FIG. 1. Black and white photograph of a portion of the test area near Bennettsville, South Carolina. The original scale was 1:20,000—this reproduction is about 1:32,000. See also Figure 5.

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Color Photo Comparison

A photo interpretation test with Panchromatic, Color, and Ektachrome IR establishes the superiority of the latter two for mapping drainage, vegetation, soils and culture.

(*Abstract on page 289*)

INTRODUCTION

A DIRECT RESULT of the action by the members of the Color Photography Committee of the American Society of Photogrammetry was a series of test flights over the Bennettsville, South Carolina, Test Area. The test was designed to obtain quantitative and qualitative information regarding the role of color, infrared and special purpose films in photogrammetric applications. The purpose of this paper is to report on a comparative photointerpretation study of a controlled test area, photographed in black and white panchromatic, color, and Kodak Ektachrome Infrared Aero Film Process E-3, also known as false-color film. Each emulsion was exposed

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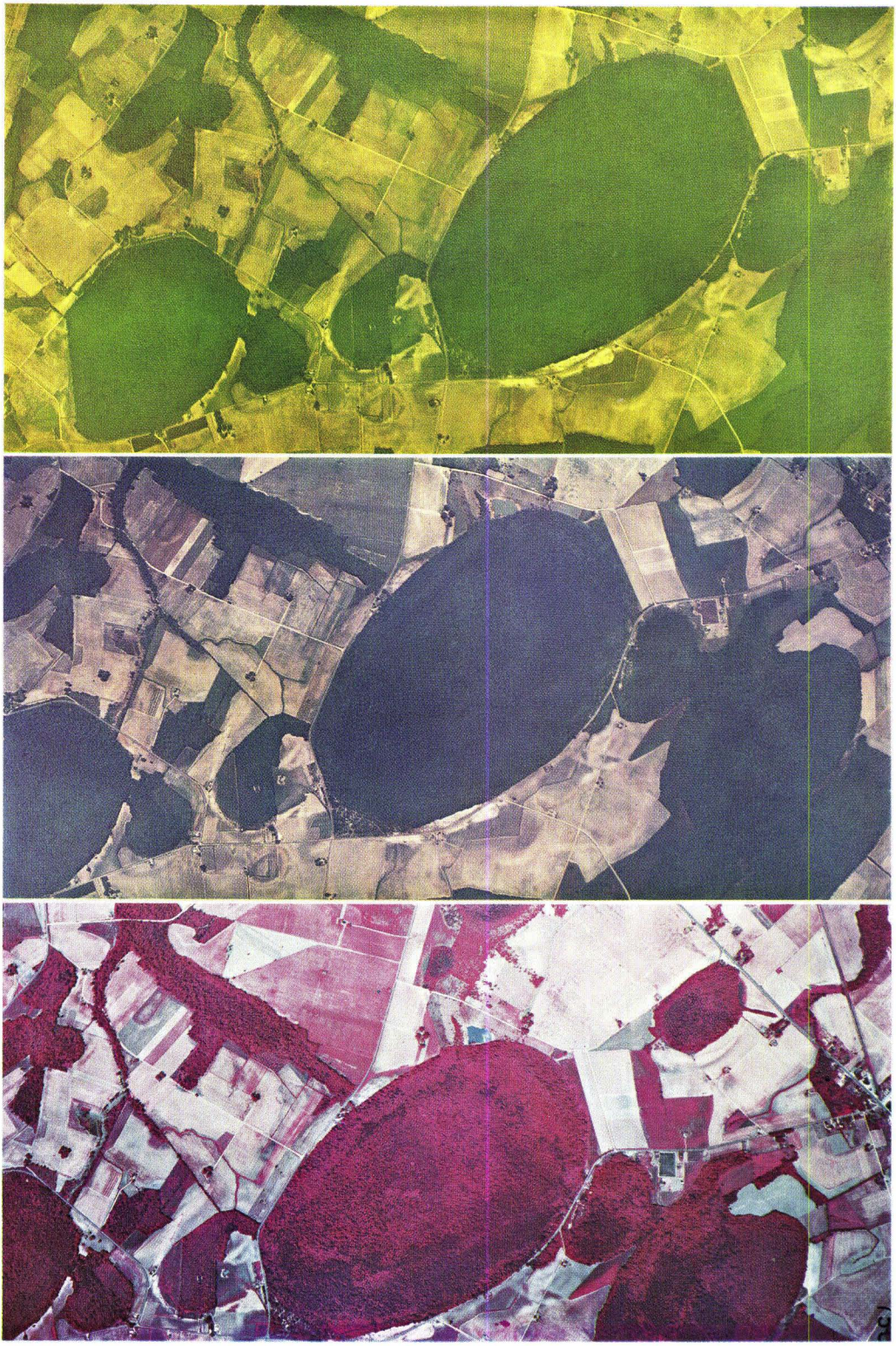
FIG. 2. Aero Ektachrome color photograph of approximately the same area as shown in Figure 1.

