never will be possible to say of a man, "He is a qualified photo interpreter" without modifying the statement in some way. It can be said "He is a qualified photo interpreter in the field of geology"—or soils, or forestry, or, to narrow the field still more, in construction materials or trafficability. Or it can be said, "He is a qualified photo-reader." "He can identify a large variety of objects on aerial photographs, but his ability to discern the significance of these objects is very limited." These distinctions between the various possible uses of aerial photographs have great significance in terms of future research in photo interpretation. These should be kept in mind at all times.

In conclusion, it is felt that the following procedures, if followed, will contribute to the solution of the dilemma of military photo interpretation by recognizing that simplification of techniques alone cannot solve our problem, and that we have resources of information and of technical skill which we must prepare to utilize fully:

1. Great care should be taken, both in the preparation and in the use of simplified photo reading keys, to emphasize their limitations in order to prevent their misuse.
2. The reserves of fully trained scientists and engineers who are also qualified photo interpreters should be increased, particularly by the device of insuring concurrent university training in the subject specialty and in military photo interpretation, aided by declassification of some military training materials.
3. Development of intelligence methods should stress the use of all sources of information in solving a problem, and should minimize the philosophy that photo interpretation is a specialized technique capable of yielding complete information without recourse to such other techniques as the study of geologic or soils maps and scientific literature.

FACTORS LIMITING THE USE OF AERIAL PHOTOGRAPHS FOR ANALYSIS OF SOIL AND TERRAIN*

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THE success and degree of reliability attained by using airphotos for analysis of problems are contingent on an understanding of the limitations. The photo user whether he is a photo reader or a photo interpreter must be cognizant of the limitations so that he can recognize conditions beyond which he can not make successful evaluations. It is important that the user as well as the administrator know the limitations. For the photo user whose daily task is working with airphotos, application of the principles and techniques of either reading or interpretation, within the limitations, will bring continued success and a high degree of reliability. For the administrator who directs the activities of the photo user and who uses the data produced by the photo user, knowledge of the limitations will let him know how far his subordinates can go, and what to ex-

* This paper was a part of the Photo Interpretation Symposium and was read by Prof. O. W. Mintzer at Nineteenth Annual Meeting of the Society, Hotel Shoreham, Washington, D. C., January 14 to 16, 1953.

† See acknowledgment.

pect from the standpoint of reliability. No one can expect to obtain the most information from photos which do not fit particular job specifications. Neither can one expect to supply information in fields foreign to his background and training.

For convenience the limiting factors have been grouped into six major categories: photographic, human, natural, method, time, and use of supplementary information. All of these limitations are important, but, of these six, those pertaining to photography, to man himself, and to natural causes are the most important.

The following discussion pertains chiefly to the use of airphotos in soil and terrain analysis.

Photography

The aerial photograph is the tool which is used to make a soils and terrain analysis; it is a storehouse of information which contains the data. Even though the photo has been taken to specifications which will best record the features desired, it is of no value to the user who is ill-equipped to use the tool. Photography has many limitations and each must be understood before the photographic image can be evaluated properly. Each operation connected with supplying the final photograph has certain limitations including type of photography, scale, stereo-optics, film-filter combinations, and print type and quality.

TYPE OF PHOTOGRAPHY

Basically there are four types of aerial photography and the photo user interested in terrain and soil analysis should understand the limitations covering the use of each. The best results in any work involving the use of tools come from using the proper tool for the job. A pair of pliers cannot be used to good advantage in place of an end wrench of just the right size, shape, and length. The same is true of photography.

The four types of aerial photography are trimetrogon, vertical coverage, continuous strip, and composite. Each type was designed for a specific job and each is best suited for that job. From the standpoint of terrain and soil study, vertical coverage offers the best possibilities; however, the others can be used in specific instances but only in a very limited way.

Trimetrogon Photography. For terrain and soil analysis, trimetrogon has the distinct advantage of showing the extent of major terrain and major soil features. For natural pattern studies, the combination left-right-vertical makes it possible to obtain the areal perspective—where major physiographic borders occur, what the border conditions are, and what the more obvious pattern contrasts between the various terrain and soil units are. From the standpoint of cultural pattern features the combination of the right, vertical, and left of a series gives a good overall perspective of a cultural unit, such as an urban area. It is then possible to locate the various parts and the space relationship of its parts within the urban area. The amount of detail is primarily a function of scale. The vertical portion of the trimetrogon series of photos, if taken in stereo-sequence, will supply the most accurate and reliable information of the three, but only of that portion of the terrain covered by the verticals. It is difficult to obtain detailed information from the obliques. The oblique photos, at best, give a picture of the extent of the major natural and cultural features.

