PHOTO INTERPRETATION SYMPOSIUM*

Introductory Remarks

Arthur C. Lundahl, Moderator†

THIS is the second symposium on photographic interpretation. The results of the symposium last year were so successful that another symposium was requested, but this time it is on a full day basis. As will be noticed from the program, more than one third of the total program this year is being devoted to photographic interpretation.

Photo interpretation has been defined as the art of examining the photographic images of objects for the purpose of identifying those objects and deducing their significance. The precision and reliability of those identifications and deductions are strongly dependent upon the nature and quality of the photographic equipment and material, and variety and applicability of photo interpretation equipment, reference materials and techniques, as well as the individual skill and experience of the photo interpreter himself.

It is apparent that improvements in the precision and reliability of photo interpretation may result from improved methods for the selection and training of photo interpreters, or from improved photo reconnaissance, equipment, materials and techniques, as well as from improved photo interpretation instrumentation, technique, keys or manuals.

Many years back it was not readily apparent that photo interpretation was to be a part of photogrammetry. Those of you who were at the International Congress and attended the final banquet will recall that Professor Schermerhorn of the Netherlands said that when photo interpretation was proposed as one of the Commissions, he wasn't sure it had a place in photogrammetry. Now, after four years, he is not only convinced it has a place, but that it is a most important place. In his estimation the greatest progress in the last four years, so far as the International Society of Photogrammetry was concerned, was in the field of photographic interpretation. The great importance and value of photo interpretation now appear to be generally accepted.

It is remarkable that in less than a hundred years the methods of the photo interpretation have developed from the beginning of an idea to the stage where the information is reliable. The results are highly applicable to many different fields, ranging from archeology to mineralogy, crime to recreation. There is no field in which photography and the interpretation thereof do not apply.

The speakers at this symposium will touch on many aspects on particular developments of photographic interpretation. After all speakers have presented their papers, they will return to answer questions which will be in written form and prepared by members of the audience. On each slip will be placed the name of the questioner, his organization, and to whom the question is addressed. At the conclusion of the formal presentation the questions will be answered to the limit of the time available.

As stated on the program the first talk will be on the subject of "Interpretability," and will be given by Dr. Duncan E. Macdonald, Director Physical Research Laboratories, Boston University.

* The list of those who read papers is on page 35. It is regretted that circumstances prevented including all papers in this issue. The omitted papers were those by Tarkington, Belcher, Kauffman, O'Neill, Whitmore and Frost. It is planned to include these papers and also the Questions and Answers in the June issue.—*Publications Committee.*

† U. S. Naval Photographic Interpretations Center, Washington, D. C.

SPEAKERS AT PHOTO INTERPRETATION SYMPOSIUM: (*Left to right*) Tarkington, Belcher, Mintzer, O'Neill, McNeil, Macdonald, Whitmore, Smith, Garver and Young. Moderator Lundahl is in the rear.

INTERPRETABILITY*

Dr. Duncan E. Macdonald, Director, Physical Research Laboratory, Boston University

The process of photo interpretation involves: (1) the identification of the object, and (2) the deduction of its significance. Identification involves primarily the photographic problem with its psychophysical components. The photographic material alone must provide suitable stimulus to the observer to enable him to make the identification. The deduction of the significance of the object, however, is more an intellectual problem. This in no way depends upon the photographic qualities, but on such things as the training, experience, background, and intelligence of the interpreter. Today, under "Interpretability," we shall concern ourselves with the first aspect, the identification of symbols recorded on photographs.

It becomes necessary to restrict the application of the generalities that are to follow. The statements apply only to good lenses, lenses where the energy distribution in the image is coherent, lenses typical of those in general use in photogrammetric fields today. Poorer quality lenses, e.g., lenses exhibiting large degrees of residual spherical aberration, do not fall under these generalities.

Historically, we are aware that there are two types of aerial photography: one type is taken by the user and is subject to interpretation; the other type is taken by the research or development agency and is subject to a numerical rating in terms of resolution or sharpness or some other physical criterion.

In general, a higher resolution number must mean a better photograph in terms of the user, or else, over the years that we have been utilizing resolution testing, progress would not have been so steadily forward. On the other hand, laboratories have tended repeatedly to overlook the user because there has been little or no attempt to relate interpretability of the photography to a quality criterion until very recently. Today we shall review some of these recent steps.

In 1942, Hansen[1] described an experiment wherefrom he concluded that a focal setting for minimum flare of the image was the setting that gave the sensation of maximum sharpness of picture to the average observer. Jones and Higgins[2] have extended this work, and have found that subjective judgments of

* Paper read at Nineteenth Annual Meeting of the Society, Hotel Shoreham, Washington, D. C., January 14 to 16, 1953.

picture sharpness correlate with edge gradients. They have further defined the psycho-physical stimulus for this sharpness judgment. Baker practiced, during the war, the technique of focussing aerial cameras for minimum flare on an image point about 1/40 mm. in diameter. Dr. Howlett[3] has long preached the advantages of a low-contrast resolution target for airborne performance, and the British follow this view. In this country, led by the U. S. Air Force, we preach of the merits of high-contrast resolution targets. Following Schade[4] in the field of electronics, we have been talking in terms of maximum contrast rendition,[5] which turns out to be minimum contrast reduction by the system, and this thought is extended to the concept of minimum contrast thresholds for the system.

It is obvious that a certain confusion of terms exists between the different agencies, each one plugging for its concept, be it resolution, sharpness, flare, gradient, threshold, contrast rendition; but in truth all are saying the same thing, and the important point to develop today is the sameness of all these approaches.

For the first time, we are on the threshold of an era wherein a physical measure of system performance can be made that will correlate with the interpretability of the resulting photograph. Let us pull these experiments together.

What is meant by maximum sharpness? Basically this means that the viewer sees best that which he is looking for—that which he is looking for becomes most easily interpreted, most easily seen—it is most clear, it is least blurry. It can be stated that, when what we are looking for is recorded with maximum sharpness, it is most easily and/or most rapidly interpreted. Maximum sharpness therefore coincides with peak interpretability.

The unaided eye has the capability of seeing detail corresponding to about 4.5 lines/mm. When looking at a photograph without optical aids, judgments as to sharpness are based on the quality rendition of these details near the visual resolution limit—details about 1/9 mm. in extent. If, at this limit, the details are well rendered, we term the picture crisp, clear, sharp.

Now assume a point image 1/9 mm. in diameter. If we focus our optical system such that we pack the maximum amount of energy into that 1/9-mm. circle, and correspondingly allow the minimum amount of energy to flow into the surroundings, we have achieved minimum flare. From Hansen's work,[1] it is seen that this focal setting provides that which the observer calls the "sharpest picture" for this view by unaided vision. We may also infer from Jones and Higgins[2] that this is the position of the steepest edge gradient. Because we have the minimum spread of energy, it means that a very low-contrast resolution test object (that particular contrast which yields a peak resolution of 4.5 lines/mm) will provide its maximum resolution reading at this same setting.

The description of this problem of packing maximum energy into the proper geometric size is another way of saying that this object is set for maximum contrast, and because it is at maximum contrast this is the setting for minimum contrast reduction by the system, and this is the same as saying that it is the minimum contrast threshold for the system.

Now let us arbitrarily pick another blur circle, say 1/40 mm. in diameter, which was that chosen by Baker on the grounds that, in practice, we were trying to record 20 lines/mm. so we should optimize focal settings for 20 lines /mm. Here the same conditions apply. We want to set for minimum flare for this dimension of image. This setting is the one which also gives the impression of maximum sharpness for this size of detail. However, we cannot see this size of detail with unaided vision, so we have no subjective judgment of picture sharpness for this detail until we view under about 4.5-power magnification. Under this condition of viewing we provide the sensation of maximum sharpness. The setting which provides this is identical with that which gives the maximum resolution setting for the particular contrast of test object which has as its maximum resolution 20 lines/mm.

But it has been shown, in the past, that the focal setting which does all this for 20-line/mm. images is not apt to be the same as that which provides the maximum sharpness at 4.5 lines/mm.