FIG. 3. Anscochrome aerial color photograph of approximately the same area shown in Figures 1 and 2.

FIG. 4. Aero Ektachrome IR photograph (sometimes referred to as CD—camouflage detection) of approximately the same area as shown in Figures 1, 2, and 3.



under essentially identical conditions, regarding camera, vehicle, and personnel over the same target area.

Arrangements for the flight by the U. S. Air Force were made by the Defense Intelligence Agency. The test was conducted under the guidance of the Coast and Geodetic Survey, over an area specified by the Color Photography Committee of the American Society of Photogrammetry. Field engineers provided by the Army Map Service were available to obtain ground identification information.

The aerial photography obtained over a three week period was flown at 2,500, 10,000, 20,000 and 30,000 feet above terrain.

After processing by the Coast and Geodetic Survey, it was apparent that not all of the photography produced was acceptable for the following reasons:

★ The flights were made over a period of several weeks. The length of time involved included unavoidable changes in weather which had some effect upon the resulting photography.

★ An exposure development test could not be made prior to the completion of the photography.

★ Atmospheric haze affected color fidelity as well as the black and white photography at the test site.

★ The camera window tint of the vehicle used, in association with the color correction characteristics of the cameras, provided a color bias in the resulting aerial photography.

GIMRADA personnel suggested that the flights at 10,000 feet had sufficient information in all three emulsions to justify detailed analysis. Working Group I was formed at the Color Photography meeting in October, 1964, in order to utilize any valid information regarding the comparative characteristics of each emulsion from the available photography. Upon re-examination of the photography, the several organizations of Working Group I, which met at Army Map Service, relinquished all tasks except photoidentification and photointerpretation, undertaken by GIMRADA, with the assistance of the Army Map Service. During this period, the Itek Corporation, Data Analysis Center, Alexandria, Virginia, offered the services of its personnel for photointerpretation under a Loan Agreement with GIMRADA. This report will be concerned principally with the results of their study and an evaluation by the author and other GIMRADA personnel.

ABSTRACT: *As the result of action by the Color Photography Committee of the American Society of Photogrammetry, panchromatic, color and Ektachrome IR photography of the same area were compared under essentially identical conditions. The study includes the identification and interpretation of drainage, vegetation, soils, and map features such as roads, railroads, and buildings. As a control the same features were identified on the ground. In addition, the photointerpretors were required to identify 42 selected photopoints that appeared photographs. On the basis of the limited study, Ektachrome IR photography proved to be superior to color and to panchromatic photography for mapping, vegetation, and drainage. Color photography was found to be superior to panchromatic and Ektachrome IR for mapping soils and culture.*

Cooperating agencies in this effort include the U. S. Air Force; the Coast & Geodetic Survey; the Eastman Kodak Company; the Ansco Corporation; the Fairchild Camera and Instrument Corporation; the U. S. Army Map Service; the Itek Corporation; and the U. S. Army Engineer Geodesy, Intelligence and Mapping Research and Development Agency.

INVESTIGATION

An RC-130 Aircraft, furnished by the U. S. Air Force, was used as the camera vehicle.

Fairchild Camera and Instrument Corporation supplied a six-inch focal length KC-4 Camera, 9×9 inch format, equipped with a Geocon, color corrected lens, from which the panchromatic photography used in this analysis was obtained. The Coast and Geodetic Survey supplied a Wild RC-8 Camera 9×9 inch format, equipped with a six inch focal length, Aviogon lens, color corrected, with an anti-vignetting filter for obtaining color and Ektachrome Infrared aerial photography.

The Ansco Corporation supplied Plestar

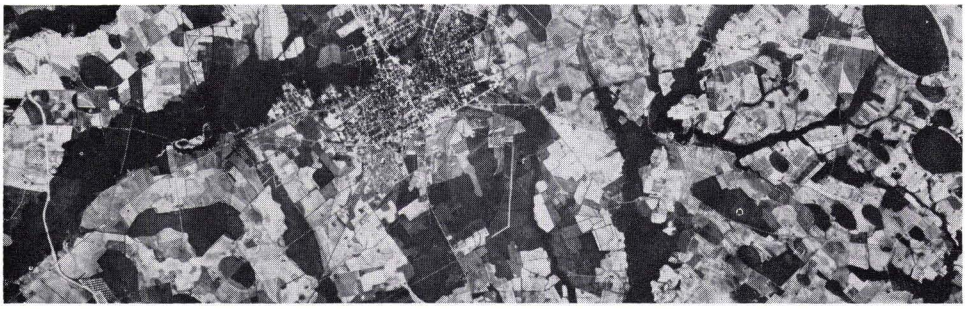


FIG. 5. Mosaic of black and white photographs of the test area showing Bennettsville, South Carolina at a scale of approximately 1:64,000.

