different types and conditions in as distantly separated areas as the Arctic and the Antarctic. The author, as chairman of this Working Group is cooperating with scientists from many countries, amongst others Canada, England, Japan, Sweden and U.S.A. It is hoped that also there will be opportunity for close cooperation with representatives from other Arctic and Antarctic interested Nations, e.g. Denmark, France, Norway and Soviet Union.

All the fellow-workers are preparing papers for Commission VII on interpretation of ice. Some of these subjects deal with the Arctic, e.g. Ice Islands, ice and shipping conditions in the North West Passage, in waters north of Alaska and along the Northern Sea Route, etc. Further, papers on Antarctic ice and ice conditions in other regions of the world, as well as glaciers, will be presented on the basis of photo interpretation.

International Sea-Ice Conference

Specially good contacts between the scientists were made at an International Conference on Arctic Sea Ice, the first conference of this kind, held at Easton, Maryland, in February 1958. This was the conference sponsored by the National Academy of Sciences-National Research Council, Washington. Recent experiences as regards Distribution and Character of Sea Ice, Ice Observation, Physics and Mechanics of Sea-Ice Formation, Growth, and Disintegration, Drift and Deformation of Sea Ice and Sea-Ice Prediction Techniques were presented in excellent papers and instructive lectures. About 80 scientists attended, representing nine countries—Canada, Denmark, England, Finland, Germany, Japan, Sweden, Soviet Union and United States. At the Conference, were shown very fine sea-ice verticals in color from the Beaufort Sea, North of Alaska, printed with U. S. Navy's new electronic scanning printers. The result was marvelous, with the finest details clearly visible even in the darkest shadows of the negatives.

All the delegates at this Conference expressed the opinion that all countries interested in shipping in Northern waters should intensify their Arctic Research.

A Technique for the Identification of Farm Crops on Aerial Photographs[1]

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Abstract: *This paper includes a description of a technique developed for the purpose of setting down aerial-photo identification criteria for various farm crops at several stages of growth in Northern Illinois. The general aspects of the photo appearance of these crops are also described.*

Geographers have long been interested in the areal distribution and intensities of production of commercial farm crops. The major problem confronted in studies of farm crops has been the development of techniques which provide both speed and accuracy in field mapping. During the 1930's, it was ascertained that certain features, mostly physical, could be mapped with speed and accuracy from aerial photographs. Aerial photographs, however, have had relatively little use in the mapping of farm crops. Before this study was begun in 1950, no definitive method of identifying farm crops on aerial photographs existed.

The technique used in the study described in this paper rests primarily on descriptions of the ground appearance and the corresponding

[1] This paper was excerpted from the author's doctoral dissertation entitled *The Aerial Photographic Identification of Farm Crops in Northern Illinois*. The dissertation, available for interlibrary loan from Northwestern University, is based on research conducted in compliance with a contract between Northwestern University and Geography Branch, Earth Sciences Division, Office of Naval Research.

aerial photographic appearance, of selected fields at nine intervals of growth from May 28 to October 19, 1950. Seemingly, the identification criteria would find greater application to specific identification problems if these several intervals of growth were analyzed, inasmuch as plants and planted fields go through marked changes in appearance from time to time throughout the growing season. The procedure, moreover, enabled the analyst not only to compare and contrast the photo appearance of different crops at each interval of growth, but also to compare the photo appearance of like crops at different intervals of growth. The procedure also enabled the analyst to find that interval of growth having optimum criteria for identification of all crops in the research area.

Secondary emphasis of the study is placed on testing the effects of variations in growing conditions and in farm practices on the aerial photographic appearance of the selected fields.

Five preliminary steps were necessary for carrying out the objectives of the study.

A definite area had to be chosen for intensive study and arrangements had to be made for acquiring aerial photographs of this area at selected intervals throughout the growing season. Arrangements for photography were made with the Glenview Naval Air Station. The area selected was a mile-wide strip $13\frac{1}{2}$ miles long in northeastern Illinois. The strip is within short flight distance from the Glenview Naval Air Station and appeared to be large enough and varied enough to contain several of the leading crops common to most agricultural regions of the United States. The area is made up of an assortment of glacial land forms and soil types.

Next, data on variations in physical conditions and in farm practices had to be compiled in order to test their effect on the photo appearance of the crops selected for study. This was accomplished in part by field mapping on aerial photographs and in part by interviews with farmers.

