*Some Observed Effects of Variations in Photo Paper Emulsion and Tone upon Stereo Perception of Tree Crowns**

MERLE P. MEYER, *Associate Professor, Univ. of Minn. School of Forestry*
AND
LOUIS H. TRANTOW, *Laboratory Chief, Mark Hurd Aerial Surveys, Inc.*

ABSTRACT: *Eight stereo pairs of aerial photos, each representing a different emulsion-tone combination, were printed from the same 1:15,840 scale fall panchromatic negatives of a forested area in northern Minnesota. As a result of tree crown count tests performed by three trained forest photo interpreters, the following results were obtained: (a) conventional cold (blue-black) tone prints produced significantly better results than were obtained with warm (brown) tone prints, and (b) some of the four different dull-surface papers tested produced significantly better results than others.*

INTRODUCTION

IT IS the cherished hope of most individuals contracting for aerial photography for interpretation purposes to someday exert a much higher degree of print quality control than is now feasible. Toward that end, this study represents the second in a series designed to obtain information relating to factors influencing photo image quality and which, it is hoped, will help to provide a basis for the development of some practical paper print quality control specifications.

A previous study by Meyer[1] indicated that, for the conditions tested, individual tree crowns were more easily identified on glossy-surface papers than on dull-surface papers. It was found, however, that the photo image loss sustained in using dull-surface papers in lieu of glossy could be reduced to a negligible level through proper choice of dull-surface paper emulsion. A limited test of the influence of photographic tone upon image quality was included in the study but the results, although seeming to indicate a superiority of brown tones, were inconclusive and provided no information of this nature with respect to dull-surface prints. The following test was accomplished in order to ascertain the comparative effects of warm (brown) and conventional cold (blue-black) tones, respectively, upon photo image quality in aerial photos printed on four different dull-surface papers. These four papers were involved in the previous experiment and each has been identified with the same code letter (*C*, *D*, *E*, and *F*) used previously in order to permit comparisons.

CONDUCT OF THE STUDY

As in the previous study, only one set of negative conditions was tested: 1:15,840 scale fall panchromatic photography of a forested area in northern Minnesota which presented a wide range of tree species, size classes and crown cover densities.

Under carefully-controlled laboratory conditions, two stereo pairs of photos (one blue-black tone, one brown tone), as described in Table I, were printed for each of the four test emulsions. Five 81.4 foot radius circular plots deemed to present the widest possible cross-section of such photo

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TABLE I

DESCRIPTION OF THE EIGHT PHOTO PAIRS TESTED

Emulsion	Developer used	Tone
C D E F	Hunt H-8	blue-black
C D E	EK Selectol 1-1, 6 grams bromide added	brown
F	EK Selectol soft, 75°F.	

image characteristics as tone, texture, size, shape and pattern (e.g., mixed pine, hardwoods, mixed hardwoods and pine, spruce) were selected, picked on the photos and all the trees considered to be exposed vertically were counted on the ground. A split plot design (2) was used for the experiment which provided for three replications (not consecutive) of the plot counts and randomization of interpreters, plots, tones, emulsions and azimuth orientation of the axis arrow of the tree count transparency plates (Figure 1).

Three trained forest photo interpreters who had had no association with the previous tests used an excellent quality mirror stereoscope with binoculars to perform the counts. The angle and intensity of lighting

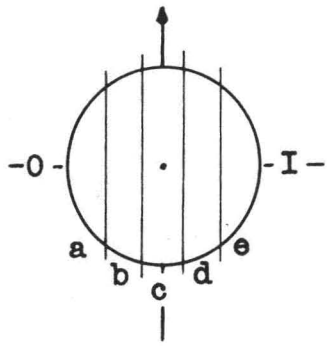

FIG. 1. Tree count transparency diagram.

was identical for all readings and no communication was known to have taken place between the interpreters during the test. When each interpreter completed the tests he was asked to score the eight stereo pairs, which were identified only with a code number, from the "Best" (eight points) through the "Worst" (one point).

RESULTS

The tree crown counts made by the interpreters were expressed as a per cent of the true number of crowns vertically exposed on the plots and averaged for the three replications (Figure 2). These mean success percentages were then subjected to analysis of variance—the results of which are portrayed in Table II.

Obviously, the introduction of a brown tone into the photo interpretation process had harmful effects upon the success of the

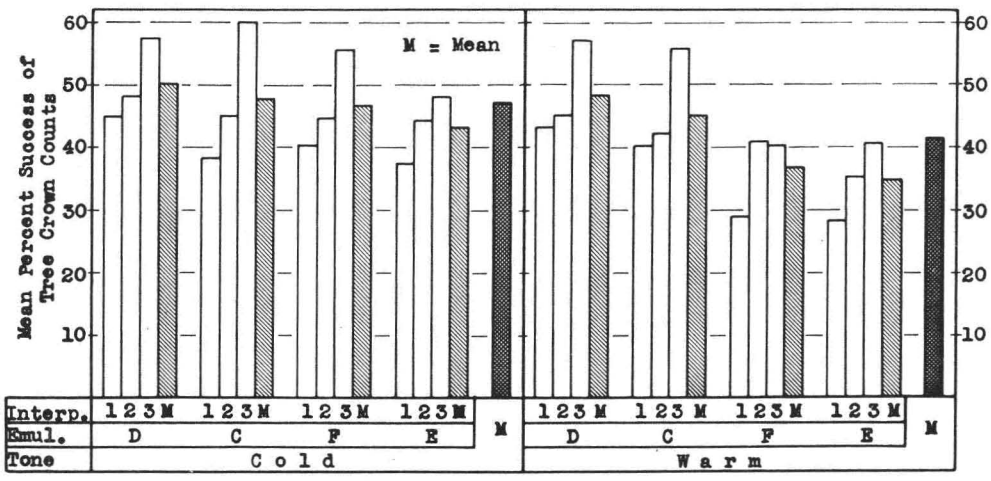

FIG. 2. Graphic summary of the mean percentage successes attained in the tree crown counts.