Figure 1 was presented last year at the International Meeting. The plot shows focal setting as a function of the image size required to provide maximum contrast rendition of the image (shown by crosses), and, compared to this curve, a second experimental curve (shown by circles), showing focal setting as a function of image size to provide the maximum probability of detection of these particular symbols. One may infer that this curve indicates that minimum flare setting corresponds to the setting which gives maximum sharpness, gives maximum edge gradient, provides the maximum ability to detect details in the picture (for any given size).

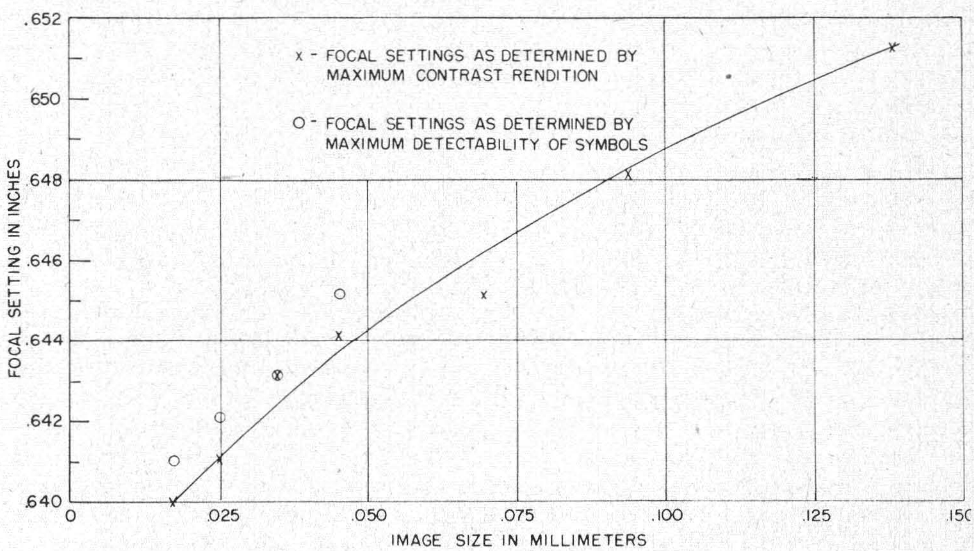

FIG. 1

As we look at this curve in Figure 1, questions may be asked, "What focal setting do we employ in practice? At what setting do we test? In what size of detail are we primarily interested? At what particular image size should we examine for sharpness or minimum flare or maximum resolution?"

In practice we rarely achieve the laboratory level of high-contrast resolution. Thus we can state that such a test, and any focal setting determined from this test, maximizes conditions at a point that is not encountered in practice. Except for this, all other tests encompass some point within the range of practice and therefore have something to be said for them.

Because we are interested in the appearance of details over a range of sizes

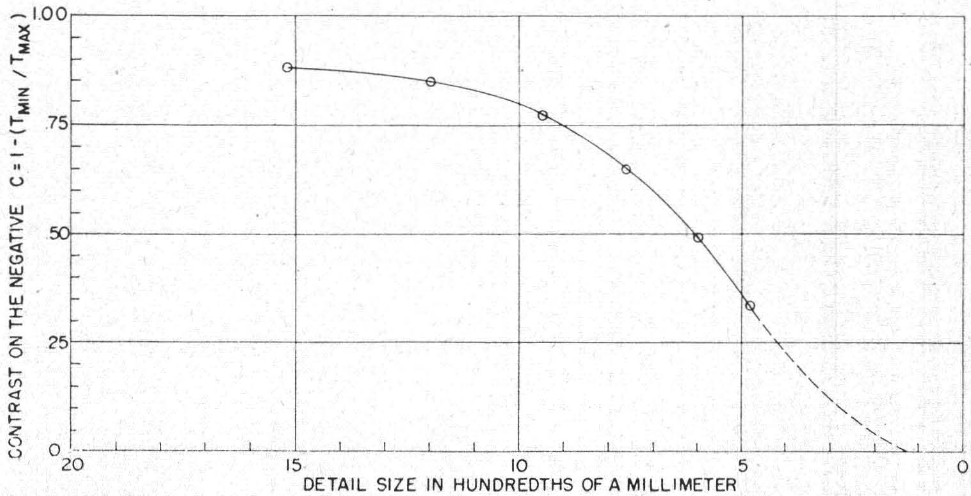

FIG. 2

and over a range of contrasts, we have previously suggested that we examine not resolution or sharpness or flare at any one point, but that we consider these phenomena over the entire range of symbol sizes that are of interest to us. We have chosen to do this in the form of a contrast threshold function. It could as well be a contrast reduction (modulation) function.

Let us spend a moment on the concept of this function. Figure 2 shows the image contrast plotted as a function of image size for the six-inch Metrogon used in conjunction with Super-XX emulsion. Because the contrast of fine detail is more reduced than that of coarse detail, clearly, to be recorded, these details must possess a greater inherent contrast than the coarser details. This is shown in Figure 3, which plots the contrast required in the object to render a detectable image as a function of the size at which it is imaged. Object contrast

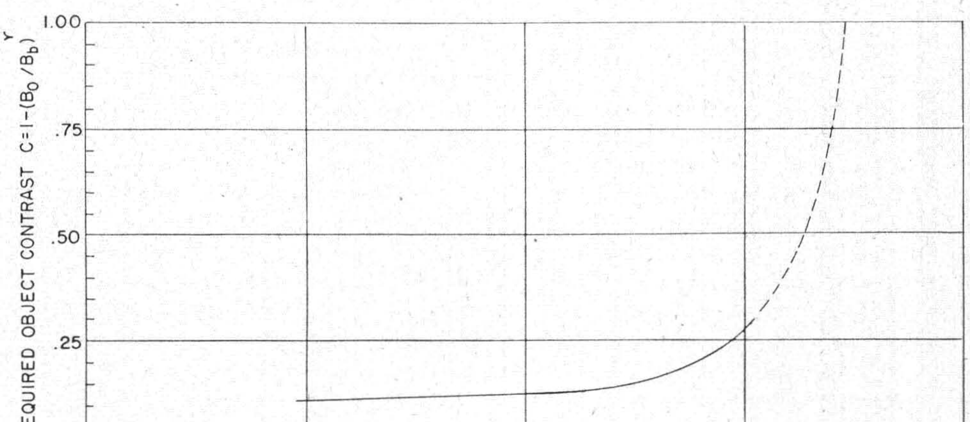

FIG. 3

is raised to the gamma power to take into account the generalities of processing conditions.

This function gives an expression of the performance over the entire range of sizes and contrasts that the system explores, rather than arbitrarily weighting any particular size or contrast.

To interpret this type of result does, however, require some weighting. Although time does not permit the development of this topic today, the method can be explained. We know the distribution in both contrasts and sizes in the object space. There are more low-contrast than high-contrast objects. There are more small than large objects. Thus we cannot assign equal value to all contrasts and sizes. Those regions where the most information is centered become most important. Thus, if the contrast distribution is $f(c)$ and the size distribu-

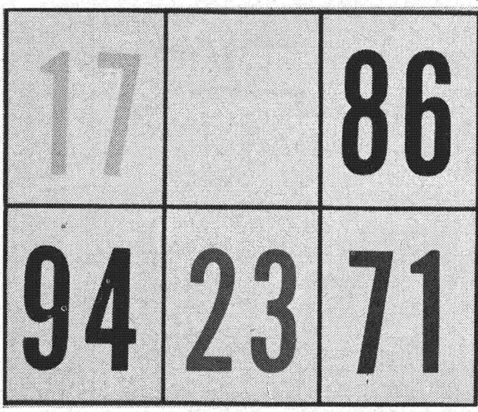

FIG. 4. Recognition at Threshold Contrast.

