*Determining the Specifications for Special Purpose Photography**

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ABSTRACT: *Many kinds of information not obtainable from conventional, small-scale, vertical, panchromatic minus-blue photography are obtained quite readily from photography flown to other specifications that have been tailored to the particular task. This paper considers, as an example, the task of determining with the aid of aerial photos the intensity of recreational use in wildland areas. Based on studies conducted at several recreational sites in the wildland areas of California, the investigators found that, for this special purpose: (1) oblique photos should be taken rather than verticals; (2) photographic flight altitudes should be close to the terrain rather than high above it; (3) helicopters should be used as the camera platforms rather than fixed-wing aircraft; (4) orthochromatic film should be used rather than panchromatic; and (5) blue light should be exposed for rather than excluded. The paper concludes with recommendations regarding a systematic procedure to be followed in deriving specifications for other kinds of special purpose photography.*

THE term "*special purpose*", as used herein, applies to photography that has been flown to specifications carefully derived to permit one important kind of information to be obtained through aerial photo interpretation. In contrast, the term "*general purpose*" applies to photography that has been flown to meet the needs, at least moderately well, of several kinds of users, be they geographers, foresters, geologists, soil scientists, archaeologists, agriculturists or topographic mappers.

Most of the general purpose photography that has been flown to date in the United States has been vertical photography, scale 1/20,000, taken on cloud-free summer days, between the hours of 10:00 A.M. and 2:00 P.M., using an $8\frac{1}{4}$ inch focal-length camera, a 9×9 inch format, panchromatic film and a minus-blue filter. During the past 25 years the ready availability of such photography has been a mixed blessing. This is apparent in many of the statements that have been made regarding the kinds of information that *cannot* be obtained from aerial photography. Often such statements show that the photo interpreter has considered only the interpretability of general purpose photography. Too often he has regarded as economically impracticable the flying of special purpose photography ideally suited to his particular needs. Actually, the only criterion that needs to be satisfied to justify the flying of special purpose photography is that the desired information be obtainable more economically through the use of such photography than by any other means.

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Just as the increased use of general purpose photography provided the greatest impetus to photo interpretation in the 1930's, the increased use of special purpose photography can provide the greatest impetus in the 1960's.

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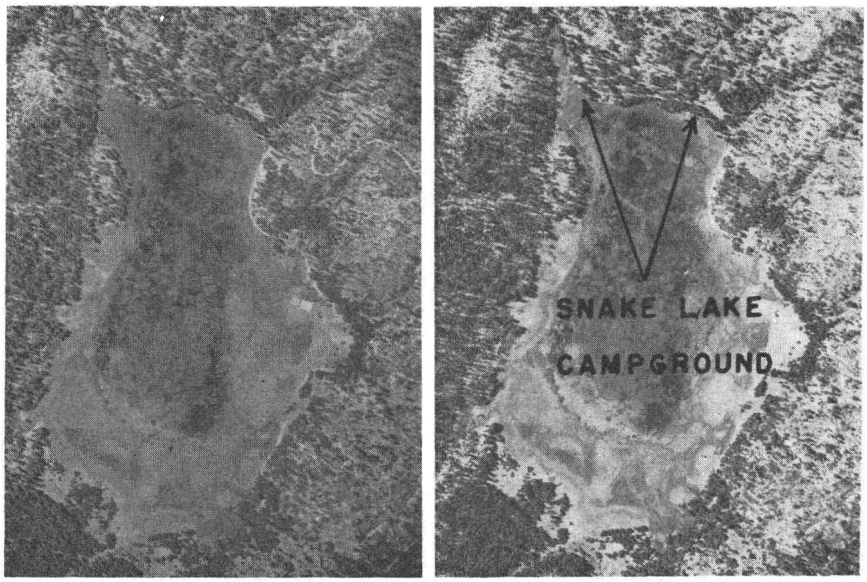

FIG. 1. Stereogram of the Snake Lake area, reproduced at contact size from conventional, general purpose, panchromatic minus blue vertical photography, scale 1:20,000. The Snake Lake Campground could not have been detected with certainty, nor could the intensity of its recreational use have been determined on photography such as this. For more suitable photography of this campground see figures 4 through 8.