Then, sample fields had to be selected for detailed study. In making selections, consideration was given to all the conditions, both natural and cultural, under which crops are grown in the area. One hundred and sixteen samples represented each of the area's major crops in association with all common variations in growing conditions and in farm methods.

Finally, plans had to be formulated for collecting data on the ground appearance of the 116 sample fields each time that they were photographed from the air. These data provided the necessary facts for distinguishing the photo appearance of crops at the nine selected intervals of growth. A check list used for collection of these data contained three categories: (1) facts related to the external appearance of individual crops which differentiated them in ground appearance from other crops; (2) facts pertaining to the natural conditions and land use practices which affected the ground appearance of individual crops; and (3) facts related to the method of cultivation and harvest of sample fields. Space was also provided on this check list for entering notes on photographs taken in the field. Black and white and color photographs were taken of the sample fields at each of the nine intervals of growth. These photographs proved to be of utmost importance in the analysis which followed.

Actual analysis of the appearance of the 116 sample fields on the aerial photographs, and comparisons of the aerial photo images with the field data, revealed that farm crops can be differentiated on aerial photographs by the unique tonal and textural qualities of their photographic images, and by objects which are commonly found in association with them. Analysis showed, however, that most variations in farm practices and in physical conditions have no effect on the photo appearance of like crops.

The Use of Tonal Qualities in the Identification

Tones of gray vary among different crops on individual aerial photographs, and among different photographs of individual crops. Tones may be nearly black, as are those representing fields of dense stands of alfalfa, or they may be nearly white, as are those representing fields of ripe wheat. Early examination of photographs revealed that tonal values registered by each crop on aerial photographs are unique at certain intervals of growth, and can be relied upon for establishing the identify of farm crops.

The use of tonal values to describe the photo appearance of crops, however, presents a number of problems. The most difficult problem grows out of variations in conditions of photography. Tones vary among sets of photographs, not only as a result of conditions inherent in the growth of crops, but also as a result of ground moisture conditions and sky conditions, and as a result of differences in camera equipment, film processing, and film printing. Such differences were screened out in this study by use of a densitometer (Figure 1), and a tone scale was prepared in densitometer values.

The densitometer incorporates a photo-electric cell to measure the relative tonal values caused by light reflected by each of the crops investigated. A beam of light projected through the transparent negative is registered on the photo-electric cell. The amount of light reaching the photo-electric cell varies according to the tonal density of the spot through which the beam passes. Variations of current from the photo-electric cell produce different intensities of light in a second lamp which is focused on a galvanometer. This is equipped with a disc-like reflector suspended on a gold thread. The disc is sensitive to the intensity of the light focused upon it and as a result rotates slightly. The reflection from the disc is projected upon a transparent metric scale. This reflection moves along the scale when the disc rotates in one direction or the other. In this way, the tonal density of individual spots on the aerial photographs can be measured in linear values in millimeters.

To use the densitometer equitably on sets of photographs taken at different times and under different conditions, an object has to be selected which always maintains a constant tonal value regardless of changes in natural conditions or time of the growing season. From the study of photographs it appeared that flat roof tops, and the intersections of concrete paved roads, did not change perceptibly in the tonal qualities of their photographic appearance throughout the growing season. On this assumption, any variations that exist in the tonal values of these features are a result of variations in photography, rather than in inherent conditions. This deduction is of utmost importance because in comparing tonal values among sets of photographs by means of the densitometer, one must first establish tonal values of controlled points whose tonal values are not inherently different but vary because of conditions of photography.

It is possible to equate the tonal value of a controlled point on one photo with that on another photo by means of a rheostat which can regulate the intensity of the beam of