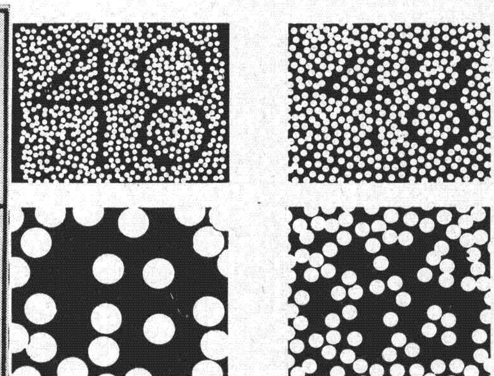
FIG. 5. Recognition at Various Object-to-Grain-Size Ratios.

tion is $f(x)$, a contrast threshold plot in terms of $f(c)=\phi[f(x)]$, rather than $C=F(x)$ as is the case in Figure 3, automatically assigns a weighting in terms of the number of symbols that will be (probably) recorded.

Let us spend just a moment to present a picture to illustrate the nature of the threshold.

Figure 4 shows the case of numerical symbols recorded at different contrasts. All symbols are of the same sharpness, the resolution of the system is the same, the image size is the same. It is clear that, in certain boxes, the numbers are below the contrast threshold and therefore are not seen. It is clear also that the farther over the threshold (up to a certain point) that the symbol is recorded, the more easily is the presence of the number detected and the more easily is the number itself recognized. As soon as we are well over the threshold, the task becomes of uniform simplicity. So we see that the threshold has a dual function: (1) if the symbol is recorded above the contrast threshold, we see it; (2) the further the symbol is recorded above threshold, the more easily it is seen, up to a certain reasonable limit beyond which the ease of seeing no longer increases.

Figure 5 illustrates the concept of threshold based on the photographic grain. Here we illustrate another basic threshold which concerns itself with photographic scale, the critical ratio being that of detail size to grain size. The photographic grain is the ultimate size threshold in the photographic system, and here we see that, as the numerical symbol approaches the threshold in size, it becomes more difficult to interpret. The number 48 is presented as a simulated image made at four different scales. The four simulated photographs are then, in effect, magnified in such a way as to give a constant size of symbol (48), whereas, the greater the magnification, the greater the grain size. The number soon becomes lost in the grain. An interesting point in connection with this presentation is that, by viewing this figure from varying distances, the ease of seeing the numbers varies. In particular, the lower right-hand box becomes most clear at eight or ten feet.

To summarize: The many approaches to evaluation of picture quality are now rapidly converging. Out of these there shall be established a reliable and meaningful test, to assess both relative performance of systems and optimum focal settings. This must weight the entire range of sizes and contrasts that may be recorded. The possible use of thresholds as the format for this test is illustrated.

The illustrations are used to show that the ease and/or speed of identification is related to the position of the symbol with respect to the threshold. We hold that interpretability is measured by the ease and/or speed with which the identifications are made. It is suggested that, if the threshold curve is plotted in terms of $f(c)=\phi[f(x)]$, the area above the threshold then becomes directly proportional to the amount of information that the system will record.

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"USE OF REFLECTION SPECTRA FOR PHOTO-INTERPRETATION PURPOSES"

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The photographic industry is greatly concerned with the measurement of color, and the very existence of this industry is proof that many and diverse color problems have been well solved.[1] The manufacturer has solved many of these problems by the application of the basic physical methods of spectrophotometry and spectroradiometry. We must know the spectral sensitivity of the film emulsions, the spectral irradiance of the illuminant to be used, the spectral transmittance of the filters, if any are used, the spectral transmittance of the optics of the camera, and other similar information. This information is required in any attempt to produce fidelity, whether in black and white or in color—that is, the faithful reproduction of the original scene. For photo-interpretation purposes, however, fidelity may not be a prerequisite, provided the object to be photographed may otherwise be detected. As all photographs, whether ground or aerial, are based on light reflected from the objects, a study

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[1] Judd, D. B., Color in Business, *Science and Industry*, page 142 (Reproduction of pictures in color), John Wiley & Sons, Inc., New York, N. Y.

of the spectral reflectances of these objects and those of the surrounding areas, may yield a spectral difference that could possibly be used to predict what spectral range is needed in the film, illuminant, filter, camera, or other associated equipment. Examples of the use of spectral absorption, spectral transmission, and spectral reflection measurements, obtained by means of spectrophotometry, will be given.

PHOTO INTERPRETATION IN RELATION TO GEOLOGIC RESEARCH*

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In this paper it is purposed to review the role of air photos in the successive stages of geologic research, to note the resulting advances in geologic knowledge, and to consider the implications of this topic for the general photo interpreter.

Geologic research is of two main types: first, to formulate concepts and principles, and, second, to apply basic principles to the study of particular areas or regions. In some instances, the two types of research are combined, but more commonly the second is separated in place and in time from the first. In both, however, the method of investigation is essentially similar, although with some difference in emphasis on particular phases. This method is what is generally known as the scientific method, and is common to all fields of science.

As outlined by Douglas Johnson, the *scientific method* involves the following somewhat idealized sequence of steps: (1) observation; (2) classification; (3) generalization; (4) invention of hypotheses; (5) verification and elimination of hypotheses; (6) confirmation and revision of hypotheses; and (7) ultimate interpretation. It is to be understood, of course, that not every research project requires all of the above steps, or that the above order is invariably followed. In comparatively simple projects, some steps may be omitted or bypassed, and in any project it may be convenient or necessary to alter the sequence, and sometimes to go back and repeat one or more steps. The basic pattern of mental discipline is retained, however, and the above listing does provide a convenient basis for discussion. It is therefore appropriate to discuss the role of air photos in each of the steps listed.

The first step is *observation*. It is in this step that the existence of a problem is recognized, and the collection of data bearing on the solution of the problem is undertaken. For problems in surficial geology, air photos are a particularly valuable source of information at this stage, offering the following advantages: (1) Areas formerly inaccessible are brought within the range of observation. Surficial aspects of desert areas, arctic regions, and other remote places, which once could be studied only by hazardous and costly expeditions on the ground, now may be examined at leisure. (2) The perspective of the air view provides a balanced, overall picture of features which, on the ground, can be seen only in piecemeal fashion, or even escape notice entirely. (3) Many surface features can be studied in much greater detail than is otherwise feasible. (4) Greater thoroughness in the gathering and recording of observational data is made possible. (5) The rate at which observation proceeds is markedly accelerated in many situations. (6) Detailed records of any given area or feature at successive points in time are readily obtained, and provide a starting point for studying such

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present-day geologic processes as the shifting of rivers, the movement of sand dunes, the modification of shorelines, and the advance and recession of glaciers. (7) As one outgrowth of the foregoing, many research problems which otherwise might escape notice are clearly revealed. This, indeed, is one of the most important advantages which the use of air photos offers.

The second step in the investigation is *classification*. It involves the comparison and grouping of factual data. In this step, the stereoscopic study of air photos permits more detailed comparisons and finer discriminations than is generally feasible in other ways.

The next three steps take place in the investigator's mind rather than through his eyes. The third step is *generalization*. The reasoning here is primarily inductive, from the particular to the general. Significant relations between observed facts are ascertained, and in some cases partial or complete explanations may be devised.

The fourth step is *invention*. This also is a purely intellectual process, leading to multiple working hypotheses, or tentative explanations for the observed phenomena.

The fifth step is *preliminary verification and elimination of hypotheses*. The reasoning here is primarily deductive, from the general to the particular. Consequences and implications of the several working hypotheses are inferred, and then are confronted with the facts of observation. If observed facts agree with expectations, the hypothesis is provisionally verified, and if not, it is eliminated.

The sixth step is *confirmation and revision*. Remaining hypotheses are subjected to closer scrutiny, and are tested on the basis of their guiding the prediction of additional facts as yet unnoticed or undiscovered. In the checking of these predictions, air photos once more enter the sequence of investigative stages. If the predictions have only to do with surface form or pattern, these may be sought and studied directly on the photos. If the predictions are concerned with subsurface conditions or materials, examination of photos gives invaluable aid in the selection of significant or critical localities for ground study or sampling, with the aid of hammer, shovel, auger, drill, or other methods.

If additional facts are found to be just as predicted, the hypothesis is confirmed. If, however, the expected facts are found to be missing, or unexpected facts are brought to light, or other discrepancies or incongruities are revealed, modifidation of the original hypothesis may be indicated. In that event, the continued study of air photos provides a further guide to the finding of significant facts for revising and testing the hypothesis, as the investigator goes back and retraces preceding stages of study.