base, Anscochrome Aerial film, a color reversal film in 9½ inch widths. The Eastman Kodak Company supplied Ektachrome MS Aerial Film, a color reversal film, on an Estar base; Ektachrome Infrared Aerial film on an acetate base; and Kodak Plus X Aerial film, panchromatic, on an Estar base. Figure 1 represents black and white panchromatic photography from a flight height of 10,000 feet. Figure 2 represents Aero Ektachrome, Figure 3 represents Anscochrome, and Figure 4 represents Aero Ektachrome IR photography.

The selection of the Bennettsville Test Area was dictated by the following considerations:

★ The U. S. Air Force indicated that the scheduling required the use of an East Coast Test Site if the flights were to be made in FY 1964.

★ The Army Map Service engineers would be available in the area to obtain the ground truth necessary for control of photointerpretation procedures.

In addition to an overall interpretation of the Test Site, which is approximately 30 square miles (Figure 5), interpretation was required for 42 photo points selected to obtain more precise ground information (Figure 6). The AMS field engineers were requested to obtain the following detailed information in each of the 42 selected ground control points:

1. Vegetation.
   a. Tree height
   b. Trunk size
   c. Tree spacing
   d. General species
   e. Ground cover
2. Type of soil (gravel, sand, rock, clay, silt, and mixtures).
3. Moisture Content.
   a. Dry
   b. Wet
   c. Marsh
   d. Flooded
4. Surface Drainage.

In cultivated areas, crop identification was requested; in populated areas, the type of structure was also requested.

A detailed operational plan was prepared by the author for the photointerpretation work to be performed by the Itek Corporation. In order to eliminate the bias which could occur from a direct comparison of the three emulsions, the interpreters were given one set of photographs at a time in stereo coverage with a small scale general map of the

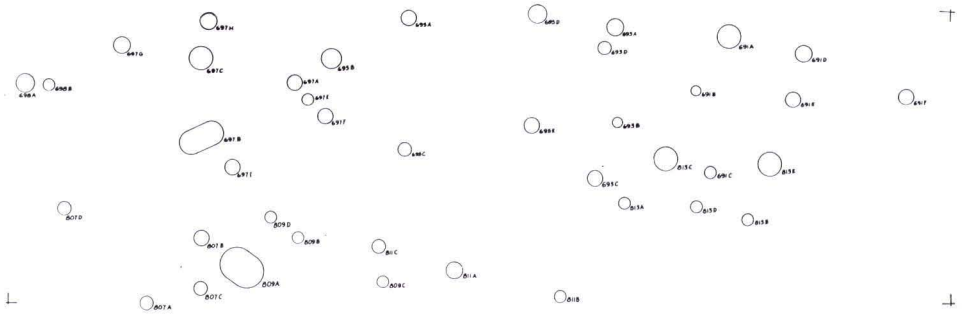


FIG. 6. Descriptive points and ground stations in test area shown in Figure 5.

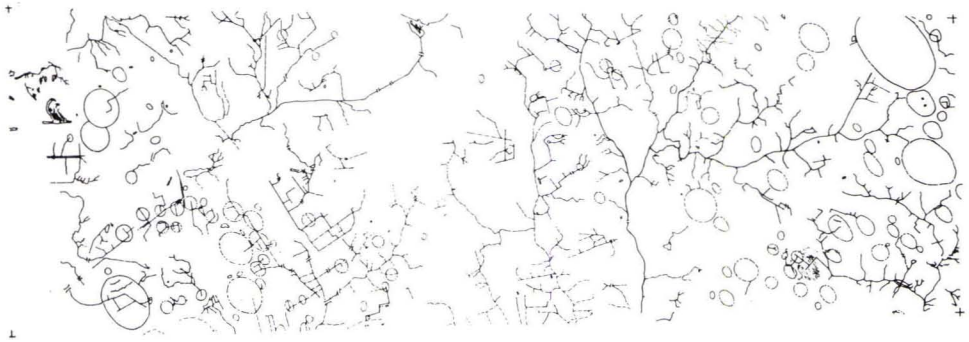


FIG. 7. Drainage map compiled from black and white photography of test area shown in Figures 5 and 6. Compare with Figures 8 and 9.

area and a text, "Geology of the Coastal Plain of South Carolina," a report by the U. S. Geological Survey, published in 1933. The instructions to the interpreters for each set of photographs were as follows:

- Prepare a drainage map at photo scale, 1:20,000, including, primary, secondary, and tertiary drainage,
- Prepare a vegetation map at photo scale, differentiating the species within observable capabilities,
- Prepare a soils map at photoscale for identification of similar soils areas, with a key for each area, and,
- Prepare a culture map at photo scale, identifying roads, railroads and special purpose buildings.