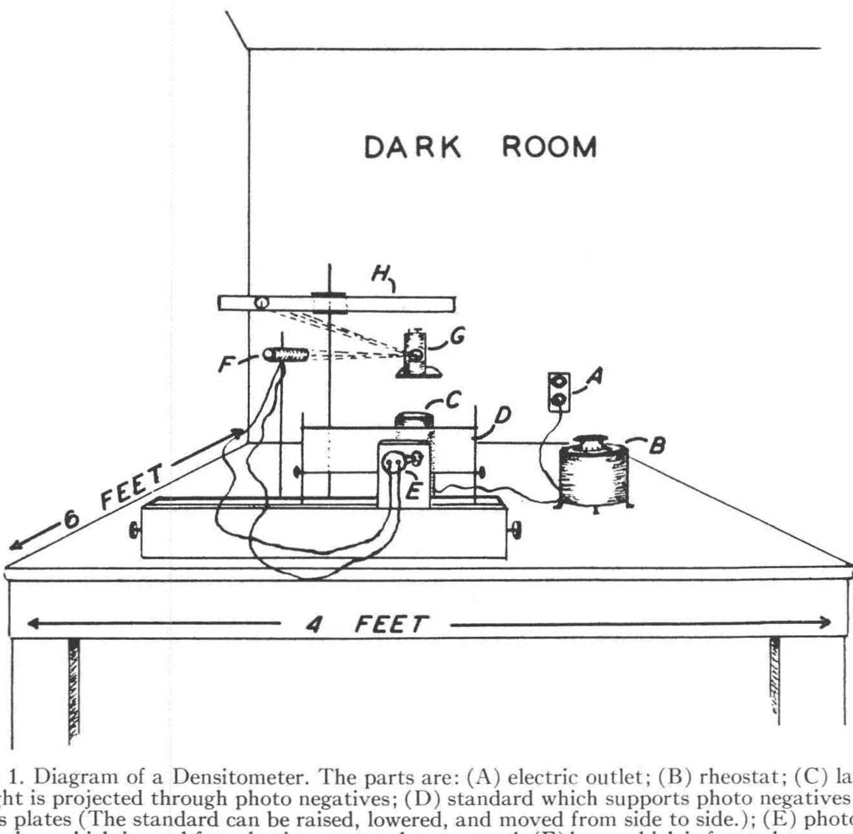

FIG. 1. Diagram of a Densitometer. The parts are: (A) electric outlet; (B) rheostat; (C) lamp from which light is projected through photo negatives; (D) standard which supports photo negatives between thin glass plates (The standard can be raised, lowered, and moved from side to side.); (E) photo-electric cell with glass which is used for selecting spots to be measured; (F) lamp which is focused on a galvanometer; (G) galvanometer; and (H) transparent metric scale.

light passing through the photo negative. Differences in two negatives caused by variations in photography can in this way be eliminated from the measurements. For example, in this study the densitometer value for a concrete road intersection was established on a given photograph. If a second photo provided a different reading for the road intersection, the light was reduced or increased so that the same densitometer reading was obtained as on the first photograph. Differences of tonal values among crops were then read directly once the photographs had been equated. Any differences were the result of inherent differences of the crops and not in the photography.

To facilitate actual operations upon photographs, a tonal scale was prepared in densitometer values. The densitometer readings on this standard density scale were based on a point of origin established on a set of photographs which appeared to possess average tonal qualities. Positive prints of this scale provide, within limits, visual scales of tonal values.

The Use of Textural Qualities in the Identification

The texture of the photographic image of individual crops varies with the external characteristics of the crops and the manner in which they have been planted, cultivated, and harvested. Texture varies also according to the manner in which the field was plowed for planting. To a lesser extent, texture reflects variations in soil moisture.

Textural characteristics resulting from the working of fields can be seen best on aerial photographs with the aid of a stereoscope. Fields appear to be "lined" if the farmer plows and plants in parallel rows (Figure 2).

Fields have a "plaid-like" texture if rows are planted at right angles to the direction of plowing (Figure 3).

Fields of corn and soybeans have a "corduroy" texture after these crops become tall enough to stand in relief (Figure 4).

Corn and soybean fields which have been inter-tilled shortly before aerial photography have a "striped" texture (Figure 5).

Some fields take on a concentric "swath" texture with harvest (Figure 6).

Other fields have parallel "swath" texture when harvested (Figure 7). Such textural properties are meaningful if analyzed in the light of farm practices.

A "mottled" texture results from variations in the soil moisture content. During those intervals of the growing season when bare soil

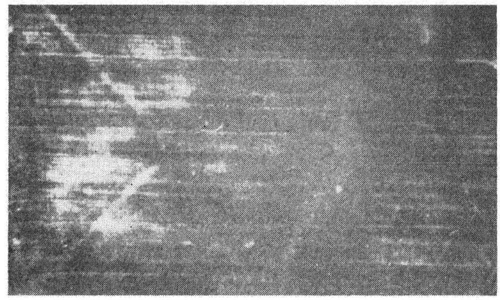

FIG. 2. Small grain field with "lined" texture. (Scale of this and other pictures is approximately 1:5500.)

