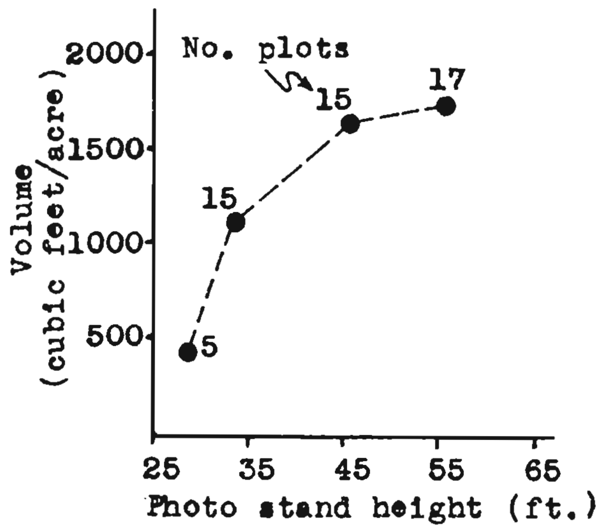

FIGURE 3. Relationship of photo stand height measurements of 8 interpreters to ground volumes of 52 1/7-acre plots. Fall pan 1/20,000 scale photos.

Figure 5 illustrates, even though the scale is known at the average datum of the measurement, under-estimation of distance and area will occur on surfaces sloping down away from the center of the photo. By the same token, overestimation will take place on surfaces sloping up away from the photo center. Despite these and other problems introduced by steep topography, it is still possible to make certain useful measurements of horizontal distance directly from the aerial photos. One must, however, observe these basic rules: (a) distances should be measured on the photo in which they lie nearest the center, and (b) only short distances should be employed.

Object Height Measurement: One of the most valuable measurements available to the photo interpreter, and which is usually the most studiously avoided, is the measurement of object height. This is made possible by the Parallax Formula, a relatively simple computation which is applicable with equal facility to photography of either flat or mountainous country — so long as the photo scale at the measurement datum is known. The necessary equipment is relatively inexpensive and varies from about

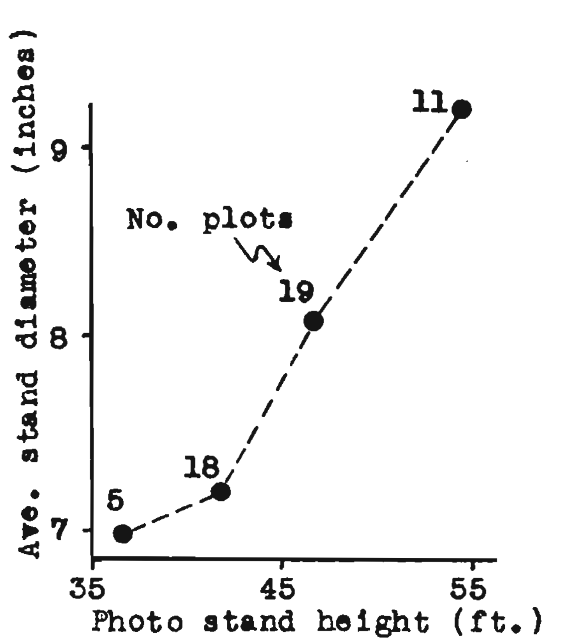

FIGURE 4. Relationship of mean photo stand height measurement of 14 interpreters to average stand diameter at breast height of 53 1-acre hardwood plots. Fall pan 1/15,840 scale photos.

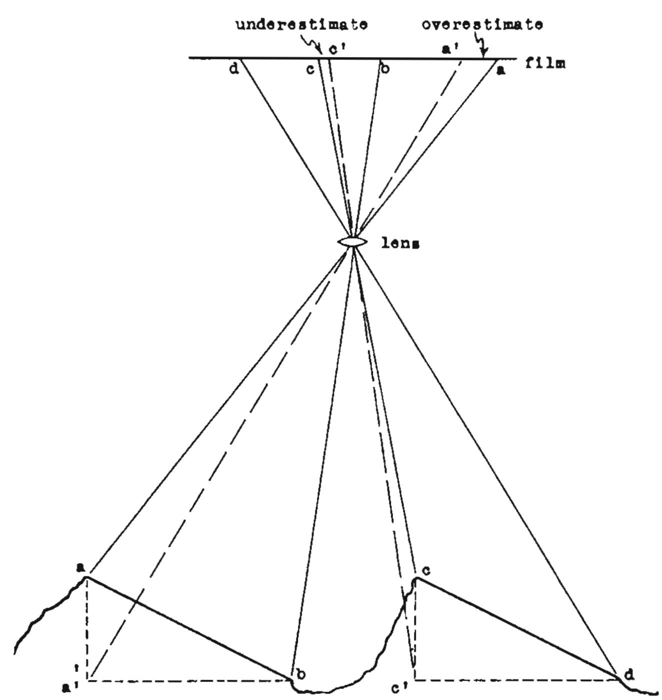

FIGURE 5. Some effects of topographic displacement upon horizontal distance measurements made directly from aerial photos of mountainous terrain.