The interpreters were not given the ground truth, they could not compare one set of photos with the other two, nor could they use the small scale map as a reference. In addition to the required maps, they were requested to make an analysis of the 42 selected photo points, and required to supply the identical information that was being procured in the field.

Over a period of six months, the same two interpreters made all of the required interpretations. Upon completion, the Itek Corp. furnished a report which included a detailed analysis of each of the 42 selected photo points with a separate list of items for the panchromatic photography, an addendum for the color photography and an addendum for the Ektachrome Infrared photography. Thirteen 1:20,000 scale planimetric maps were furnished for the comparison. They included a drainage map, a soils map, a vegetation map; and a culture map for each emulsion; a separate map was prepared locating each of the 42 photo points; as well as 1:20,000 scale photomosaic. During this period the AMS field engineers were obtaining the ground truth.

Zeiss mirror stereoscopes with six power magnification were used for the Photo interpretation; Stereometers were used for making elevation measurements. The two interpreters used in this task were skilled in mapmaking and field geologic investigation procedures.

STUDY RESULTS

Rather than a direct comparison of the information content or interpretability of the three types of photography; the photointerpretation procedures resulted in the preparation of three independent studies and no distinction was made between the Anscochrome and Ektachrome films. The following is an account of the interpreters findings.

DRAINAGE

A visual comparison of the overlays shows an increasing amount of drainage density mapped from panchromatic (Figure 7), color (Figure 8) and Ektachrome IR photography (Figure 9), mapped in that order. In the interpreter's opinion, the Ektachrome IR photography affords a rapid and accurate means of mapping drainage. Streams and bodies of water appear dark brown to black; muddy water around various excavations appears bluish in tone because of the reflectivity of the sediment. Tertiary and intermittent drainage lines are readily observed because of their darker tones, which contrast with the surrounding areas. The higher moisture content of intermittent streambeds even though dry show a dark image. The confidence level for drainage interpretation is highest on the Ektachrome IR photography. Compare ponds in Figures 1, 2, 3 and 4.

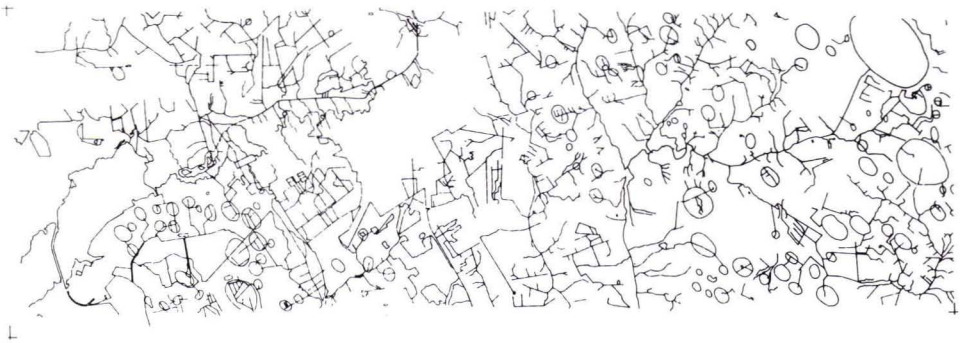


FIG. 8. Drainage map compiled from color photography. Compare with Figures 7 and 9.

VEGETATION

The two vegetation maps compiled from panchromatic (Figure 10) and color photography (Figure 11) indicate almost the same information density; the Ektachrome IR photography (Figure 12) however, shows almost twice the detail that can be interpreted from the other two emulsions. The ability of the photointerpreters to determine the density of vegetative growth appeared to be equal for all types of photography, but their ability to extract vegetative detail was far greater on Ektachrome IR photography, since the deciduous trees, crops and grasslands show a predominantly red tone, whereas the coniferous trees which absorbed more infrared appeared in tones of purple. Single trees or small groups of one species standing in an area surrounded by another species, were easily recognized. An outstanding feature of the IR film was the ease with which cultivated and fallow cropland could be mapped; while two classes of cropland could be determined from the panchromatic and color photography, four classes could be mapped from the Ektachrome IR photography. These results are applicable only to this region and for this season of the year.

SOILS

(Reference Figures 13, 14, and 15). A comprehensive soils study was not attempted, since a field trip would have been necessary. However, the soils were mapped under the premise that similar soils appear in similar tones and patterns. Approximately the same density of soil information was mapped from each type of photography.