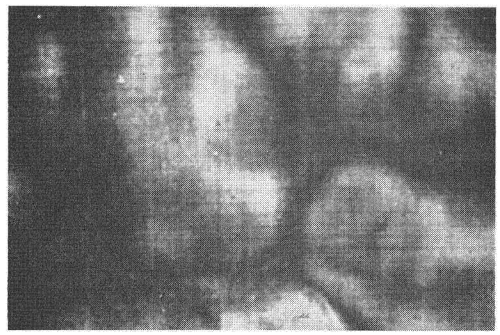

FIG. 3. Small grain field with "plaid-like" texture.

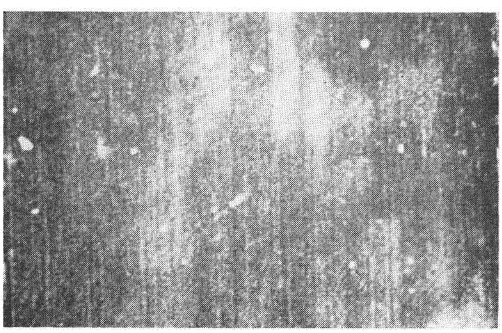

FIG. 4. Corn field with "corduroy" texture.

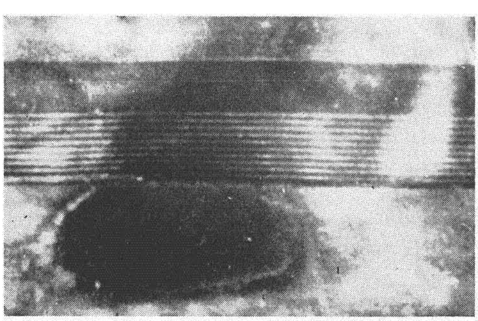

FIG. 5. Corn field with "striped" texture.

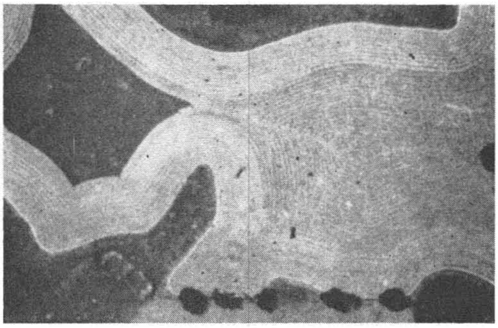

FIG. 6. Hay field with concentric "swath" texture.

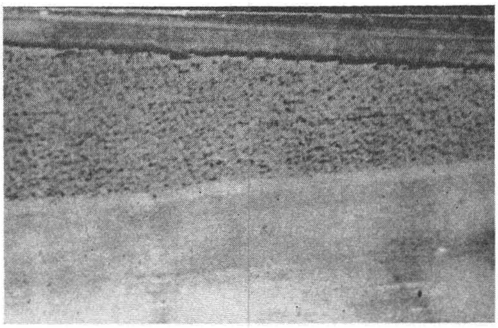

FIG. 7. Corn field with parallel "swath" texture. Shadows appear along the northern edges of unharvested portions of fields.

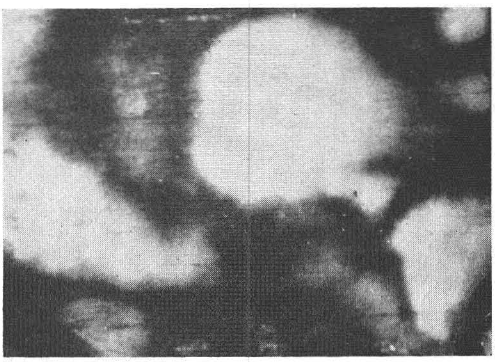

FIG. 8. Corn field on May 28. Mottling is distinct.

dominates the field, soil mottling is plainly visible on aerial photographs (Figure 8). As crops begin to cover the soil, mottling disappears (Figure 9). Mottling is full of meaning to the photo interpreter who knows the status of ground cover of crops at various intervals of the growing season.

THE USE OF ASSOCIATION OF OBJECTS IN THE IDENTIFICATION

Objects which are commonly associated with certain crops are further clues to their

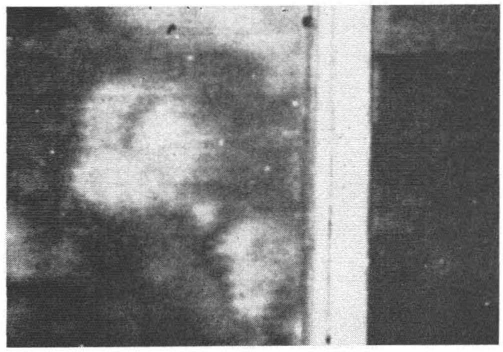

FIG. 9. Corn field on the left was photographed on July 21. Darker portion on the right was photographed on October 5. Mottling becomes less distinct with growth of the crop.