It should be pointed out that, in this sixth step, the use of air photos may be important both for research problems originally initiated with the aid of photos, and for those initiated entirely from other lines of approach, without the aid of photos. For the latter, in fact, the new evidence provided by photos may be of particular value, and may even be decisive. An example is found in recent studies of the Channeled Scabland of eastern Washington. This area is characterized by a unique assemblage of remarkable features—a widely denuded lava surface with a network of huge, abandoned channels, together with innumerable dry waterfalls, abandoned gorges, and other anomalous features. This area has been a subject of lively controversy among geologists for nearly three decades. One school of thought has maintained that the phenomena in question can be explained only on the basis of catastrophic flooding on an unprecedented scale. The other school of thought insists on more gradual development by more "normal" processes. Choice between these conflicting hypotheses depends, in part, on the presence or absence of corollary features which could be attributed to floods of different intensities. Two types of evidence recently studied on photos contribute in an important way to the solution of the problem, and to the enlargement of our present knowledge of landforms as well. The first is the occurrence, at many places, of giant "ripple marks," which are of striking appearance from the air, but are comparatively featureless from the ground view. It seems very unlikely that these features could have been produced under any ordinary conditions of flow in the area. Significant also is the occurrence of sharply truncated island-hills of loess in the midst of the bare lava surface, a feature previously noticed but never before studied in the degree of detail now possible. The size, shape, and pattern of these hills is difficult to reconcile with stream work on any ordinary scale. Thus by providing new lines of evidence, and by permitting the restudy of older lines of evidence with greater precision, air photos play a valuable part in striving toward a settlement of a controversial problem of long standing and exceptional character.

The seventh and final step in research is *statement of the preferred interpretation*, with due regard to the range of its applicability, and the degree of probability of its validity. To this end, for innumerable research problems in surficial geology, air photos have played a vital role in aiding the formulation of the problem, in supplying essential factual data for attacking the problem, and in providing a basis for testing, and if necessary, revising provisional interpretations. As an outgrowth of these applications of air photos, geologic research has been given a great impetus, and our knowledge of geologic phenomena has grown by leaps and bounds. Basic concepts have been refined, enlarged, and revised, particularly in the fields of geomorphology and Pleistocene geology. Much of the older work, made without benefit of photos, has been outdated. The textbooks and reference works on many subjects await revision. The application of basic concepts to regional mapping has been influenced in a similar way. The rate of mapping has been speeded up, and a higher degree of precision has become feasible.

At this point, it may be asked, "what bearing does all this have on the work of the general or non-geologic photo interpreter?" The answer is that both the methodology and the results of geologic research provide valuable background information to any photo interpreter who deals with terrain in one way or another.

In the first place, an appreciation of the need for geologic research, and of the broad fields in which opportunity for research exists, aids the interpreter in realizing the limitations of his work. All research springs from an awareness of current ignorance, and proceeds with the hope of reducing the areas of ignorance. Air photos, by revealing features which are difficult to explain in terms of conventional ideas, have contributed to an awareness of the inadequacy of existing knowledge. The photo interpreter who assumes that all terrain features which he sees on photos can be forced to fit into existing geologic categories, displays an ignorance of the areas of ignorance, and cannot know when he is on safe ground.

In the second place, and on the positive side, it may be said that the results of geologic research, made both with and without the aid of air photos, and concerning both principles and regional applications, provide valuable information for the interpreter's work. Increasingly detailed knowledge of the earth's surface features makes for more particularized and definitive interpretation from photos, especially for the interpretation of subsurface conditions from surface expression. It would be incorrect to assume, however, that existing knowledge is adequately summarized in available textbooks and reference works. Textbooks sometimes are known to perpetuate the errors of the past, and there is always a considerable time lag between the announcement of research results, and the incorporation of these results in works of more general character.

In the third place, research projects devoted specifically to photo interpretation procedures, to produce trustworthy results, must be based on scientific methods of investigation, and thus may be guided by the systematic investigative procedure followed by the geologist. Random, empiric, or uncritical methods can lead only to dissipation of effort and resources.

Finally, it may be said that, except in relatively simple situations, many photo interpretation problems partake, in some measure, of the nature of research projects, and the approach to them may be expedited by due regard to the research procedures followed by the geologist. A realization of the painstaking nature of the several steps taken by the trained researcher to avoid error and insure accuracy may lead to an increased awareness of the need for caution in drawing conclusions from photo interpretation, and may offer guidance to the correct understanding of complex conditions.

As Johnson has so aptly remarked, "No device, however perfect, can wholly deprive the human intellect of its capacity for making mistakes. . . . The most that we may reasonably hope is by correct methods of research to reduce the chances of error to a minimum, and to raise to a maximum the probability of discovering the real causes and relations of things."

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TREE COUNTS ON AIR PHOTOS IN MAINE*

Harold E. Young, Assistant Professor of Forest Mensuration, Forestry Department, University of Maine, Orono, Maine

Introduction

The applications of air photos to the field of forestry have been widespread during the past decade. Foresters from one end of the country to the other have found a variety of ways to usefully employ them; however indications of their limitations within each forest region have become apparent because of such factors as characteristics of individual tree species, stand density, and topography. Thus there is a definite need to know the limits within which information can be extracted from air photos in the light of present photographic and photo interpretation equipment within each of the forest regions.

It is the purpose of this paper to explore the limits of photos interpreted at different air photo scales and different film filter combinations in Maine in order to evaluate the mensurational information that can be obtained from air photos of the spruce-fir region of the northeast.

Photo interpretation is highly subjective in nature and thus is considered an art. In the process of performing this study, photo interpretation was reduced

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to quantitative measurement and analyzed by regression analysis. Similar and better quantitative analysis is necessary to change this art to a science.

Methods

AERIAL PHOTOGRAPHY

A flight line approximately two miles long was selected; it extended across the University Forest which is adjacent to the campus at Orono. This particular flight line was chosen because it included a wide variety of forest types and conditions representative of the general region.

The range of air photo scales tested was determined by precedent and limitations of available equipment. A 8.25 inch focal-length aerial camera was used for all of the photography. A scale of 1:15,840 or four inches to the mile is now most commonly used for forestry purposes in the northeast. For study purposes this was the smallest scale to be considered and the five others that were selected are: 1:12,000, 1:10,000, 1:7,500, 1:5,000 and 1:3,500. Endlap of 60 per cent was obtained for each scale.

Photography of all scales was obtained using infrared film with a minus blue filter and by color film using the filters furnished by the company supplying the film. Black and white positive transparencies were prepared from the infrared film. Thus it was possible to evaluate and compare mensurational information on color film, infrared film contact prints, and black and white positive transparencies of the infrared film for one flight line at six different scales.

September 9, 1949 was a completely cloudless day with a minimum of haze in the vicinity of Orono, Maine. Color photography of all six scales was obtained at approximately noon time, in a total elapsed time of about 20 minutes. One week later weather conditions were similar and the infrared film was exposed at approximately the same time of day and in the same elapsed time.

FIELD WORK

The field party consisted of Mr. John Walker and Mr. Miles Dodge, at that time seniors majoring in forestry at the University of Maine, and the author. Fourteen forest stands were selected to represent different species compositions and total height. One quarter acre circular plot was located in each stand. Prior to final selection of the plot, the field party assured itself that the plot center could be accurately located on the large-scale air photos.

The procedure for each plot was as follows: A planetable was set up at the plot center. A one chain tape was used to measure the distance from the plot center to each tree four inches and larger in diameter at breast height, and this was located on the map sheet by use of an alidade. The total height of several dominant and codominant trees was measured on the plot. After all of the tree measurements had been made, the crown canopy was sketched in on the map sheet.

LABORATORY WORK

The plot centers were pin pricked in the field on the 1:3,500 semi-matte contact prints of the infrared film. In the laboratory the plot centers were carefully located on the semi-matte prints of the other five scales. Circles in black ink representing the periphery of a quarter acre plot for each scale were than placed around the plot centers. It was considered inadvisable to pin prick the plot centers on the transparent film.