While many examples might be given to justify this bold statement, only one will be given here. This is a discussion in some detail of the development of specifications for aerial photography that would meet a specific requirement of the United States Forest Service: determining with the aid of aerial photographs the intensity of recreational use in wildland areas.

With the increased importance of recreation, one can easily justify the limited funds required to fly special purpose photography that will permit a photo interpreter to measure the intensity of recreational use in wildland areas. To be useful for this purpose, the aerial photographs must permit identification of individual recreationists, their campsites, vehicles and equipment. It is not necessary, however, that the photographs be suitable for many other purposes as well.

A portion of a general purpose photograph is seen in Figure 1. It includes the Snake Lake Campground on the Plumas National Forest in California, the area in which most of the tests reported herein were conducted. This photography obviously is of little value in relation to the problem at hand for several reasons, including the following: (1) the *scale* is much too small to permit discernment of individual recreationists and the features of interest associated with them; (2) the *angle* is not suitable for discerning recreational use, most of which takes place beneath the canopy of trees overhanging this recreational site; (3) the *film-filter combination* that was used is not suitable for revealing the necessary photographic detail in shaded areas; and (4) the *time of photography* is not suitable, in that it was taken several years before the date when a survey was to be made of the intensity of recreational use in the area.

The accompanying figures show how these deficiencies can be overcome by deriving specifications necessary for the special-purpose photography required for this particular task.

Recreationists are recorded and counted with ease on large-scale oblique photography, when they are not obscured by overhead vegetation (see Figure 2). Considerable difficulty is encountered, however, when the recreationists and their vehicles are partially obscured, even when the photograph is taken at low altitude (Figure 3). Since conventional small-scale, panchromatic minus-blue aerial photography does not provide the information required for making a recreation-use survey, specifications must be tailored to the task. A series of test photographs was made in order to derive the required specifications.

The Snake Lake Campground, at which the photography was taken, is situated at an

FIG. 2. Low-altitude aerial oblique photo showing the ease with which recreationists can be located and counted on large-scale aerial photography when they are not obscured by overhanging vegetation. Note in this example that photo interpretation of shadows can be of great value in differentiating between recreationists and other features. If "down-sun" oblique photos had been taken, or if the shadows had been diffused by an overcast sky, interpretation would have been much more difficult.

elevation of 4,200 feet and is a small Forest Service Campground adjacent to a lake that receives moderately heavy summertime use. It has five family units—that is five fireplaces and associated tables. The area was photographed both from the ground and from a helicopter, at various altitudes and angles between 11:00 A.M. and 12:00 noon on July 15, 1960. Campers were occupying only one family unit at this time, so the population of

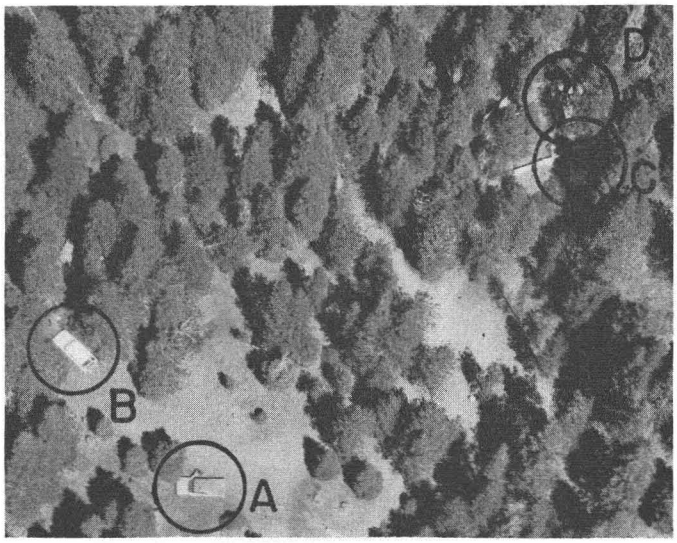

FIG. 3. A near-vertical large-scale photo taken from a helicopter of a heavily used campground. Note that vehicles such as A and B are readily discerned, as compared with C, which lies in dense shade, and D which is obscured by overhanging tree crowns. The use of some film other than a conventional high-contrast aerial film would have facilitated seeing objects which are in shaded areas, such as vehicle C. (Compare with figure 8.) The selection of a suitable camera station for the taking of oblique photography would have facilitated seeing objects which are obscured by the crowns of overhanging trees, such as vehicle D. (Compare with Figure 5.)

the area was temporarily increased to a total of 17 persons by the use of a few forestry students from the nearby University of California Forestry Camp.