$2.00 for a parallax wedge to $65-100 for a parallax bar. It takes, however, some 14-20 hours of concentrated training and practice in order to become reasonably proficient in its use. Trained and armed with a parallax measurement device (the bar, preferably) the interpreter finds a whole new range of capabilities available to him — among which are generally acceptable measurements of ground elevation, object height and slope.

Here again, as with all such photo measurements, the interpreter must learn not only the tools of application, but their limitations as well. The average forest interpreter will, for example, encounter a consistent negative error in the measurement of forest stand heights. This is due to the inability of the photography to resolve the tips of the trees — a factor which varies with the general tree shape. For instance, in one study in northern Minnesota (2) involving measurement of forest stands on 1/15,840 (4″ = 1 mile) scale photography, the average interpreter was 9.9′ low in his estimate of mean height of all conifer stands, whereas he was only 2.3′ low in his estimate of the mean height of the hardwood stands involved.

Despite the previously described problems involved in the measurement of horizontal distances in photography of mountainous country, good estimates of ground slope can often be made. Table 1 illustrates a portion of the results of a study made in southern Norway (4) in very steep country for which 1/10,000 scale aerial photography was available. Obviously, by using short distances and staying near the photo center when making horizontal measurements, relatively little error was incurred.

TABLE 1. Results of some slope measurements made on 1/10,000 scale aerial photographs in the Bömoen area in Norway. Only a ruler, simple stereoscope and parallax bar were used.

Photo pair	Relationship of 2 farm bldgs. on mountainside	Measurements: From the photographs	Measurements: On the ground
A	Elevation difference	49 meters	51 meters
	Horizontal distance	185 meters	180 meters
	Slope	26.5%	28.4%
B	Elevation difference	45 meters	49 meters
	Horizontal distance	155 meters	155 meters
	Slope	29.0%	31.6%

Combined Measurements: A relatively recent development in forestry has been the attempt to provide better means of forest stand classification through the use of combined photo measurements. For example, both photo stand height and photo density have been shown to be significantly related to ground-measured stand volume. Unfortunately, neither of these photo measurements has, in itself and on the average, proven a reliable predictor of stand volume, diameter class or basal area. However, it has been found to be feasible to employ a combination of photo measurements in order to arrive at acceptable estimates of ground conditions. Such a prediction equation is developed through regression analysis of the data provided by measurement of a large number of representative photo plots by trained interpreters. The plots are also, of course, carefully measured on the ground from the standpoint of the forest stand features of interest. The relationships between the photo and ground measurements are usually not linear and, consequently, suitable programming and the use of electronic computers is employed to develop the best possible prediction equation. Table 2 provides an example of an equation and table developed for the purpose of predicting gross volume in Scotch Pine and Norway Spruce stands in southern Norway (1). A similar table (2) developed at the University of Minnesota Cloquet Forest Research Center was tested in southern Koochiching County by 11 trained interpreters. Ten of the 11 interpreters obtained volume estimates which did not vary significantly from that measured on the ground plots used in the test (3). Work is now under way to improve this table, develop others and design workable sampling schemes for use in collecting forest management data.

TABLE 2. Preliminary Aerial Volume Table for Coniferous Forest Stands in Southeastern Norway[1].

Stand height [2] (meters)	Crown density (per cent)[3] 5	15	25	35	45	55	65	75	85	95
	—cubic meters per dekare—[4]									
8	1.0	1.8	2.3	2.7	3.0	3.4	3.7	3.9	4.2	4.4
9	1.3	2.3	2.9	3.4	3.9	4.3	4.7	5.0	5.4	5.7
10	1.6	2.8	3.6	4.3	4.8	5.3	5.8	6.2	6.6	7.0
11	1.9	3.3	4.3	5.1	5.8	6.4	6.9	7.4	7.9	8.4
12	2.3	4.0	5.1	6.0	6.8	7.6	8.2	8.8	9.4	10.0
13	2.7	4.6	6.0	7.1	8.0	8.9	9.6	10.4	11.1	11.7
14	3.1	5.4	7.0	8.2	9.3	10.3	11.1	12.0	12.8	13.6
15	3.6	6.2	8.0	9.4	10.7	11.8	12.8	13.8	14.7	15.6
16	4.1	7.0	9.1	10.7	12.2	13.5	14.6	15.7	16.7	17.7
17	4.6	7.9	10.2	12.1	13.8	15.2	16.4	17.8	18.9	20.0
18	5.1	8.9	11.5	13.6	15.4	17.0	18.4	19.9	21.2	22.4
19	5.7	9.9	12.8	15.2	17.2	19.0	20.5	22.2	23.6	25.0
20	6.4	11.0	14.2	16.8	19.1	21.0	22.7	24.6	26.2	27.7
21	7.0	12.1	15.6	18.5	21.0	23.2	25.0	27.1	28.8	30.5
22	7.7	13.3	17.2	20.3	23.1	25.5	27.6	29.8	31.7	33.5
23	8.4	14.5	18.8	22.2	25.2	27.8	30.1	32.5	34.6	36.6
24	9.2	15.8	20.4	24.2	27.4	30.4	32.8	35.4	37.7	39.9
25	9.9	17.2	22.2	26.2	29.8	32.9	35.5	38.4	40.9	43.2
26	10.8	18.6	24.0	28.4	32.2	35.6	38.4	41.6	44.3	46.9
27	11.6	20.0	25.9	30.6	34.7	38.4	41.5	44.8	47.6	50.4
28	12.5	21.5	27.8	32.9	37.3	41.2	44.5	48.1	51.3	54.2