Plots were located on the transparent film in the following manner: The circular quarter acre plots for each of the six scales were scratched on acetate. A stereo model was set up using a transparency and an infrared contact print. The plot scratched on the acetate could then be properly located on the transparency. The next step was to replace the contact print with the stereo mat transparency. This was a time consuming process but seemed to be satisfactory.

A binocular mirror stereoscope with four-power lens was used over a light table for all photo interpretation including the contact prints. To minimize personal bias the analysis of each of the 14 plots was made at the smallest scale proceeding progressively to the largest scale. This was done for each film/filter combination before proceeding to the next one.

It is well to point out that all of the laboratory data presented in this paper was obtained by the author who is acutely aware of the following: (1) that he participated in all of the field work, (2) that photo interpretation is highly subjective in nature, reflecting eyesight, previous experience, and reasoning ability.

ANALYTICAL WORK

Standard regression analysis technique was employed to account for variation in tree counts in terms of measurable variables.

RESULTS

The 1:3,500 scale air photos were examined stereoscopically prior to making any actual tree counts. It became apparent that the total height and crown width of each tree could not be measured because of the stand density, so this phase of the project was abandoned. Spruce and fir, which are similar in appearance could not be separated, so they were lumped in a Spruce-Fir group. White Pine could not be consistently differentiated from Hemlock, so these two species were lumped in a pine-hemlock group. All of the hardwoods were placed in a group as none of the individual species could be identified. Cedar could not be separated from spruce and fir, but since most of it grows in the shade of other trees it was excluded from this study.

The actual ground tally by species is shown in Table 1. After the tree counts had been completed in the laboratory, the air photo count per specie group per plot was converted to a percentage of the actual ground tally by use of this

TABLE 1. ACTUAL NUMBER OF TREES BY PLOT BY SPECIES GROUP

Plot No.	Pine-Hemlock	Spruce-Fir	Hardwoods	Total
1	22	2	0	24
2	53		19	72
3	31	12	6	49
4	2	9	36	47
5	5	15	8	28
6	20	24	8	52
7	6	64	4	74
8	14	45	4	63
9	14	89	0	103
10	30	34	3	67
11	16	2	0	18
12	16	17	6	39
13	44	1	0	45
14	14	18	5	37

table. These percentages were then plotted for each plot at all six scales as shown in Figures 1 and 2. An examination of the data for all 14 plots in this graphic form indicated that there were no significant differences between film/filter combinations with respect to accuracy of tree counts by specie groups for the available scales.

Further examination of this graphic material disclosed that the range of accuracy of tree counts from the smallest to the largest scale was of the same general magnitude for all plots but that for any given scale the range of accuracy was highly variable between plots. The actual ground tally in Table 1 was again scrutinized indicating considerable differences in stand density between plots.

To determine the significance of the air photo-scale and the ground tally, a measure of stand density, with the accuracy of tree counts, a regression equation of the form

$$Y = b_0 \; b_1x_1 \; b_2x_2 \tag{1}$$

where

Y = the per cent of trees counted on the air photo
x_1 = the reciprocal of the total number of trees per plot
x_2 = the reciprocal of the photo scale
b_0 = the equation constant
b_1, b_2 = coefficients

was tested by observation equations obtained from the spruce-fir data on five

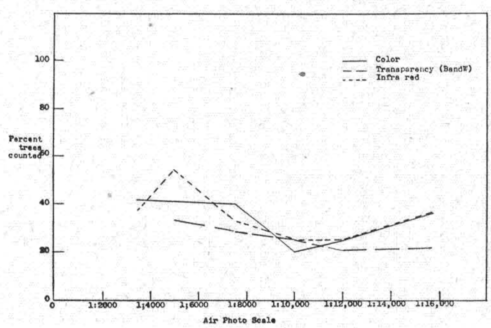


FIG. 1. Comparison of Film/filter Combinations with Spruce-Fir Counts. Plot No. 6.

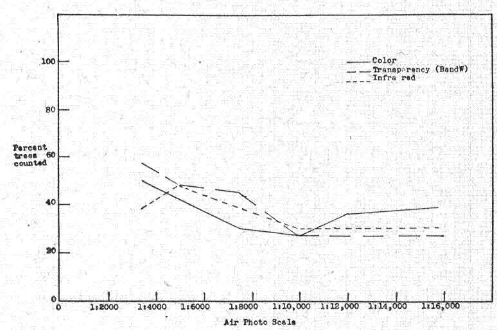


FIG. 2. Comparison of Film/filter Combinations with Pine-Hemlock Counts. Plot No. 13.

plots. In the analysis of variance it was found that the two variables were significant at the one per cent level, and the two variables accounted for 90 per cent of the variations in tree counts. The equation for spruce-fir appears as follows:

$$\text{Per cent of trees counted} = -30.49 + 2{,}715.89x_1 + 82{,}835.41x_2 \tag{2}$$

This is depicted in graphic form in Figure 3.

A similar regression equation was tested with observation equations obtained from the pine-hemlock data from all 14 plots. X_2, the reciprocal of scale, was highly significant, but x_1, the reciprocal of the total number of trees per plot was not significant. X_1 was replaced by x_3, the number of pine-hemlock per plot. The analysis of variance of the regression equation for pine-hemlock using x_2 and x_3 as the variables resulted in both being significant at the one per cent level and the two variables accounted for 52 per cent of the variations in tree counts. The equation for pine-hemlock is as follows:

$$\text{Per cent of trees counted} = 30.57 + 114.63x_3 + 106{,}794.83x_2. \quad (3)$$

This is shown in graphic form in Figure 4.

For the spruce-fir equation, stand density is accounted for in terms of all of the trees on the plot; whereas for the pine-hemlock equation the number of pine-hemlock per plot is the measure of stand density. The contribution of stand density to the equation for each species group is depicted in Figure 5 as a means of effectively comparing the two.

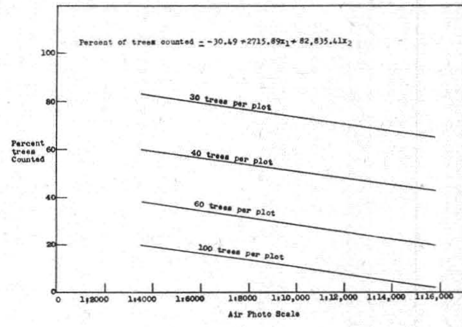


FIG. 3. Graphic Presentation of the Spruce-Fir Equation.

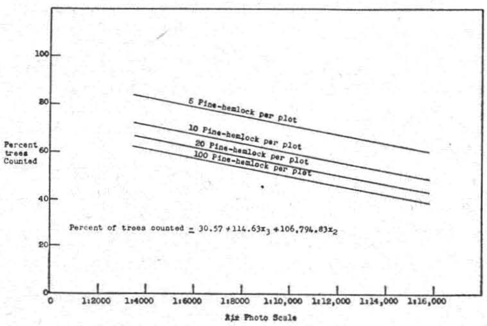


FIG. 4. Graphic Presentation of the Pine-Hemlock Equation.

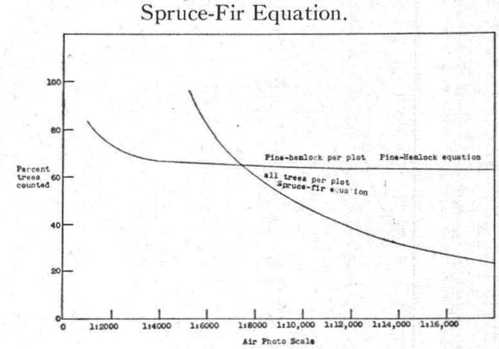


FIG. 5. Contribution of Stand Density to the Pine-Hemlock and Spruce-Fir Equations.