Vertical Photo Coverage. The most common, most practical, and most easily used photography for general terrain and soil studies is vertical coverage. If vertical photos are taken to a scale suited to the job requirements, and if they are of good quality, then the photo user has the best possible tool to work with in conducting his terrain and soil study. Vertical coverage can be assembled into an uncontrolled mosaic in a short period of time for the purpose of area study in order to obtain the areal perspective—"the lay of the land." When assembled thus, the photo user can compare areas and he can rate them in a priority system based on the job requirements. The major natural and cultural features can often be delineated easily by contrasts in surface features. As the user sees items requiring detailed study then the verticals can be reviewed and studied stereoscopically. Thus, an area can best be studied in great detail stereoscopically using complete coverage verticals.

Continuous Strip Photography. This type is excellent for obtaining details along a beach, a road, a railroad, or along a narrow strip across an area of importance. This type of photography is well adapted to surveys of railroads, highways, airfields, beaches, columns of vehicles or troops. Since such photography can be obtained in stereo-sequence the value is greatly increased. From the standpoint of terrain and soil analysis, the use is extremely limited since area coverage per unit of picture is very small and distortion is very great, particularly along the edges. The use for terrain might be limited to spot or strip checking of questionable details—such as a group of buildings, damage to a railroad yard, or type of cover on a particular land form, perhaps for purposes of verification of previously made predictions.

Composite Photography. This type of photography is ideal for coastal area mapping or for mapping along the lines of a triangulation net. Since one picture, which is a composite of 5, 7, or 9 photos, is obtained, stereo-depth perception is altered in portions of the composite photo, particularly at photo-match lines. Area coverage of high quality can be obtained, but the difficulties of stereoscopic vision makes evaluation of relief very difficult.

PHOTOGRAPHIC SCALE

The scale of photography imposes one of the most serious limitations on the results to be obtained for any study. There is no one standard scale which will satisfy the many users of aerial photography. There is one basic fact: it is impossible to have area coverage and large scale in the same single print—a fact, which, simple as it seems, is often ignored. Because of this, compromises must be established—one must be adjusted, or even sacrificed, at the expense of the other.

A scale of 1:2,000 may be excellent for identification of minute details such as vegetation and vehicles. Such a scale is far too large for terrain and soil studies because analysis is contingent on the study of all parts of an area, not only the minute surface details but the relationship existing between them. Hence, some area coverage must be present in the photos, The great number of prints required for area coverage precludes use of this scale for terrain and soil studies because of the expense and the great amount of time required for area study. Mechanical difficulties are of considerable importance. Such items as re-cycle time of the camera, low altitude, image motion, and shutter speed must be considered.

A scale of 1:5,000 may be past the optimum for identification of vehicles and minute natural features, and some small equipment. This scale may be satisfactory for identification of vegetation and some cultural features. However, at such scales, because the area coverage per print is still small, it is difficult to determine and study relationships between various terrain or soil area units. At scales of 1:5,000, area coverage still requires a great number of prints, certainly more than needed for successful terrain analysis.

A scale varying between 1:10,000 to 1:20,000 provides an excellent working range for terrain and soil analysis. The area covered per print is good and stereo-depth perception of relief is good (provided long focal length lenses have not been used). Some minute details may be lost to detailed study, particularly people, vehicles, and some equipment. General area relationships are easily determined and studied, details of individual plants or trees are gone, but the general arrangement and density of timber stands are not influenced. Such details as gully characteristics and some of the more outstanding special features are easily seen and can be studied in detail. Good stereo-relief representation is possible and topographic positions as well as slopes can be evaluated. The number of prints required for general area coverage is not considered excessive.

Scales varying between 1:30,000 to 1:60,000 and beyond provide excellent area coverage in the broadest sense. Major physiographic details are easily seen, studied and bounded. Relief must be great before stereo-vision is practical. Only relief forms of the greatest order are clearly differentiated. The very small details are lost. For example, major gullies can be seen and plotted but their characteristics are lost. Land forms can be delineated only when great contrast in pattern occurs (field patterns, changes in vegetation, changes in photo tone etc.). Slopes associated with various land forms can not be seen or distinguished. Such cultural features as roads, railroads, bridges, and buildings can be identified—but their structural details cannot. Few prints are required to cover an area. Mechanically, such photos are easily obtained; however, such items as haze, crab and tilt become of great concern during flight.

