Suggestions for Adjusting Bias of Photo Points in Mountainous Country

EARL J. ROGERS,
*2333 Holmes Run Drive,
Falls Church, Virginia, U. S. Forest Service*

ALDRICH (1) and Hartman (3) have described different methods of obtaining uniform distribution of photo points in mountainous country. Within a stereo-pair of aerial photos these schemes are satisfactory. Other schemes are necessary to obtain uniform distribution between stereo-pairs.

Because Aldrich's plan requires the same number of photo points for each stereo-pair, more points will occur in areas of higher elevations than those of low ones. This causes a bias in favor of the higher elevations. Hartman has qualified his technique by limiting its application to mountains with differences in elevation of less than 1,000 feet. Evidently he recognized that his scheme results in a bias in distribution of photo points between stereo-pairs.

With some alterations Aldrich's technique could be applied so that a uniform distribution of photo points would be maintained between stereo-pairs of aerial photos as well as within stereo-pairs. This may be accomplished in two ways. First, the graphical triangulation scheme for pass points (Church and Quinn (2)) that is used in planimetric map compilation can be applied with or without maps. This scheme is preferred because it would remove all bias in one operation. The distribution of the photo points is based upon an assumed undetermined scale and may approximate the average scale of the first stereo-pair of aerial photos. The second stereo-pairs are oriented relative to the scale of the first stereo-pair through the use of pass points. These points are near the lateral margins of the strip nearly opposite the centers of the photos. If convenient, the pass points may be the photo points. When photo points are not used for pass points, such pass points must be located on the dot pattern. They establish the plotting scale of the second stereo-pair. A similar scheme is followed for each stereo-pair thereafter.

A second scheme requires topographic maps and is perhaps a little simpler to apply. The center of each photo is located on a topographic map. This may be done by any simple means, such as using cultural or relief data or even plotting machines. Then the photo plots are distributed in proportion to the ground distance between photo centers. For example, if the aerial photos cover 1,200 linear miles and there is need for 48,000 photo points, there should be 40 photo points for each mile of photography. If the distance between photo centers is one mile, the stereo-pair should have 40 points. But if the distance between photo centers is reduced to 0.8 mile by increasing the rate of exposures in high country, only 32 photo points are needed. Similarly, for a distance between photo centers of 1.25 miles 50 photo points are required. In other words, the distribution of photo points is directly proportional to ground distance between photo centers. If adjustment within the stereo-pairs is necessary, Aldrich's or Hartman's scheme may be used.

Ferguson (4) devised another scheme for adjusting bias caused by clustering photo points in high country. This scheme is based upon weighting of photo points by relative area and it requires the use of topographic maps. It was used at the Northeastern Forest Experiment Station of the U. S. Forest Service when significant bias was encountered. The Ferguson technique may be illustrated as follows:

Table 1 shows acres represented by a given photo area and for various photo scales representing 100 foot intervals of elevation. The steps in calculation are:

(1) Calculate average elevation of the county from sample points on topographic maps. (In two-thirds of all cases, approximately 50 samples will be sufficient for average elevation of ±50 feet.) Example: *1,925′*

(2) Calculate photo scale at average elevation of the county. About 10 scale checks scattered throughout the county will be sufficient. Details of

TABLE 1

NUMBER OF ACRES FOR A 5″×5″ SQUARE BY PHOTO SCALES REPRESENTING 100-FOOT CHANGES IN ELEVATION

(FOCAL LENGTH OF LENS, 8.25 INCHES)

Scale	Acres	Scale	Acres	Scale	Acres
12,785	651.5	15,840	1,000.0	18,894	1,422.8
12,931	666.4	15,985	1,018.4	19,040	1,444.9
13,076	681.5	16,131	1,037.1	19,185	1,466.9
13,222	696.8	16,276	1,055.8	19,331	1,489.4
13,367	712.1	16,422	1,074.9	19,476	1,511.8
13,513	727.8	16,567	1,093.9	19,622	1,534.5
13,658	743.5	16,713	1,113.3	19,767	1,557.3
13,804	759.5	16,858	1,132.7	19,912	1,580.2
13,949	775.5	17,004	1,152.4	20,058	1,603.5
14,094	791.7	17,149	1,172.1	20,204	1,626.9
14,240	808.2	17,294	1,192.0	20,349	1,650.3
14,385	824.7	17,440	1,212.2	20,494	1,673.9
14,531	841.6	17,585	1,232.5	20,640	1,697.9
14,676	858.4	17,731	1,253.0	20,785	1,721.8
14,822	875.6	17,876	1,273.6	20,931	1,746.1
14,967	892.8	18,022	1,294.5	21,076	1,770.4
15,113	910.3	18,167	1,315.4	21,222	1,795.0
15,258	927.9	18,313	1,336.7	21,367	1,819.6
15,404	945.7	18,458	1,357.9	21,513	1,844.5
15,549	963.6	18,604	1,379.4	21,658	1,869.5
15,694	981.7	18,749	1,401.0		

this technique are described by Rogers (5). Example: *19,450′*

(3) Calculate average elevation of forest area in the county from a sample of about 50 forest photo plots. Example: *2,250′*

(4) Subtract average elevation of county from average elevation of forest. Example: 2,250′−1,925′=325′

(5) Locate in the *Scale* column (table 1) the nearest value to the average scale for the county calculated in step (2). Nearest value to 19,450 is 19,476. This represents 1,511.8 acres.

(6) For photo scales that are 325 feet above the average elevation of the county, scale increases by three rows in table 1 and is equivalent to 1,444.9 acres.

(7) Divide the acres in step (6) by the acres in step (5). This is the area bias for forest land area. Example: 1,444.9 ÷ 1,511.8 = .955

(8) The forest area computed from photo points is multiplied by the ratio calculated in step (7) for the adjusted forest area in acres. Example: 268,000×.955 = 255,940 acres.

Other schemes can be devised for use of this weighting technique, such as weighting each photo point by its elevation rather than using averages. An adjustment of some kind is necessary to assure an unbiased sample of the photo points in mountainous terrain. A test of the significance fits only the area where the test is applied and cannot show conclusively whether or not adjustments are necessary for other areas. The minor extra cost of insuring an unbiased sample is a good investment and may avoid subsequent criticism as to the accuracy of the results.

REFERENCES

1. Aldrich, R. C., 1955, "A Method of Plotting a Dot Grid on Aerial Photographs of Mountainous Terrain." *Journal of Forestry*, Vol. 53, No. 12, p. 910.
2. Church, Earl and Quinn, Alfred O., 1948, "Elements of Photogrammetry." *Syracuse University Press.*
3. Hartman, Fred J., 1947, "A Simplified Method for Locating Sample Plots on Aerial Photographs." *Forest Service, Northeastern Forest Experiment Staion*, Station Note 7.
4. Ferguson, Ronald, 1947, "Acres for Various Photo Scales Corresponding to 100 Foot Change in Elevation." *Northeastern Forest Experiment Station*, unpublished data.
5. Rogers, Earl J., 1948, "A Shortcut for Scaling Aerial Photos." *Forest Service, Northeastern Forest Experiment Station*, Station Paper 20.