An F-8 hand-held aerial camera with a 15-inch focal-length lens was used. This camera was loaded with Super XX Aerial film. Each exposure was 5×7 inches. Exposures were made at altitudes of from 30 to 600 feet and from nearly every side of the campground. The photos were processed and printed by the U. S. Forest Service in San Francisco. Additional contact prints were made by a commercial photographer with the intention of bringing out detail in shaded areas.

All of the aerial photographs were taken from a Bell G-3, three-place helicopter with the right-hand door removed to facilitate the taking of photos from that side.

The 17 people that were distributed throughout the Snake Lake Campground occupied a total of nine locations; some of the recreationists were spotted individually, while others were in groups of two to four. Five vehicles (a sedan, jeep, station wagon, half-ton pickup and "4×4" two-ton truck) were parked within the campground.

The photographs were interpreted in detail. A poor camera station gave the result shown in the top photo of Figure 4. The middle photo of Figure 4 provides a closer view, but adds little information. The bottom photo of Figure 4 shows two of the recreationists, one of the picnic tables, and one of the fireplaces, but is still far from optimum photography. The top photo of Figure 5 represents the best camera station of the series; on this photo all of the persons and vehicles in the area of the photograph were detectable. This photograph was taken from approximately 30 feet above the lake and demonstrates the success obtainable with a helicopter; it can be maneuvered to the exact x, y and z coordinates of the pre-selected camera station, and allows a good choice of horizontal and vertical angles for the aerial camera at the instant of photography.

The bottom photo of Figure 5 illustrates the same exposure printed for detail in the shadows, which facilitates identification of the truck, the man lying on a sleeping bag, and the persons sitting at a fireplace. If the layout of the campground had been considered in advance, and if the tables and fireplaces and been so positioned as to facilitate the observation of recreationists from this particular camera station, there would have been even greater ease in interpreting recreational use from this photo. Even now, the desirable rearrangement of campground facilities could be accomplished quite easily, and without the need for locating these facilities in bright sunshine or in otherwise objectionable spots.

TABLE 1

FACTORS GOVERNING PHOTO-IMAGE CHARACTERISTICS*

I. The photographic tone contrast between an object and its background is governed primarily by:
- a. Light reflectivity of the object and of its background
- b. Spectral sensitivity of the film
- c. Spectral transmission through the filter
- d. Spectral scattering by atmospheric haze

II. The sharpness of a photographic image is governed primarily by:
- a. Aberrations of the lens system
- b. Focus of the lens system
- c. Image-motions at the instant of exposure
- d. Characteristics of the photographic materials

III. The stereoscopic parallax characteristics are governed primarily by:
- a. Height of the camera lens above the base of the object photographed
- b. Height of the object photographed
- c. Distance between successive exposure stations

* From article by Colwell in PHOTOGRAMMETRIC ENGINEEERING, Vol. XXV, No. 5, 1959.

A second series of exposures was made on August 19, 1960 of a portion of the same campground. A single camera station was used, approximately 15 feet above the ground, atop an extension ladder (Figure 6). This series was designed with the intention of testing various film-filter combinations. The ladder was so situated that the campground was photographed at essentially the same scale as that of the most successful of the previous helicopter photographs of the area (Figure 5). A speed graphic camera was used, having a focal-length of only 6 inches as compared to 15 inches for the F-8 aerial camera. Consequently, the distance of the ground camera-station from the center of the area photographed was chosen to be approximately 2/5 that of the aerial camera station, so that a comparable scale of photography would be obtained.