DISCUSSION

There is a natural tendency for the vegetation existing on any given unit of land surface to utilize all of the available sunlight. This is generally accomplished by rapid growth of the portion of the plant exposed to the sunlight until there is a closed canopy over the earth. The shade tolerance of many tree species is an additional complication to the photo interpretation of vegetation. Shade tolerance is defined as the ability of a tree to survive and grow either completely in the shade of or partially in the shade of another tree or trees. In the northeast spruce, fir, and hemlock are shade tolerant. White pine on the other hand is intolerant of the shade of other trees and will only grow in full sunlight.

Spruce and fir have long conical crowns that normally extend about halfway down the tree bole with branches that are seldom long. Pine and hemlock have irregular shaped crowns that extend approximately one third of the way down the bole with some branches that are quite long. Mature hemlock trees appear similar to white pine on an air photo, but it is not difficult to separate these two from the spruce-fir group.

The northern hardwoods (yellow birch, beech and sugar maple) cannot be identified individually in summer photography. The crown canopies in pure hardwood stands are so dense that on comparatively small-scale photography (1:15,840) it is difficult to separate one tree from another.

The shade tolerance of spruce and fir is so great that the mutual shading between these species as well as the close proximity of any other species materially affect the accuracy of tree counts on air photos. In pure spruce-fir stands it is even difficult to single out individual trees because only the conical tree tips, at most, stand out on the air photos. Therefore as the stand density increases the accuracy of tree counts on air photos decreases.

Pine-hemlock are not easily confused with other tree species on air photos and so can be counted without any decrease in accuracy due to the presence of other species on the plot. The density of pine and hemlock, however, is of major importance. If the stand density of these two species is such that the crowns are touching, or if the branches of adjoining trees appear to be interlocked, then the accuracy of tree counts on air photos will be materially affected.

It is interesting to note that the effect of air photo scale is the same in both equations. A reduction in scale from 1:3,500 to 1:15,840 reduces the accuracy of tree counts by about 20 per cent in both equations. This is based on actual ground tally.

Summary and Conclusions

Air photos in color and infrared photography were obtained on an experimental flight line located on the University Forest at the following scales: 1:3,500, 1:5,000, 1:7,500, 1:10,000, 1:12,000, 1:15,840. Fourteen quarter-acre circular plots were located on the ground along this flight line representing a variety of forest conditions. A planetable and alidade were employed to map all trees on each plot and to make a crown canopy sketch.

Laboratory work was limited to tree counts as the stand density eliminated the possibility of measuring the height and crown width of each tree. A binocular mirror stereoscope and light table were used to make all counts on the color transparencies, contact prints of the infrared film, and black and white positive transparencies from the infrared film. No significant differences were observed between the tree counts made on the three media.

Regression analysis was used to derive equations that would account for the variation in accuracy within the spruce-fir group and within the pine-hemlock group. A reduction of air photo-scale from 1:3,500 to 1:15,840 reduced the accuracy of tree counts on air photos approximately 20 per cent in both equations. The second variable in each equation is a measure of stand density. Stand density for the spruce-fir equation is measured in terms of all of the trees on the plot because of the shade tolerance of these species. Stand density for pine-hemlock is measured solely in terms of the presence of these species on the plot.

In the northeast, the natural density of mixed softwood stands or pure stands of pine and/or hemlock is such as to preclude measurements of total height and crown diameter of every tree in the stand. Scale and stand density materially affect the accuracy of tree counts at all scales tested, with the accuracy of tree counts at the commonly used scale of 1:15,840 being much too low to be considered on an operational basis. It is therefore concluded that in Maine with existing film/filter combinations and the air photo-scale commonly used, mensurational information about the forest trees is limited to the forest stand as the unit of measurement.

ACKNOWLEDGMENT

The author acknowledges the splendid cooperation of the Eastman Kodak Company which supplied all of the film and processing material, and the James W. Sewall Company which did all of the flying and processing.

AERIAL PHOTO-INTERPRETATION BY THE FOREST SERVICE*

Raymond D. Garver[1]

Activities of the Forest Service, an old-line bureau of the United States Department of Agriculture, logically fall into three broad classes: National Forest Administration, State and Private Cooperative Programs, and Research. Aerial photographs and maps are useful tools in all such work.

National Forest Administration uses aerial photographs in the management of some 180 million acres of land in varying sized holdings in 42 States and territories. Of primary importance in forest and range land protection and management are adequate transportation routes. Aerial photographs are widely used in preliminary location of roads, trails and landing fields, resulting in lowered costs and a better final job. Stereo-pairs of photographs are useful in identifying control points, rock out-crops, timber, swamps and in plotting the general location of roads or trails so as to avoid or reach timber as the need may be, and obtain desirable exposure. Low-level photographs are sometimes taken to handle difficult construction and bridge location. The Forest Service is now using photographs for preparing topographic maps of high precision.

Aerial photographs are especially valuable in fire control planning and in actually fighting fires. One of our western regions takes photographs of going fires, develops the films and makes prints in the air in 15 to 20 minutes, then drops them in tubes to the ground crews. Experience with this method as compared to past practices in which an appraisal of the location and extent of a fire had to be ascertained by foot travel recommends it highly. Stereo-pairs of photographs show not only topography, particularly important in fire control plans, but disclose the kind of vegetation in which the fire is located. To experienced fire fighters, such information indicates the fire fighting technique that most likely will be effective in controlling and putting out the fire. In actual practice, the fire may be discovered and located in several different ways, such as lookout tower and airplane observers, for plotting on a map. By reference to photographs of the area, fire fighters and the dispatcher's office can lay out the attack. They can tell at a glance whether the fire is accessible by roads or trails, type of burning fuel, whether power equipment can be used, availability of water for quenching the blaze, and places for dropping smoke jumpers in case this method of putting a crew on the fire is selected. Aerial photographs lend realism to plans for combating fires should they occur and in deciding alternative attacks, in case a so-called "blow-up" develops.

Sales of timber from national forests totaling some 4.5 billion board feet annually require not only a knowledge of correct silviculture for each type and stand-size of timber, but an over-all inventory of each forest. The first step is an inventory to determine the location of the timber, acreage, volume, stand size, species, types, condition, growth, accessibility, and desirable cutting practices as a basis for management plans designed to use and to improve the growing stock. Maps giving types, stand-size, and stocking are needed in all cases, and in the west, contours are generally desired.

The second step is the use of these data to guide timber sales, cutting practices, and logging operations. Coupled with a certain amount of ground tech-

* Paper read at Nineteenth Annual Meeting of the Society, Hotel Shoreham, Washington, D. C., January 14 to 16, 1953.

[1] Director, Nation-wide Forest Survey, Forest Service, U.S.D.A.

nique, aerial photographs are fast becoming an essential reference in timber management. Boundaries of working circles, management units and often individual sales are plotted on photographs for transfer to base maps, together forming working tools for timber sale administration. Areas in need of planting or of thinning can also be outlined.

Another major type of correlated land management on national forests covers the range resource which provides seasonal forage for more than one million cattle and horses, and three million sheep. Just as in timber management, the range manager must have an inventory of the forage resources, and maps and photographs on which to outline vegetation types, livestock allotments, and range improvements. Often also shown are soil types, estimates of range carrying capacity, and kind of stock to which the area is best suited. These data are used to work out the permissible number of stock to be grazed on a given area. Aerial photographs are considered particularly useful in considering range plans with users, and in preparing general cover maps showing timbered areas, location of water, open grassland and under stereo, nature of the terrain, i.e., rough, rolling, flat, and most accessible routes to a given area.

State and Private Cooperative Programs are carried on for the most part in cooperation with the individual States to encourage private timber growing through assistance in preventing and suppressing forest fires, reforestation of denuded areas, good management of woodlands and farm forestry extension activities. Plans for these various lines of work invariably include maps and increasingly aerial photographs to supplement them. The latter are especially useful in indicating the strategic location of fire towers and roads, and in going fires the type of fuel and topography. In forest management assistance, including tree planting, cutting plans for woodlands, and harvesting, utilization and marketing the forest products, maps and aerial photographs play an important part.

A few hours work spent in interpreting recent aerial photographs will yield as much information as days and days of field travel would collect. Many forest-land owners are buying aerial photographs for use in handling their properties. Among States, Ohio has recently provided complete State coverage of aerial photographs for its foresters for use in fire prevention and suppression, and in forest management assistance.