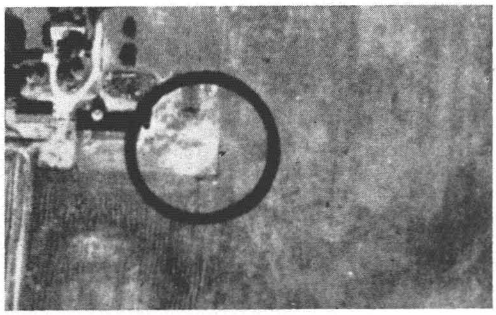

FIG. 10. Straw stack in the corner of an oats field.

identity on aerial photographs. By use of a stereoscope, one may identify straw stacks in fields of small grain (Figure 10). Hay stacks help to identify hay fields (Figure 11).

The presence of cattle and of lanes leading to barns help to establish the identity of rotation and permanent pastures (Figure 12). It may even be possible to identify implements in fields at certain times of the growing season (Figure 13).

LIMITATIONS TO THE IDENTIFICATION

There are limitations to the aerial photographic identification of farm crops. During early intervals of growth, the spring planted crops have identical photo appearance. All are lined and mottled and none has distinctive tonal quality. After late July or early August, the three small grains have been harvested; and their appearance is so similar that they again cannot be differentiated.

For the area studied, optimum conditions for identifying crops on aerial photographs occur between July 15 and July 30. During this period, the spring planted crops cover the ground so that they are reflected in a distinctive manner on aerial photographs; and har-

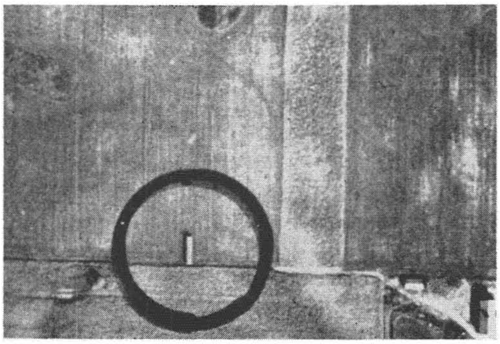

FIG. 11. Hay Stack near the corner of a hay field.

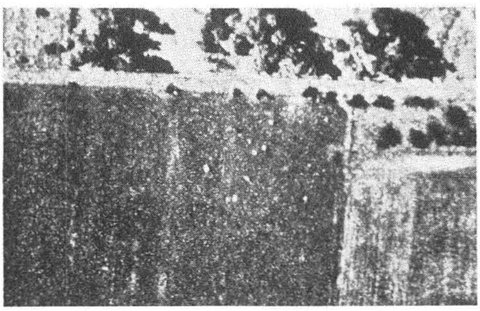

FIG. 12. White flecks in the center of this photograph are cows in a rotation pasture. The light band across the upper half of the photograph is a lane leading to the barns of the farmstead.

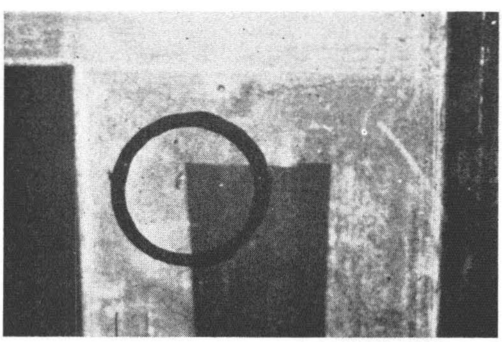

FIG. 13. Hay field being cut by tractor and mowing machine (circle).

vest of small grains which leads to confusion in their identification has not been started. Fields of oats have a darker tone than fields of barley; and winter wheat is marked by the lightest of all tones that are found on all sets of photographs (Figure 14). By mid-July, moreover, fields of corn have acquired a rougher texture than fields of soybeans and corn is tall enough to cast a shadow which can be seen along the northern edges of the fields (Figure 7).