Stereo pairs were taken for each film, filter and exposure combination. The series of 20 stereo pairs was completed between 12:00 NOON and 12:36 P.M. The film types used were: 1) Kodak Verichrome Pan; 2) Kodak Super XX; 3) Kodak Tri X Pan; 4) Kodak Royal Orthochromatic film; 5) Kodak

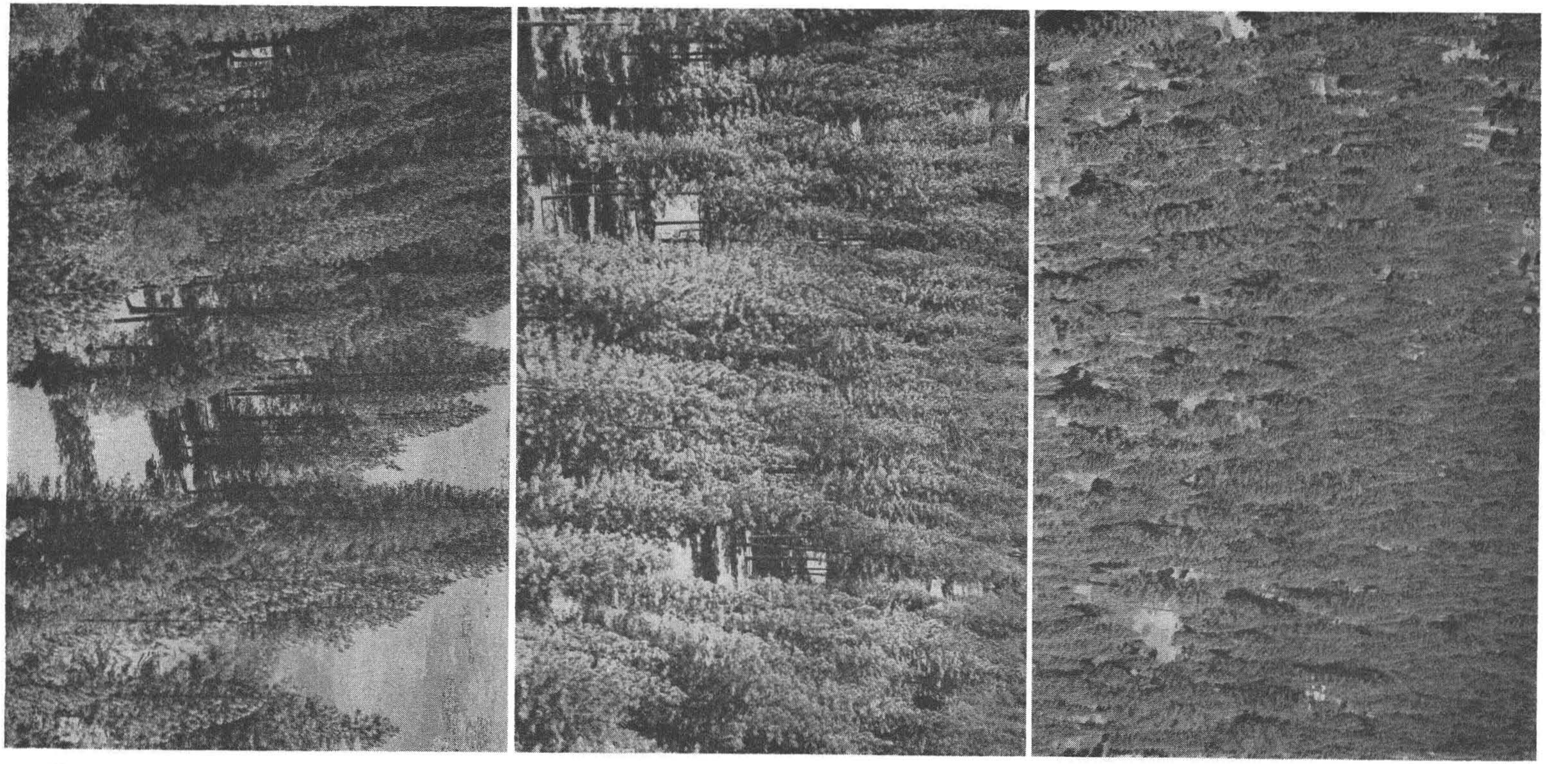

FIG. 4. *Right:* Large-scale oblique aerial view of an area in which there are many recreationists, vehicles, picnic tables and fireplaces, all of which are undetectable on this photograph. Improper choice of camera station has resulted in most of these features being hidden by the foliage of trees. *Middle:* A view at larger scale of the same area. The additional detail discernible here is of no value in determining the intensity of recreational use. *Left:* A view at still larger scale, taken from a slightly more favorable camera station. On the original photo it was possible to detect two recreationists, one picnic table and one fireplace in this view, but not nearly as well as in Figures 5 and 8.