GEOLOGY

No geologic structures (folds or faults) or rock outcrops were observed in any of the three types of photography studied. The major landform of the area is characterized by low relief, slightly hummocky, and the surface topography is probably deeply underlain by unconsolidated sand and gravel (typical Atlantic Coastal Plain) as evidenced by numerous excavations and pits throughout the area. Many Carolina Bay type of depressions with accompanying sand ridges were observed throughout the project area.

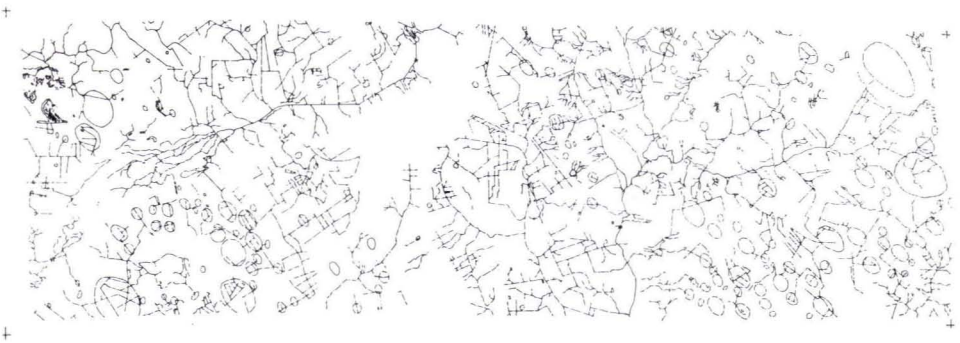


FIG. 9. Drainage map compiled from Ektachrome IR photography. Compare with Figures 7 and 8.

FIG. 10. Vegetation map compiled from black and white photography of test area shown in Figure 5. Compare with Figures 11 and 12. *Legend*: (1) Heavily wooded. (2) Woodland thinned by logging. (3) Cultivated field. (4) Thinned woodland. (5) Cleared field; brush. (6) Fallow field. (7) Grass. (8) Orchard. (9) Marsh. (10) Residential or industrial. (11) Strip mine.

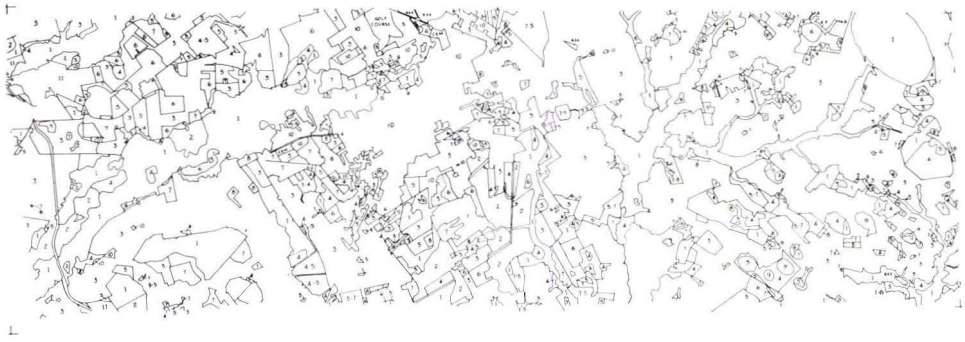


FIG. 11. Vegetation map compiled from color photography. Compare with Figures 10 and 12.

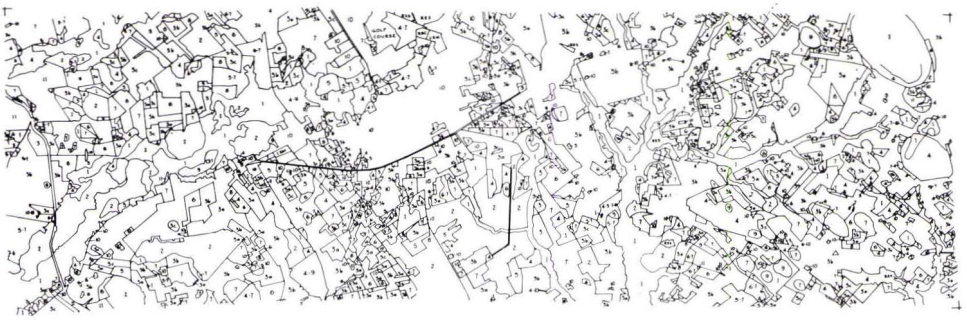


FIG. 12. Vegetation map compiled from Ektachrome IR photography. Compare with Figures 10 and 11.