THE EFFECT OF VARIATIONS IN FARM PRACTICES

Fields of a given crop, which undergo variations in farm practices, vary only slightly in photo appearance. One major exception is the distinctive difference between fields of a given crop when that crop is harvested for different purposes. Those crops of hay and corn which are grown for silage take on harvest markings at earlier dates respectively than do hay crops grown for winter forage and corn crops grown for the crib or for market. In fields of silage corn, there is also absent that texture which is characteristic of mature corn stand in the shock (Figure 15).

Aerial photographs do not give clues to variations in: (1) use of the field during the previous year; (2) season of plowing and discing; (3) seed varieties; (4) date of planting; or (5) composition and amount of fertilizer used with the crop.

THE EFFECT OF VARIATIONS IN PHYSICAL CONDITIONS

Although variations in landforms and soil types and variations in weather can be de-

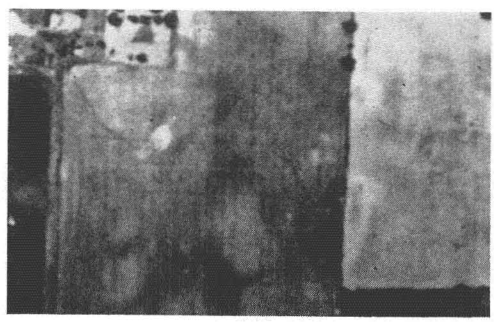

FIG. 14. Barley, oats, and winter wheat on July 21. Oats (center) has the darkest tone whereas wheat (right) has the lightest tone.

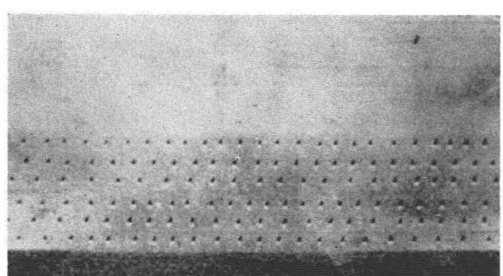

FIG. 15. Rows of corn shocks may be traced across the central portion of this field.

tected on aerial photographs, the size and complexity of these variations are such that their effect on the aerial photo appearance of crops in the research area cannot be measured. Nearly all boundaries marking major changes in landforms are coincident with boundaries between cropped and uncropped lands. The only conceivable effect which soil variations have on the photo appearance of crops is the "mottled" texture which results from tonal variations. Weather conditions are so broad in areal spread that they extend beyond the limits of the area studied. A heavy rain which flattened small grains in July, for example, damaged all small grain crops in the study area. Whereas this damage helped to differentiate small grains, it presented no variations in the photo appearance of the three small grains.

Summary

In summary, farm crops can be differentiated on aerial photographs by the unique tonal and textural qualities of their photographic images, and by objects which are commonly associated with them. Variations in farm practices and in physical conditions have little effect on the photo appearance of farm crops. Optimum criteria for differentiating from crops in Northern Illinois are found on aerial photographs taken during the second half of July.

Evaluation of Several Camera Systems for Sampling Forest Insect Damage at Low Altitude

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ABSTRACT: *Large-scale color photos can be used to appraise damage caused by several forest insects. Inherent with large-scale is blurring; this negates the advantages of having a large image. Several camera systems were given limited tests to find a simple and inexpensive way to overcome image-motion. The authors feel that this can be done best by using cameras equipped with extremely fast shutters.*

Introduction

CONVENTIONAL aerial cameras are not equipped for image-motion compensation. Nevertheless, they are satisfactory for taking color photographs to be used in detecting and locating bark beetle outbreaks in mature timber (1), (7). They are also satisfactory for photographing single dead trees or groups of trees at a medium scale (1:7920) since they present off-color images that an interpreter can easily distinguish from healthy green trees. Conventional aerial cameras cannot, however, be used satisfactorily for photographing light insect defoliations, or the terminal growth of young trees killed back by weevils. Here the material to be photographed offers targets which are small and difficult to record on film; hence, large-scale photography must be used. When conventional cameras are used, the result is considerable image blurring.

A blurred image is elongated on a photo. Thereby much fine detail is obscured. Blurring occurs during each aerial exposure and is caused by image-motion due to movements of the camera or airplane in relation to the ground surface. The naked eye detects it when an image point on a photo is larger than 1/100 inch (5). When image motion from all causes is kept to less than 1/250 inch, a photograph will have acceptable sharp definition. Figure 1 illustrates the effect that blurring has on image clarity. Other factors such as poor film resolution, faulty development, and inadequate lens systems contribute to poor-quality photography, but are not related directly to blurring.

Because of the need for large-scale, sharp