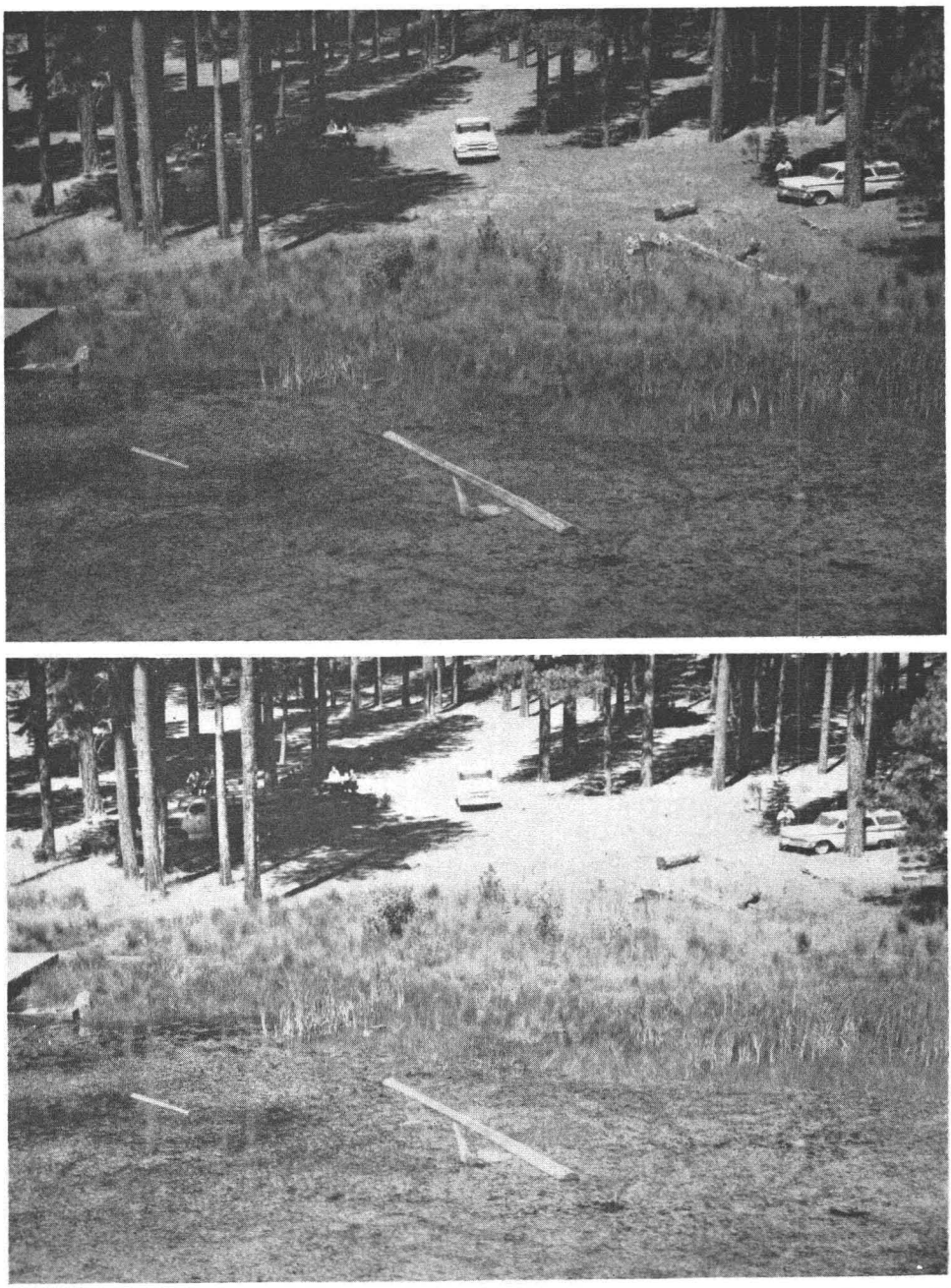

FIG. 5. *Top:* Same area as Figure 4, but photographed from a more favorable angle. On the original photo, the seven recreationists, three vehicles, three picnic tables, two fireplaces, and one sleeping bag located in this part of the Snake Lake Campground could all be seen. However, some were very difficult to detect because of the density of the shadows. *Bottom:* A second print made from the same negative as above, but with an effort to provide maximum detail in the shaded areas. Compare the left half of this view with the terrestrial photographs of Figures 7 and 8 which were taken from an extension ladder.