CULTURE

(Reference Figures 16, 17, and 18). Three detailed culture maps were completed, in which roads, railroads and cultural features were shown. In a visual comparison of all three maps the same information is apparent in maps compiled from color and Ektachrome IR, whereas slightly less information was interpreted from panchromatic photography. While the amount of information was not appreciably greater, the photointerpreters found working with color or Ektachrome IR to be more satisfactory regarding speed and confidence.

SPECIFIC AREAS

Two specific areas in the city of Bennettsville were analyzed in detail on the three types of photography. For cultural determination, the color photography appeared to be most advantageous.

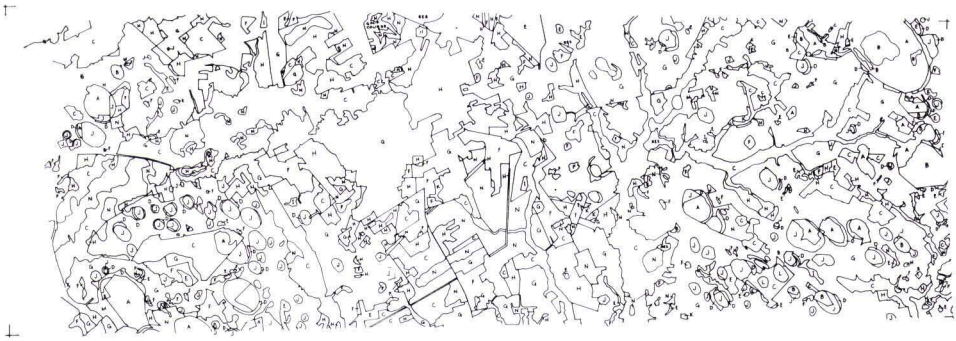


FIG. 13. Soils map compiled from black and white photography of test area shown in Figure 5. Compare with Figures 14 and 15. *Legend* (in addition to that indicated in Figure 10): (3a) Early planting. (3b) Late planting. (3c) Possibly fallow.

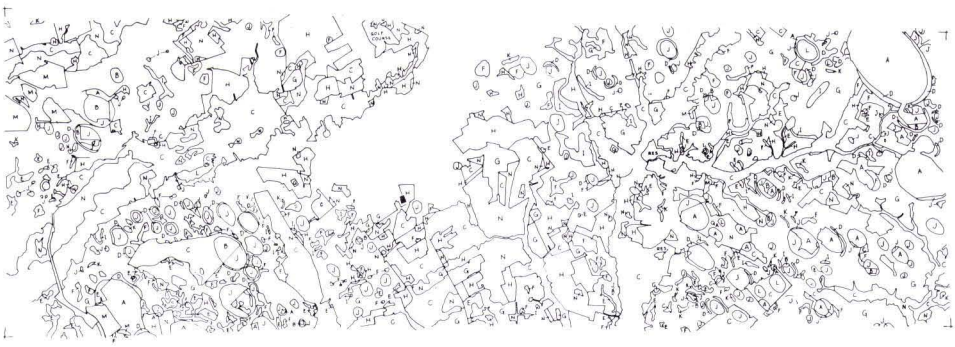


FIG. 14. Soils map compiled from color photography. Compare with Figures 13 and 15.

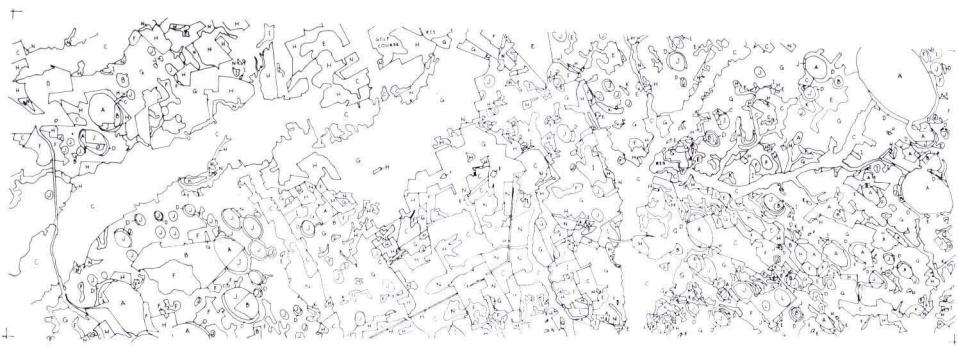


FIG. 15. Soils map compiled from Ektachrome IR photography. Compare with Figures 13 and 14.

PHOTO POINT IDENTIFICATION

Each of the 42 pre-selected photo-points were studied by the interpreters and an attempt was made to list the specific items requested of the field engineers. Figure 6 shows the distribution of the 42 photo points. Table I lists the items of information requested along with the number and correctness of response by the interpreters.