STEREO-OPTICS

The illusion of depth perception made possible by stereo-photography can be altered considerably by varying the focal length of the camera lens, the distance between centers of photos, and the altitude. This is a serious limitation for terrain and soils. The combination of long lens and high altitude provides excellent stereo-depth perception for minute objects and is a decided improvement for their study; however, for general terrain and soil study these are of minor importance. In order to obtain comparable stereo-depth perception of objects it is necessary to vary factors constantly and in direct proportion; however, in practice this is impossible because of the limitation of size of film. Hence, the photo user must evaluate relief seen on a stereo-photo sequence in the light of the altitude—focal length—center distance relationship. This also becomes a critical limitations when the photo user must work with photos which vary considerably from the standpoint of stereo-optics. It is difficult to evaluate heights and slopes using a set of photos having one depth perception, and then to change to another set of photos where the depth perception has been altered considerably. The same area is often unrecognizable from the standpoint of relief when comparing two different conditions of photography. This limitation cannot be stressed too greatly.

FILM-FILTER CHARACTERISTICS

Normally the best combination of film-filter for average photography, and certainly the one most commonly used, consists of a high speed panchromatic aero film used in combination with a minus-blue filter for normal haze penetration. When exposed and developed properly, the film will render a wide range in tone values and provide an exçellent negative roll for final printing, either on paper as a print or on film as a positive. Speed and color sensitivity of the film change considerably as different filters are used. Normally, these items should be of little concern to the terrain and soil analyst since at most, the only items which actually change are those having considerable surface area of a particular color, such as the natural soil color or the color of vegetation. However, it may become a decided limitation when photographing a forested area in the fall when a variety of colors exist. The use of high red sensitive emulsions (infra red film) with orange, red, or infra red filters has particular use in timber studies where it is desirable to separate conifers from deciduous trees.

Film—filter combination need not become a serious limitation if the photo user realizes that he is working with monochromatic tones ranging from white to black which represent the collective result of many items including original color of object, moisture, angle of sun, color sensitivity of film, color of the filter, exposure, color of light at time of photography, processing techniques, potential of processing solutions, print paper characteristics, printing solutions, and printing techniques.

PHOTO COVERAGE

Terrain and soil analysis should never be made from too small a number of prints representing an area. Sufficient photo coverage of an area should be available to enable the observer to determine the extent of local conditions and the expected variations.

PRINT, TYPE, QUALITY, AND PRESENTATION

The methods of presenting aerial photos for use in map work or in other interpretation studies are important and sometimes may become limitations. The photos may be provided in either contact or enlarged size; they may be assembled into an uncontrolled mosaic; they may be provided in stereo-pairs; they may be printed on a variety of paper surfaces, contrasts, and weights; index sheets may be furnished; or fully controlled mosaics can be made and supplied. Each method of presentation has its advantages for certain uses and each method may become a limitation if used improperly or as a substitution. Normally, vertical prints are made contact size (the more popular sizes are 7×9, 9×9, or 9×18 inches). When prints of the above sizes are made in stereo-sequence they are of practical size for use in detailed analysis. Simple pocket stereoscopes can be used which will permit a considerable amount of magnification of physical features as well as provide sufficient field of vision for establishing the area concept. Enlarged prints give added visual detail only by providing a picture at a much larger scale; the mere fact that photos are enlarged does not enhance the survey or create finer detail.

The chief use of an index sheet is in showing the location of existing air-photos in a given region. These sheets are made by making a photo copy of all photos assembled. They can often be used to a limited extent in soil mapping, particularly in areas where major physiographic features are not complex and where soil patterns do not vary greatly. Major boundaries can be located and drawn on the index sheet, but the final boundary should be located from detailed stereoscopic study of contact photos.

Controlled mosaics of an area provide an accurate map from which measurement of distance can be obtained. Their use in terrain and soils study should be confined to the study of major physiographic units, contrasting soil patterns, or to the determination of differences in vegetation. The amount of detail necessary for complete detailed terrain and soil analysis cannot be obtained from study of a mosaic.