[1] Based on 83 plots (i.e., 65 1-dekare plots and 18 .5-dekare plots) in southeastern Norway.

[2] Average height of dominants and codominants (measured in the field).

[3] Average photo estimate by three interpreters used in table construction.

[4] Total volume of all trees inside bark.

Table equation: $V = 0.0071H^{2} \cdot \sqrt{D}$

Where, V = volume in M^3/dekare
H = stand height in meters
D = crown density in per cent

Multiple correlation coefficient (R) = 0.857

Conclusion: In a space of time totalling only slightly over a decade, aerial photographs have emerged as one of the most useful, revolutionary working tools the earth scientist has ever possessed. Despite their tremendous value from the standpoint of the level of intensity at which they are currently put to use, far less than their potential usefulness is probably being realized. Although aerial photos have been almost universally adopted as a part of the equipment and method of all earth feature and natural resource analysts, a comparatively small amount of research effort has gone, and is going, into assessment and improvement of currently available photo interpretation systems.

The examples presented in this paper have, necessarily, been concerned primarily with forest resource photo interpretation. Let it be said, however, that workers in other area specialties are finding the potential uses of photo interpretation to be no less promising and intriguing. It will be a great pity, indeed, if we should continue to overlook the additional rewards inherent in its further development.

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POLITICAL SCIENCE

Favorite Sons: Obsolete Presidential Candidates

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With the 1964 national nominating conventions slightly more than a year away, nationwide political attention will once again be focused upon the presidential sweepstakes race. Inasmuch as the party controlling the presidency, the "in-party," almost never discards an incumbent, the president is virtually assured renomination by the Democrats; consequently politicians in both parties and the American voters will be concerned chiefly with the selection of the Republican candidate.

At this juncture it is impossible, of course, to predict flatly how many of the leading Republican contenders will openly toss their hats in the ring. But it is safe to assert now that no matter which candidate formally enters the race early next year, Republican organizations in several states, operating under a time-honored custom, will once again choose favorite son candidates to head their convention delegation. Unlike yesteryear, however, when favorite son candidates were frequently chosen as presidential candidates—and successfully elected—the favorite sons of 1964 and future presidential election years will not achieve the nomination prize. Why?

It will be the purpose of this paper to show that the changing forces in the presidential nominating process—especially the growing influence of the presidential primaries since World War II—have for all practical purposes ruled out the possibility of a favorite son ever again winning the party nomination at the national convention.

I

The declining influence of favorite son candidates has not sufficiently attracted the attention of political observers, although the trend has been observable for more than a generation. The last time a Republican national convention selected a favorite son candidate for president and elected him was in 1920 when Senator Warren G. Harding of Ohio became the convention choice on the tenth ballot after the three leading contenders, Major General Leonard Wood, Illinois Governor Frank O. Lowden, and Senator Hiram Johnson of California, became hopelessly deadlocked. The Democratic party has not selected a favorite son presidential candidate since John W. Davis of West Virginia was chosen in 1924 on the 103rd ballot, following a ten-day balloting stalemate between New York's Governor Alfred E. Smith and Senator William Gibbs McAdoo, Secretary of the Treasury in President Wilson's cabinet and son-in-law of the former president.

Before proceeding further, let us clarify the term "favorite son." In political parlance a favorite son is a home-state presidential aspirant who may or may not be a serious contender for the nomination. The types of favorite sons and the roles that they may perform can be classified generally into five categories:[1]

1. *Outstanding* favorite sons, who usually come from

[1] Material in this section is based, in considerable part, upon the discussion of favorite sons found in Paul T. David, Malcolm Moos, and Ralph M. Goldman (ed.), *Presidential Nominating Politics in 1952* (Baltimore: Johns Hopkins Press. 1954), I. 186–188. Additional information on favorite son candidates may be obtained in Clarence A. Berdahl, "Presidential Selection and Democratic Government," *Journal of Politics,* XI (February 1949), 35–40.