DISCUSSION

The detailed specifications which had been prepared by the Color Photography Committee of the American Society of Photogrammetry *could not be implemented as planned*. Since so many operations were scattered about through several agencies, coordination became the principal problem. As mentioned in the beginning of this paper, the

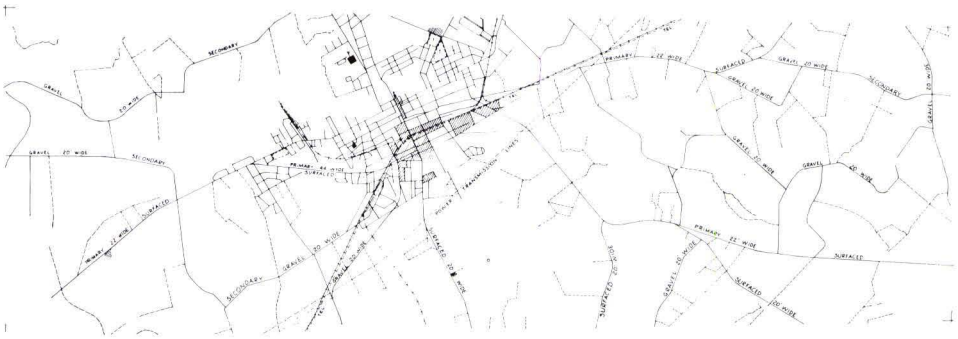


FIG. 16. Culture map compiled from black and white photography of test area shown in Figure 5. Compare with Figures 17 and 18.

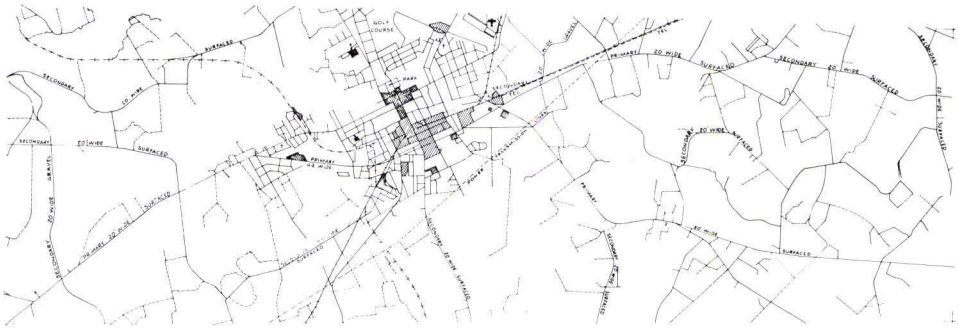


FIG. 17. Culture map compiled from color photography. Compare with Figures 16 and 18.

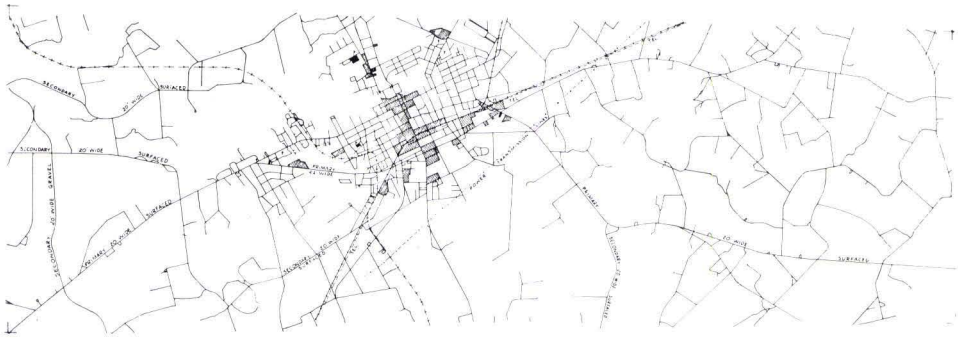


FIG. 18. Culture map compiled from Ektachrome IR photography. Compare with Figures 16 and 17.

U. S. Air Force furnished the vehicle and crew for exposing the aerial photography, however, it was not possible to fly over the pre-selected test area within the time scheduled. The Coast and Geodetic Survey furnished technical advice and photographic assistance as well as processing facilities, yet circumstances did not permit exposure development tests, which are considered essential for this type of mission. No standard color panels were emplaced in the field. The Army Map Service field engineers were on the ground, with their full support in obtaining ground truth, yet several months elapsed between exposing the photography on 8–22 June 1964 and obtaining ground information from October to December, 1964.