The quality of the final photograph is very important and can often become a limiting factor in determining the final answer in an area. However, if the photo user evaluates the print tones in the light of its general appearance, as a photograph, he will know how much to rely on the grey values recorded. If a photo has a certain amount of "snap," creates a pleasing appearance, has a long tone gradation (white to black), good average reflected density (not too dark or not too light), and if it compares well with the rest of the photos in the above qualities, then care in processing has been followed and the user can be sure that tone gradations are representative of changes on the ground. If the prints in a flight strip vary—one light—one dark—one spotty—one faded—one muddy—etc., then the user must realize that very poor photo workmanship entered into the picture and tone gradations are unreliable.

Photography in all phases is very exact; emulsions are developed to accomplish certain things within certain limits and excellent results will always be obtained if those limitations are not exceeded. The human element has complete control over the chain of events necessary to get a final print, and for this reason the human element becomes the greatest factor in creating that print. The photo user must realize that the best results are obtained when the tools fit the job and when the user knows their limitations.

Human

As pointed out by Dr. Roscoe, USAF: "The airphoto is the window through which the viewer projects his background to determine what is in the view." It is within the province of the photo user to identify, analyze, evaluate, and interpret that which is in the view. Man, therefore, becomes the greatest limiting factor to successful photo analysis. There are many items which affect the results of the photo study and they are: background, training, experience, stereo-vision, imagination, interest, ability to follow logic and reason, and a good work or study area.

STEREO-VISION AND STUDY AREA

Of prime importance is the ability to see stereoscopically. To do this requires good vision with both eyes. The photo user should be capable of perceiving the fine details in a photo, and he should be constantly trying to develop his powers of observation. The study area should be comfortable and well-lighted since serious eye strain may result from poor working conditions.

BACKGROUND, TRAINING, AND EXPERIENCE

The photo reader is limited to identification, recognition, and delineation of objects, either man made or natural. Constant marking of drainage will improve the skill of the observer and make obtaining greater drainage detail possible. The photo reader requires little or no background to delineate forests and to bound major land forms. When following a guide which points out what to look for, the photo reader can obtain considerable descriptive information about land forms and about vegetation, without knowing their names or the true significance. The same is true of cultural patterns.

The photo interpreter's job is more detailed, more complex, and requires more background, experience, and training than that required by the photo reader. The photo interpreter must be an analyst. The process of identifying and evaluating the earth's surface features from airphotos requires the following: the use of logic and reasoning; an understanding of the "rhyme and reason" of how a given deposit developed; the ability to establish the origin; and the ability to trace the sequence of events responsible for its present form. It is, therefore, important that the photo interpreter, who wishes to evaluate the natural terrain features, possess a knowledge of some of the basic principles of some of the earth sciences. It is not necessary that the interpreter be an expert or a highly trained specialist in all of the natural science fields or even one of them to obtain valuable information from airphotos.

The prediction of certain of the engineering characteristics of soils, such as profile development, texture, etc., requires, in addition to a knowledge of some of the principles of pedology, considerable field sampling experience and an engineering background. Without such knowledge and experience it may not be possible to predict engineering characteristics.

It is more important that the interpreter be able to recognize changes in vegetation or changes in bedrock types, and to be able to realize that such changes often may mean changes in the natural soil conditions. Herein lies the importance of interest, background and training. An engineer who maintains considerable interest in geology and pedology will possess a keen appreciation for the relationship between natural conditions and problems. Many engineering problems are more closely related to the materials on which a structure lies than to the theoretical aspects of certain design formulae. He will evaluate natural situations in the light of potential engineering problems.

The wise interpreter uses his background and training to the fullest extent; he consults the literature and seeks the help of others in fields other than his own. The wise interpreter couples his studies with field sampling as much as possible since this broadens his perspective and develops self confidence. He must develop, or possess, a keen imagination since he has, by necessity, altered his vantage point from the ground position to a position some place above and he now sees it through a stereoscope. He must visualize how the ground looks from his new vantage point in the air. In this manner, photos will be used wisely and accurate findings and predictions will result.

Natural

This limitation applies largely to the natural features of the terrain pattern. In order to evaluate the natural terrain features properly, certain conditions existing at the time the photographs were obtained must be considered. Usually, these can be interpreted and evaluated by observing deviations from the normal for a particular natural pattern feature. The limitations imposed by nature include the anomalies caused by climate which on air photos are reflected in photo grey tones, erosional features, and vegetation.