FIG. 6. A terrestrial camera station from which photographs were taken analogous to those of Figure 5. The sole purpose of erecting this station was to permit the taking of additional photography which would simulate that taken from the air. In this way several parameters involved in deriving aerial photo specifications could be investigated without the need for additional flights in a helicopter. It was possible to take the terrestrial photos more quickly, more economically and under more carefully controlled conditions. The camera station shown here was erected in less than 15 minutes. It consisted simply of two extension ladders supported in place by ropes to nearby trees and to stakes driven in the ground. For examples of the photography taken from this station, see Figures 7 and 8.

infrared—with and without an 89A filter; 6) Ektachrome Type E-3; and 7) Ektacolor Type S.

The use of infrared film (Figure 7), increases the difficulty of seeing detail in shaded areas. This is because there is little scattering of infrared light by the atmosphere and, therefore, there is little infrared in the diffuse sky light to illuminate shaded areas. The best results were obtained with the use of Orthochromatic film (Figure 8). This film is sensitive to short wave-lengths which are scattered a great deal by the atmosphere, and hence better detail is discernible in the shaded areas.

The following general conclusions are supported by this study:

(1) When aerial photography of a wooded campground is obtained without regard to specifications, the photography is likely to be almost worthless for measuring the use of recreational facilities.

(2) The following specifications should be adhered to when flying aerial photography of a wooded campground to measure recreational use:

(a) The altitude should be 500 feet or less so that persons and their equipment will be imaged at a sufficiently large scale to be interpretable.

(b) The camera station should be selected to avoid tree crowns that hide the spots where recreationists and their equipment are most likely to be situated.

(c) The photographic film should be of low contrast. Virtually all aerial photographic films are purposely made to be of high contrast in order to offset the reduction in tone contrast between an object and its background that results when taking photography at high altitude through atmospheric haze. If the

FIG. 7. An infrared terrestrial photograph of part of the Snake Lake Campground taken from the camera station shown in Figure 6. Despite the favorable angle of photography, many pertinent details cannot be discerned in this view because they lie in the dense shadows, characteristic of infrared photography, as explained in the text.

FIG. 8. An orthochromatic terrestrial photograph of the same area shown in Figure 7, but on which detail in the shaded areas is quite readily distinguished for reasons explained in the text. Photography such as this could be consistently duplicated from a low-flying helicopter. At the time campgrounds are being constructed, attention might well be given to the future need for aerial photographic inventory of their recreational use. Facilities might then be sited so as to facilitate this inventory, without impairing the attractiveness of such campgrounds for recreational use.

same high-contrast film is used for taking photography at *low-altitude* and in the typically *haze-free atmosphere* of a wooded campground in a wildland area, there is little reduction in tone contrast and the photograph tends to show only bleached-out detail in the high-lights and impenetrable dark tones, void of detail, in the shadows.

(d) The photographic film should have high sensitivity to relatively short wavelengths of the visible spectrum, and perhaps also the long wavelengths of the ultraviolet spectrum. At a typical forest recreation site, the people and objects to be photographed are often in shadows and hence are illuminated by diffuse skylight, which is rich in short wavelengths (ultraviolet, blue and blue-violet). For this special-purpose photography the distance from camera to subject would never be more than a few hundred feet so the usual problem of penetrating haze with short wavelength photography does not arise.

(e) The photographic filter should *transmit* short wavelengths and *absorb* long wavelengths of radiant energy. Most filters used in aerial photography do just the opposite. Instead of using the conventional "minus blue" filter, which transmits all but blue light, it would be far better, when taking low altitude photography, to use a "plus blue" filter, which would transmit *only* blue light (and perhaps some of the ultraviolet radiant energy).

(3) When aerial photographic measurements of recreational use are contemplated, consideration might well be given to certain of the aerial photo specifications at the time a campground is being laid out. If, for example, due consideration is given to the problem of defilade, a favorable aerial camera station might be decided upon in advance. The locating of facilities (such as picnic tables, outdoor fireplaces, and parking spaces) might be such as to minimize defilade from this camera station, without impairing the usefulness or attractiveness of the facilities.