TABLE II

RESULTS OF ANALYSIS OF VARIANCE OF THE MEAN PERCENTAGE SUCCESSES ATTAINED IN THE TREE CROWN COUNTS

Source of variation	DF	Mean square	F	Table value	
				5%	1%
Bet. interp.	2	2,026.3286	8.85*	4.46	8.65
Bet. plots	4	3,418.4090	14.93*	3.84	7.01
Exp. error (a)	8	229.0248			
Total (a)	14				
Bet. tones	1	906.3997	55.71*	4.96	10.04
Plots×tones	4	43.0744	2.65	3.48	5.99
Exp. error (b)	10	16.2712			
Total (b)	15				
Bet. emulsions	3	671.1618	26.69*	2.78	4.16
Plots×emulsions	16	37.5697	1.49	1.83	2.35
Tones×emulsions	3	143.5197	5.71*	2.78	4.16
Plots×tones×em.	12	28.6506	1.14	1.93	2.53
Exp. error (c)	56	25.1457			
Total (c)	119				

* Significant at the 1% level.

crown counts. Not only is this evidenced by the significance of the difference between the mean counts produced by the two types of processing, but also in the significance of the tones *X* emulsions interaction. The latter was apparently due to the fact that the loss of photo image detail as a result of using brown tones was, comparatively, much greater for emulsions *E* and *F* than it was for emulsions *C* and *D*.

Keuls's sequential method of testing, as presented by Snedecor (2), was used to test the apparent significance of the differences between emulsions. This indicated the following: (a) the mean tree counts attained on emulsions *C* and *D* did not differ significantly from one another, (b) the mean counts attained on emulsions *C* and *D* differed significantly from those attained on emulsions E and F, and (c) the mean counts attained emulsions *E* and *F* differed significantly from one another.

Keuls's test was also applied to the tones *X* emulsions interaction in order to

TABLE III

TRUE DIFFERENCES IN PER CENT BETWEEN MEAN TREE CROWN COUNTS MADE ON THE COLD TONE PHOTOS

Paper emulsion	Mean comparative count of tree crowns by three photo interpreters
D	Counted 5.0% more tree crowns than on emulsion C
	7.2 F
	16.1 E
C	Counted 2.1% more tree crowns than on emulsion F
	10.6 E
F	Counted 8.3% more tree crowns than on emulsion E

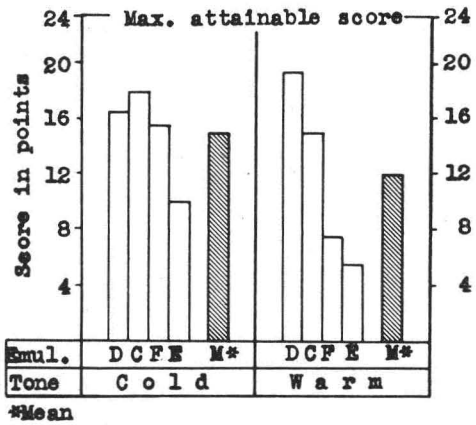

FIG. 3. Graphic summary of the scoring of the test photos by the interpreters.

obtain some idea of the relationship between emulsions within the blue-black tone group. The results indicated that a significant difference did not exist between emulsions *C*, *D* and *F* nor between emulsions *E* and *F*, but that a significant difference did exist between the mean of emulsion *E* and those of emulsions *C* and *D*. This relationship can perhaps be visualized somewhat better by referring to the comparisons in Table III.

The results of the numerical scorings of the test photos by the interpreters are summarized in Figure 3 and, in general, are found to correspond remarkably well with the results of the crown count test: (a) emulsions *C* and *D* received the highest score for all conditions tested, (b) emulsion *F* was scored next to poorest in both tone groups and received a much lower score in the brown tone than in the blue-black, and (c) emulsion *E* received the poorest score in both tone groups and also received a much lower score in the brown tone than in the blue-black.

CONCLUSION

In view of the agreement between the results of this study and the one previous, an important factor governing quality of photo image detail definitely appears to be paper emulsion.

Since it is apparently possible to detect differences in paper emulsion quality by means of image counts and photo interpreter reactions, the selection of the best available papers becomes a generally feasible step in print quality control at the purchaser level. The establishment of such standards of quality should further serve to induce development of improved paper emulsions at the manufacturers' level.

The introduction of the best available paper emulsion into the photo interpretation process is, of course, no guarantee in in itself of maximum attainable print quality. Tight quality control of the many other influencing factors must also be maintained throughout the entire contact printing process in order to provide desirable uniformity of tone and contrast of the prints. Many of these other factors effecting photo image quality are also in need of considerable study in order to ascertain their respective roles and to find means of controlling them.

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