Research is a third major class of Forest Service work, and is directed to the solution of problems on some 600 million acres of forest, and a like area of pasture and range land. In the eastern United States these two classes of land cover about one-half of the total land area, and in western United States about three-fourths. It includes studies of forest and range problems, forest influences, fire control, forest products, and forest economics, including the Nationwide Forest Survey. Aerial photographs are used to a greater or less extent in all these lines of research, but especially in the Forest Survey to which the succeeding discussion will be directed.

What is the Forest Survey? It is the only comprehensive national survey of facts on the condition and use of timber resources, both public and private—one of the Nation's great basic natural resources covering one-third of the total land area. Survey findings on forest areas, timber stands, timber growth, timber drain and prospective requirements for timber products are essential to every important Federal and State forest policy and to the development of measures necessary to balance the Nation's timber budget. They are also essential to private production and development programs of every important wood-using industry.

How is the Forest Survey conducted and what part does aerial photography play in the technique? Although the technique varies somewhat among forest regions, underlying all survey field plans are these basic similarities: (1) use and interpretation of aerial photographs, and (2) classification and measurement of the trees on sample plots ($\frac{1}{5}$ to 1 acre in size) to obtain specific information on forest areas, timber volumes, quality, stocking, species, growth, depletion, and site. Because the Survey is national in scope and objectives, the technique from the standpoint of funds and practicality must be based on a design in which representative samples, sufficient in number to give a prescribed degree of accuracy to final results, are classified and measured.

Aerial photographs are used in at least four important ways. They aid in classifying land into cover types, in preparing forest type maps, in dividing the timber on the land into stand-sizes, and in measuring the area in each classification. Probably these items are clear from the titles, except "stand-size" which classifies areas into sawtimber stands of trees of commercial species of a minimum diameter and larger, in sufficient numbers to yield at least 1,500 board feet per acre in the East and 4,000 board feet in the West; pole timber stands of trees 5 inches in diameter and larger, of commercial species that do not qualify as saw-timber stands; seedling and sapling stands of trees less than 5 inches in diameter; and nonstocked forest land not covered by the above three classes.

Some effort has been made to estimate the timber stand volume directly from photographs, but results to date have not yet justified adopting the procedure in our technique as standard practice. Efforts have been directed to the development of individual tree volume tables based on crown diameter and total height of trees, both measurable on aerial photographs. Another approach was stand-volume tables in which the total volume per acre would be given. These were based on average stand height, average crown diameter, and stand densities usually broken down into five classes. Tests have also been made of sample plot estimates of volume from photographs with ground measurements of the same timber as a check on the former. The results of these few tests were encouraging, but they have not yet led to satisfactory procedures for survey purposes. Obstacles, of course, are the limitations imposed by the aerial photographs available to the Survey, such as the impossibility of seeing the understory timber, difficulty of precise measurements of individual trees, uncertainty of species identification, distortion in rough country, and inadequate skills and instruments for complete interpretation of the timber information such photographs disclose.

Aerial photographs are especially useful as a permanent record of the location of sample plots which will be remeasured in periodic resurveys.

How acceptable a job can be done depends especially on the quality and scale of photographs, kind of film used, whether recent or old photographs are used, and the effectiveness of the photo-interpretation technique. Results to date seem to indicate that the Survey, considering cost and the probability of being able to get prints now and in the future, favors black and white contact prints from panchromatic film with a minus blue filter in the West, and in the East prints from infra-red film with a minus blue filter if separation of softwoods and hardwoods is required, at a scale of 1:15,840 using $8\frac{1}{4}$-inch focal-length cameras in both cases. In the West panchromatic prints are favored because of better resolution and less dense shadows, which seem to make it less difficult to measure tree height, identify species and estimate understory conditions; in the East, infra-red prints are preferred principally because they bring out by contrast a separation of the softwoods from hardwoods. Although stated rather dogmatically these specifications are subject to change and quite probably do not represent the final decision. Research is needed to prove or disprove our current opinions which are largely based on empirical tests made in the conduct of the Survey. Some testing is going on, some is being planned, but much more is needed. Foresters need instruments and techniques which will permit greater precision in the measurements of diameter and height of individual trees, or otherwise get at the volume of stands of timber, than can be made with the usual run of inexpensive, quickly operated tools developed over the past few years, such as the parallax wedge, crown diameter and stand density scales, stereograms, dot grids, etc. All possible credit, however, is due the men who have developed these and other similar aerial photograph working tools. It is believed that the engineers have made much better progress than the foresters in working out and developing instruments and techniques for precisely measuring and mapping features disclosed by aerial photographs.

Among the unsolved problems in making the most of aerial photographs in forest inventories, two that should be within reach are: (1) generally applicable methods and measuring devices for estimating timber stand volume within a sampling error of say 5 per cent or better per billion cubic feet, and (2) identification keys to classify stands into major species and groups of minor species. Without doubt some ground studies to get information on timber growth, quality and defect, will always be required. Along with such work, checks on the volume estimates and species identification obtained from photograph interpretation could be made as needed. In order to reach this level of technique the most suitable photographs will be needed.

To determine the best kind and scale of black and white photographs there is need for well planned and executed research, because without research there evidently is no mutually accepted answer to the question of just what is needed. Another possibility is color transparencies, but the literature on these is not encouraging regarding their potentialities in natural resource inventories. Some information on many of these points is of course available in the *Manual of Photogrammetry*, but I hope this panel can furnish additional suggestions for guidance in improving the technique of the Forest Survey. Probably some engineer might say, "if you foresters had better training in photogrammetry and mapping, it would help," and that quite likely is correct, but I am hopeful that we can rise above our present level with what we have.

Good base maps are needed as a starting point for practically all segments of forestry work. Aerial photographs are increasingly becoming essential in preparing such maps. These maps customarily show rivers, creeks, lakes, roads, trails, railroads, cities, towns, boundaries of political subdivisions, sometimes contours or hatching to indicate topography, etc., nearly all discernible on aerial photographs. Such maps supplemented by recent aerial photographs of proper scale and quality provide one of the most essential elements in improved forest management and protection.

MACHINERY FOR THE PHOTO INTERPRETER*

Gomer T. McNeil, Photogrammetry, Inc., Silver Spring, Md.

Photo interpretation is an art. The photo interpreter relies on instinct, experience and an acutely developed perception. In a sense he is like the early aviator for he flies by the seat of his pants. Now it has been said that there are old pilots and there are bold pilots, but that there are no *old* bold pilots.

The photo interpreter, unlike the pilot, has been given little more to work with than a stereoscope and photographs. The type of stereoscope that most interpreters use is widely praised because it is cheap and the interpreter can nevertheless see through it. While this economy is laudable, as a prime criterion it serves only to handicap the interpreter still further.

At the same time, the interpreter himself often resists the intrusion of exactitude into his art. The tradition of mystery and the knack for interpretation is naturally strong in thinking of a skill which has succeeded mightily *without* precision. The interpreter reasons that more intelligence can sometimes be extracted now than can readily be used and, except for larger scale photography, can anything more be desired?

This paucity of practical devices to extend the interpreter's range of action is not in keeping with the American concept of the amplification of human effort by machinery. There may be too much concern for photography as an end result rather than for photography as an intelligence means. What happens after photo delivery has aroused only subordinate interest. This is unfortunate.

The situation may be partly ameliorated by several devices made for the photo interpreter and now known to be either on the drawing board or in an early production stage. These instruments range from machines for precision photo orientation and measurement to designs that aid the photo interpreter even before he becomes a photo interpreter.

For instance, it seems logical that if individuals are to engage in work which is obviously dependent on good vision, that periodic ocular system testing should be part of the selection and personnel maintenance technique. A kit is now being developed to meet this need; it consists of a battery of vision tests adapted to photo interpretation and photogrammetric requirements. The tests are designed so that they can be administered reliably even by untrained laymen who have never seen the test before. Testing can be completed in five minutes or less, and no additional equipment is required. Moreover, the entire package weighs only a few pounds, is less than a $\frac{1}{4}$ cubic foot in volume, and can be mailed conveniently to any part of the world.