(4) The larger the number of recreational sites to be inventoried in a given area, the more economical it will be to fly aerial photography for this purpose. For example, in an area of heavy recreational use, 30 campgrounds might be inventoried in a single two-hour period, using only one helicopter manned by a pilot and aerial photographer. To do the same job on the ground in the same time might require 15 to 30 enumerators, depending on the travel time between sites. Furthermore, the speed of the aerial technique will help to overcome inventory duplications or omissions resulting from movements of the recreationists from one site to another, during the time the inventory is being made.

Despite the encouraging results obtained in this study, its scope was quite limited. Consequently, there cannot yet be stated with certainty the full extent to which aerial photographs will prove useful for estimating the intensity of recreational use in wildland areas. Nevertheless, it can be stated that, in this example as in many others, conventional general purpose aerial photography has been found to be virtually worthless, while photography flown to proper specifications has proved to be of great value in helping to derive the desired information.

The exact procedures to be followed in determining the specifications for special purpose photography will, of course, vary with the nature of the problem. As this example has demonstrated, however, it is helpful to consider at the outset the respects in which conventional photography is not suitable for the intended purpose. Then it is of assistance to consider exactly what the factors are that govern each photo image characteristic that is deficient in the conventional photography. For example, photography flown for some special purpose may be found to be primarily deficient in *tone contrast*, between the object or condition that is to be identified and the background against which it is imaged; on the other hand, the photography may have adequate tonal characteristics but lack adequate *image sharpness*; or it may have adequate tone contrast and image sharpness characteristics, but be lacking in the proper *stereoscopic parallax characteristics* for the special kind of interpretation that must be performed.

If, prior to the taking of the photography, a three-dimensional resolution target has been placed somewhere within the area that is to be photographed, subsequent photo interpretation of the target will provide a quantitative analysis of the tone, sharpness and parallax deficiencies in the image.[1] From his knowledge of the primary factors governing each of these photo image characteristics (see Table 1), the photo interpreter can then decide how to obtain more suitable photography. For example he will be able to determine whether he should (1) try a new combination of photographic film and filter for improvement in the tone contrast, (2) reduce camera vibration in order to improve sharpness, (3) increase the stereo base between successive exposures to provide better stereoscopic parallax, or (4) attempt a combination of these and other remedies as suggested by Table 1.

Such a systematic procedure for improving photo-image quality and developing suitable specifications for special purpose photography is far better than one employing only "trial-and-error" methods, and relying entirely on empirical good luck for solution of the problem.

[1] See Colwell, R. N., 1959, "The Future for Photogrammetry and Photo Interpretation": PHOTOGRAMMETRIC ENGINEERING, v. XXV, no. 5, p. 720.

ERRATA

1961 YEARBOOK (Vol. XXVII, No. 2), p. 198 Commission IV of International Society for Photogrammetry. The name of the Reporter from U. S. A. is Edmund S. Massie, Jr. and not Anthony P. Dean.

1961 YEARBOOK (Vol. XXVII, No. 2), p. 271. The address for Washington representative should be 929 Highgate Road instead of 229.

Vol. XXVII, No. 3 (June 1961) p. 421.

The last line of Eq. 14 should be

$$= \left[\frac{1}{2}\left(\frac{v}{h}\right)\dot{x}_f \sin\beta\right] t^2,$$

and not

$$= \left[\frac{1}{2}\left(\frac{v}{h}\right)\dot{x}_f \sin\right] t^2,$$

Equation 15 should be

$$a = \left[\frac{1}{2}\left(\frac{v}{h}\right)\dot{x}_f \sin\beta\right] t_e^2.$$

and not

$$a = \left[\frac{1}{2}\left(\frac{v}{h}\right)\dot{x}_f \sin\right] t_e^2.$$

Equation 34 should be

$$\dot{y}_{i\alpha} = f' \frac{v}{h \sec\beta} - \dot{f}' \tan\alpha',$$

and not

$$\dot{y}_{i\alpha} = f' \frac{V}{h \sec\beta} - \dot{f}' \tan\alpha',$$