Color fidelity was one key to the entire project, and the *color bias*, which appeared as an overall green tone in one color emulsion and as an overall blue tone in another type of emulsion, led some agencies to withdraw from the evaluation procedures. This author is of the opinion that the color fidelity is not as

TABLE I

TOTAL NUMBER OF ITEMS—237

	Panchromatic	*Color*	*Ektachrome IR*	*Field*
Correct Response	136	163	165	237
Incorrect Response	69	47	45	
Not Answered	32	27	27	
Ratio Correct/Total Number	136/237	163/237	165/237	
Ratio Incorrect/Correct	69/136	47/163	45/165	
Ratio Not Answered/Correct	32/136	27/163	27/163	
Ratio Not Answered/Total	32/237	27/237	27/237	

much a consideration in photointerpretation as color differentiation. This is substantiated by the results obtained using Ektachrome IR Photography, which is a color distortion medium. To be more specific, if a building, a field tone, or a geological formation differs in hue from its surround, then it has its own characteristics and facilitates its identification. It was on this basis that GIMRADA undertook the photoidentification and photointerpretation task, which was the only evaluation procedure performed by Working Group I. It must be stressed, however, that the exact nature of the color distortion, if any, should be known.

In checking the work of the photointerpreters, furnished by the Itek Corporation Data Analysis Center, a detailed comparison was made of the planimetric maps which were compiled. The comparison indicated that the *color IR Photography reveal much more drainage information* than can be obtained from panchromatic black and white photography. Differences between the information supplied by either color or IR film are not as great. The confidence level for drainage determination is highest in the IR transparencies, with color and panchromatic following in that order.

With regard to the vegetation analysis, an overlay comparison of all three planimetric maps displays the *superiority of IR film over color or panchromatic film for the classification of vegetation.* The spectral response of the coniferous trees *vs* deciduous trees as well as young crops *vs* bare ground show a greater contrast in Ektachrome IR Film than in the other mediums. Comparison of the three soils maps is not conclusive since the photointerpreters need field information to make a valid specific analysis. The data derived are relative.

In the mapping of cultural features, the photointerpreters *have more confidence in the selection of detail* from the IR and color photography than from the panchromatic black and white photography, although the amount of detail is not significantly greater.

The numerical analysis of the specific items requested in the 42 selected photo prints was obtained by totalling all of the individual items requested from the field engineers and cross checking this information with the same requests made of the photointerpreters. The correct responses for color were approximately *20 per cent greater* than panchromatic black and white, and 22 per cent greater for IR film. Conversely there were *fewer errors* for color photography than for items extracted from black and white photography. The error ratio was also less for IR photography. Items not determined which included tree trunk size, tree spacing and depth of ditches were approximately equal for all three emulsions.

CONCLUSIONS

On the basis of the limited study described above, the photointerpreters drew the following conclusions.

Ektachrome IR photography is superior to color and panchromatic photography for the mapping of *drainage and vegetation.*

Color photography is superior to panchromatic and Ektachrome IR for the purpose of mapping *culture and soils.*

Panchromatic photography is *inferior* to Ektachrome IR and color photography in each of the several categories studied. The interpreters believe that they were unable to draw any concrete conclusions from the study because the quality of the photographs supplied was not the best, the ground truth was not available to them and they were requested that all three sets of photographs not be visually compared. This experiment has consisted of a comparison study of a small typical area carried out with photography obtained

under less than ideal conditions, less than adequately controlled, and compounded by inferior quality materials. The interpreters suggest that the information gleaned from this study be used as a reference for planning future studies, and not as conclusive evidence that any one of the three types of photography is superior in performance in any one of the categories studied. The interpreters were not fully aware, because of the test procedures, of the success which accompanied their interpretations.

Recommendations

The investigators recommend that consideration be given to controlled sensitometry for exposure prior to acquisition of the photographs and to testing and controlling the resolution and color response of each type of photography by photographing resolution targets and color panels laid out on the ground in the target areas.

In order to evaluate fully the merits of the three types of photography for military, industrial, agricultural, and geologic interpretations, it would be beneficial to obtain coverage of several different areas, as no one area will contain sufficient variety of data to permit a complete and detailed study of all possible problems. Ground truth and geodetic control should be compiled and individual targets should be selected to cover the widest range of subjects possible.

The most effective method of study would be to employ a group of two or more interpreters of approximately equal experience and capability who will be allowed to compare visually the three sets of photography with access to all ground truth and geodetic control. The interpreters should compile a chart listing terrain and cultural features that can best be interpreted on each type of photography, while recording their individual comments for each feature as the project progresses.

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Mr. Barry Shelkin, Itek Corporation.

Working Group I Members

Mr. James P. Webb, Chairman, AMS

Mr. Paul H. Alban, AMS

Mr. S. W. Dossi, AMS

Mr. J. W. Elliott, USFS

Mr. F. W. Masek, AMS.

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