PHOTO TONES

Photo tones are influenced materially by prevailing environmental conditions—they may be upset locally and altered radically from one season to another. Exceedingly contrasting photo tones (when excessive surface water appears to be present) may indicate photography taken immediately after a rain, particularly if surface water is seen in low spots in the fields. On the other hand photos which have been printed on extreme contrast paper or from high contrast original negatives may also be of high contrast and will be unreliable unless such factors are taken into consideration. Normally, light-textured and well-drained soils will photograph light in tone, while poorly drained and fine-textured soils will photograph dark in tone. Such a statement is true if the influence of environment has been considered properly. Dry sand in the form of a dune on a dry sand plain will photograph light in tone, probably the same tone as that of the sand plain. Dry sand in the form of a dune on a moist sand plain will photograph light in tone against a dark grey background. In humid regions, clay soils photograph dark, and silt and sand photograph light. In arid regions, both sand and clay might photograph with the same tone.

EROSION

One of the elements of the soil pattern is that pertaining to erosional features. This element is reliable provided the rainfall—runoff—erosion characteristics are evaluated correctly. In general, gully cross-section and gradient are reliable indicators of soil texture; however, the climatic conditions under which the gullies were formed must be considered. This limitation can be illustrated in comparing erosional features of clay shale areas in arid-badland regions with those of clay shale areas in humid regions. In arid regions, intense rainfall of short duration usually carves soft clay shales into fantastic shapes with unnatural vertical slopes. In areas of uniform rainfall, in contrast, gullies in clay shales have softly rounded slopes. Thus, for gullies and slopes to be used with a high degree of reliability it is necessary to decide whether erosion has taken a long period of time to develop or a relatively short period of time.

VEGETATION

There are many items which become limiting factors when considering vegetation. One of the important factors is that the vegetation is constantly changing and that the factors governing the establishment and changes in vegetative cover are often local in effect. The interpreter who has cognizance of the complex nature of plant characteristics together with theory of plant succession can evaluate the significance of cover types more skillfully than one who is uninformed. Burned over areas must be studied thoroughly and evaluated properly before one can say that a change in vegetation accompanies a change in soils or ground conditions. The evaluation of vegetative cover as a soil indicator is difficult in a burned over area because of the complex factors effecting the restoration.

Other factors which are of importance are altitude, precipitation, exposure and prevailing winds. The season during which photos were taken becomes important when evaluating timber. The general season of the year may be indicated by the coloration of the foliage of deciduous trees or by the absence of foliage in the case of winter photography. It is up to the interpreter to piece together the various factors affecting the establishment of cover type and to apply that knowledge to each individual situation.

Method

The results obtained are dependent to a considerable degree upon the approach followed of the method used. The random method of photo study is the least reliable. The photo reader who has little or no background can go only so far in his study. He can merely locate, outline, and describe the more obvious features, natural or cultural. The photo reader who has some background in a particular field can go much farther in his study, even to the extent of making some identification of objects familiar to him: he may even ascribe some significance to the objects he identifies, but only objects which are known to him. Should he have a guide which establishes a procedure to follow he can go still farther, even to the extent of getting reliable information on the characteristics of objects foreign to his background. Should there be in existence a "photo key" which explains as well as pictures objects, particularly in subject specialities other than those familiar to the reader, he can obtain considerably more information than without the key. However, the reader using a photo key is limited by the background of the key maker as well as by his own background. The photo reader and the photo interpreter who follow a systematic method will obtain far more information then one who follows a purely random method. The photo user who follows a random method must, by necessity, rely purely on background, and he is limited to studies in his own field. The random method encourages snap decisions which becomes a limitation. It also encourages making decisions in other fields, which is a limitation. The use of a guide which establishes a systematic procedure will enhance the survey and result in more accurate determinations and in covering wider fields of interest than the purely random method.