Two stereo-mechanical devices, one for direct height finding and the other for slope determination, are also to be made available in a flat, compact format. Their use should free the photo interpreter from having to compute these findings.

Another instrument, now ready for production, permits rapid measurements on oblique photographs with an accuracy which encourages reconnaissance exploitation. No mathematics are required for the operation of this device; even the location of the decimal point is indicated in the answer. In a matter of a few minutes, it is possible to obtain ground distances, vertical heights, ground measurements of regular or irregular areas, bearings from the camera position and distances from the camera station. All this may be done semi-automatically

* Paper read at Nineteenth Annual Meeting of the Society, Hotel Shoreham, Washington, January 14 to 16, 1953.

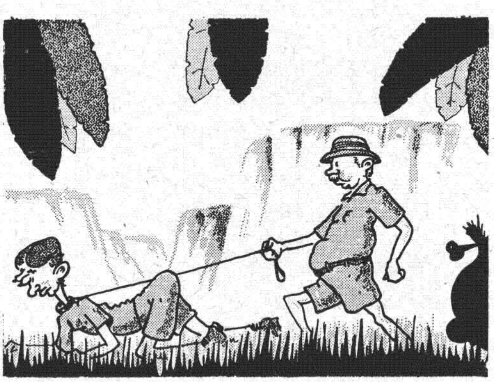
on a single photograph by non-photogrammetric personnel. When overlapping obliques are available it is also possible to find approximate differences of elevation. Built-in features even include provision for correcting for image distortions due to curvature of the earth and refraction by the atmosphere. The device is flat and light; at the same time it is rugged enough to be used as a field instrument.

A tri-purpose metrical camera has also been designed to record position, azimuth and secondary control by triangulation. It should prove useful to the interpreter in geographically locating ground photography. The design of the camera is such that the heavens may be photographed from the same location as the surrounding terrain, thus permitting accurate orientation of the photography by means of the stars. A map can in fact be prepared from the combination of rounds of exposures and the star images. This equipment weighs only about 20 pounds and is rugged and reliable.

The significance of the development is that the exploration of vast, uncharted areas, for minerals or other purposes, is made easier and less expensive by photographic assistance from the metrical camera. For instance, explorers and prospectors must determine the coordinates of locations of interest with sufficient accuracy to guarantee finding the same spot again. By using the metrical camera they can not only orient themselves precisely but they do not even have to attempt to determine their location by conventional means.

If a find is made in a sparsely settled area, or if a route is to be laid out, the metrical camera may be used to photograph the site, the surrounding area and the stars above. The photography need not be developed or interpreted, nor position location attempted, until the expedition returns to base. Locations may then be determined from the photography. Maps may be prepared from the photo data and descriptions of terrain may be written and illustrated by the photos, all of this work being done under optimum working conditions.

It is hoped that all of these instruments will be displayed during the next Annual Meeting. These developments and others may be the beginning of the emancipation of the photo interpreter. Photo interpretation may, in fact, become a science as well as an art. If more and more techniques are supported by and based on reproducible experiment and scientific reasoning, as well as on experience, the assessment of the findings will rest on a more substantial footing. The decisions made by the photo interpreter will always have to be somewhat intuitive, because he deals most often with human activities which by nature



"A"

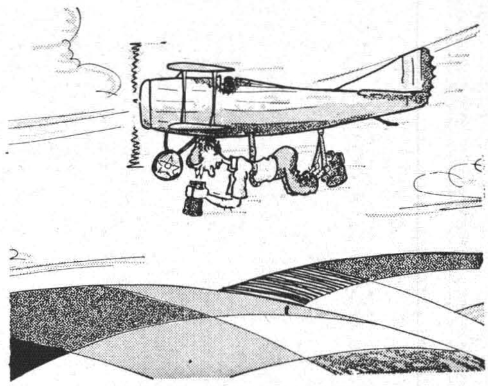
We must start, naturally enough, with the progenitor of the modern interpreter who had his start with the early military scouts. There he learned to rely on instinct to sniff out his findings. You may note that even then the lack of equipment was beginning to make his eyeballs bulge.

have unpredictable elements. However, his analyses will stem from an evaluation of facts and not as much from the emotional sum of his feelings.

A few pictures will illustrate the need for instrumentation support for the photo interpreter.* Thanks are expressed to Lt. Jack Cahill, of the United States Navy, who drew these original cartoons on his own time as a friend of the Society.

"B"

In World War I the interpreter was finally permitted to discard his leash and take to the air, where binoculars increased his scope and powers.

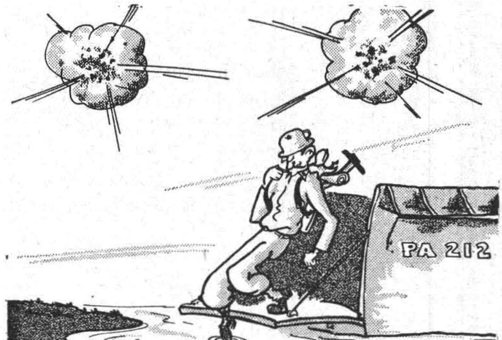


"C"

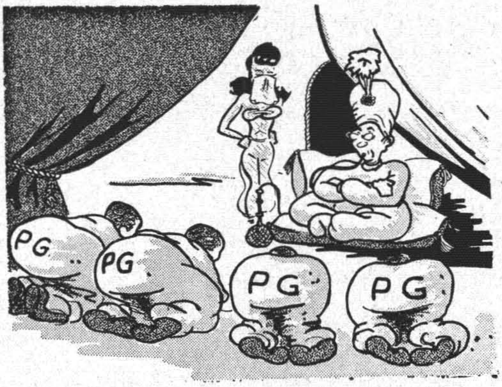
Here, at the beginning of World War II, the interpreter took his first real step in the direction of becoming a *photo* interpreter. He was given very little to work with.

"D"

During World War II, despite scant equipment and techniques which had to be developed on the spot, the photo interpreter made tremendous strides. His contributions established the potential of photo interpretation so firmly that modern military operations are unthinkable without him. Even civil applications of photo interpretation have been aided by military developments. These men brought their skills and determination as far forward as they were needed.

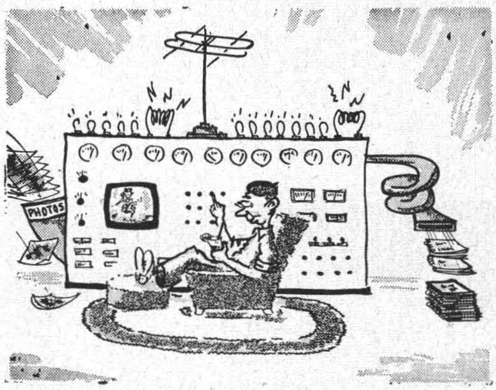


* Any resemblance to persons living or dead is purely coincidental.



"E"

This is a portrait of a photo interpreter some years hence. Here, the interpreter, represented as the Sultan-Of-All-He-Surveys, has at his beck and call the metrical support of the photogrammetrists.



"F"

This is the Pushbutton Photo Interpreter of the future. He has become sufficiently mechanized so that his brain and his still bulging eyeballs are now perfectly complemented by machinery developed by the photogrammetrist and other scientists. The photos come in one end and reports drop out the other.

NEWS NOTE

Establishment of a subsidiary company at Salt Lake City, Utah, to serve expanding mapping requirements in the West, was announced on March 19 by Aero Service Corporation of Philadelphia, worldwide aerial mapping company. The subsidiary, Aero Service Corporation (Western), will compile topographic maps and photomaps for oil and mining companies located in the west, as well as produce maps for highways, cities, flood control, irrigation studies, and other engineering uses.

Aero Service Corporation (Western) will employ the same mapping methods and equipment as the parent company. The Salt Lake City location will bring better service for Aero's Western clients, company officials said. The parent company is the oldest flying corporation in the world, and its mapping crews are now at work in Africa, Europe, the Middle East and Far East, and South America.