Time

Time is often a limiting factor because of the large number of prints necessary to be studied in detail in conducting a study. It takes time to perform the operations necessary to study an area thoroughly. Many situations, either natural or cultural, are easy to identify, describe, and evaluate because they are simple in their form, or they represent a common or standard occurrence. If the number of prints is not too great, then accurate results can be obtained in a short amount of time. Complex areas, either natural or cultural, are difficult to study. A systematic procedure takes time. Large areas should be studied first in mosaic form (assembled photos—uncontrolled) in order to gain the broad perspective and to make general predictions. Next, the detailed stereo-study is performed, photo by photo, until the entire area has been covered. Notes should be taken, questionable areas should be marked, conferences with others should be held—all of which requires time. Continued working on photos, hour after hour without a break, results in eye strain and considerable fatigue which may be a contributing factor in producing unreliable results. There is always a tendency to make snap decisions when working under pressure—these should be avoided —they are costly and will result in erroneous answers.

Supplementary Information

The wise analyst will correlate predictions made from air photos with other sources of information such as published literature, maps, first hand sampling, or the observations and experience of others. When possible the photo user should field check accessible areas with photos in hand. The photo user should understand the importance of the work of others in the form of published maps and literature and he should know how his survey can be aided by such work. The wise analyst knows, and is familiar with, the chief sources of literature and he is capable of screening the literature to determine which points are applicable and which are not. Before the photo user can use maps or transfer data he must understand the purpose of the maps, the philosophy behind the map units or legend, and how to correlate such legend units with airphoto patterns. Equally important is an understanding of the accompanying text and the terminology used by the various technical fields of use.

The photo user should realize that most maps are places to start a photo survey; they become a point of departure from a map to the photo. For example, a geology map will be of great aid in giving to the photo user the parent material of an area, giving him the general lithology and extent of various formations. Usually the scale of most geology maps is such that minute details can not be shown. Rocks will be mapped by age and general lithology. It is up to the photo user to study the accompanying text for details about the materials. After the photos have been located or plotted on the particular map and the parent materials determined then the photos are used to obtain the minute surface details, such as refinements in border, culture, etc. These are items which cannot be shown on most of the maps. Thus, the use of such maps is limited to general orientation—to providing a basic understanding of an area.

In a similar manner, topographic maps can be used to great advantage provided the photo user understands the limits controlling their use. A topographic map, which has been well made, is an expression of the landscape which reflects origin and erosional history, if interpreted properly. Only the best topographic maps, those having large enough scale with small contour interval, are of any real benefit in correlating minute details. At best, most topographic maps provide a clue to regional, and sometimes local physiography. The real advantage is that such maps provide knowledge of physiography of the area which can be a starting point for work with airphotos.

In areas where maps do not exist, the photo user must obtain all information from photos coupled with whatever bits of information he can obtain from other sources. The airphotos, in many instances, do provide a means for checking the maps, and it is up to the interpreter to know or to recognize such a condition and to be able to evaluate maps or literature for their reliability.

Acknowledgment

Part of the material in this paper was assembled while the author was on a leave of absence from Purdue working at Army Map Service in connection with preparation of a field manual. The author wishes to thank the representatives of the Army Map Service for their views and their assistance, and for permission to use this material in this paper. He was unable to attend the Annual Meeting of the Society and wishes to express his thanks to Professor O. W. Mintzer, Case Institute of Technology, for reading a summary of the paper.

QUESTION AND ANSWER PERIOD

Mr. Lundahl

Attention will now be given to questions asked by members of the audience. The first questions will be answered by Dr. Macdonald. He will be followed by other participants in this Symposium.

Dr. Macdonald

A question asked by S. T. B. Losee of Abitibi Power and Paper Co. is "Should focal setting for minimum flare replace that for maximum resolution for photos on which accurate measurements are to be made?"

Consistent with the thoughts expressed in my paper, my answer is in the affirmative. If we are accurately to determine the position of an object which is to be imaged at a 1/10-mm. diameter on the film, our best possible setting will be that which gives us the most favorable energy distribution over that 1/10-mm. diameter image, so that it is most clearly and most sharply rendered. This rendition will enable most precise measurement.

Lieutenant Frank Chambers of N.P.I.C. has asked "How are contrast and resolution affected by color? Would you discuss how or whether interpretability is affected in aerial color photographs?"

Although the gray scale in color photography is less than that in black-and-white, it is still adequate to handle the brightness range encountered in the typical aerial scene. Color film adds the dimension of color contrast; this is of advantage to interpretability and this advantage does not rely on the correctness of the color rendition. More important, however, color film has no grain. Because of this grain effect, color film becomes a particularly good example of why a resolution number is particularly not good in measuring the interpretability of a picture. At 12 lines/mm. on color film, one can obtain more detailed information than from a cor-