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Use of ERTS Data for a Multidisciplinary Analysis of Michigan Resources

ERTS Project No. 321
Proposal ORD-1158
Contract NAS5-21834
Investigator Numbers: UN-004, UN-666, UN-068, UN-671
Type II Progress Report No. 3. March 21, 1974

Introduction

ERTS project 321 is organized into three tasks, each with its own principal investigator; (1) Forestry, Dr. Wayne Myers; (2) Agriculture, Dr. Gene Safir; and (3) Soils and Landforms, Dr. E. P. Whiteside. Due to similar phenology and overlapping test areas, efforts in the agriculture and forestry tasks have been closely coordinated. However, the soils and landforms task is being conducted separately. The project includes two subcontracts with the Environmental Research Institute of Michigan. The objectives of the first subcontract are to apply standard multispectral recognition processing procedures to ERTS-1 multispectral data and related airborne MSS underflight data, and to assist M. S. U. personnel in the analysis and interpretation of recognition maps and other extracted information in working toward the goals of the prime contract. The purpose of the second subcontract is to develop new techniques for estimating the proportions of unresolved materials in individual resolution elements of multispectral scanner data. Material from the subcontractor's Type II progress report to M. S. U. is incorporated in the main body of this report.

Aircraft multispectral scanner data collected to supplement the ERTS data analysis efforts also are being processed and analyzed. There were flights on 25 August 72, 19 October 72, and 8 June 73.

Data processing and analysis support is being provided for three separate tasks, each with its own MSU principal investigator: (1) Forestry, Dr. Wayne Myers, (2) Agriculture, Dr. Gene Safir, and (3) Soils and Landforms, Dr. Eugene Whiteside.

Report of Progress Since the Beginning of the Fifth Reporting Period for Agriculture and Forestry (Tasks 1 and 2)

The August 25, 1972, ERTS frame which includes Lansing, Michigan, has been under analysis for the agricultural and forestry tasks. This is the area for which analysis results were reported at the March 1973 Symposium on Significant Results from ERTS-1. The early results were made for field-center pixels in fields scattered throughout the test area. Recent efforts have been on analyzing fields of sufficient size in a 2x7-mile area in Eaton County, Michigan and 2x2 mile areas in both Clinton and Ionia Counties.

In the 2x7-mile area, field-center pixels have been assigned for some 96 fields, and recognition results have been tabulated for five classes recognized with the same signatures employed in the earlier work. Twelve individual signatures were employed -- two each for corn, soybeans, soil, and trees, and four for the senescent vegetation class.

Table I summarizes the recognition results achieved. For each class it lists the number of fields considered, the total number of pixels, the percentage of pixels classified as each of the various classes, and the percentage of pixels not classified. These are followed by tabulations of correct and incorrect identification, first as a percentage of the total number of pixels and then as a percentage of those classified. The last column gives the percentage assigned from other classes. Overall recognition is 80 to 85%, depending on the criterion used, i.e., whether the averaging is performed over points, over plots, over classes by point, or over classes by plot (for example, averaging over classes by plot means that the average correct percentage for each plot (field) in a class is computed, these are averaged to obtain an average for the class, and the average over all classes is final result). Soil is well recognized (95%). Accuracy in forested areas was 88%, with missed detections being classified as corn. In previous processing of this data set it was noted that forest edges and brushy areas were frequently misclassified as corn. Soybean recognition was slightly lower (85%), but false alarms were low (6.7% as senescent vegetation, while the remaining 8.4% were not classified). Recognition of the senescent vegetation class was 76.8% and corn recognition was 75.5%. Some large corn fields had scattered pixels classified as trees, but the largest number of missed detections were as senescent vegetation (16.8%).

Several problems were encountered in assigning pixels to field centers for this data set:

(1) Determination of the correct field boundaries and crop identification from the photointerpreter's overlays was difficult because:

(a) The scale was too small; new overlays were drawn finally for 4X enlargements of the photographs.

(b) Some fields outlined actually were two or more fields combined and occasionally contained dissimilar crops.

(2) When vertices of too small or too narrow a field were digitized in a computer-aided pixel-assignment procedure, the process of insetting the pixel selection boundaries by 3/4 of an ERTS spatial resolution element caused a cross-over of inset boundaries and spurious pixel assignments. Manual editing was required to either eliminate or correct these cases.

The field location procedure was almost completed for the 2x2-mile test areas in Clinton and Ionia Counties. Most of the problems described for the Eaton County area also were encountered here but were lessened because small fields were excluded from the outset. Further photointerpretation helped to determine the content of the small overlays and ground truth of the area. This should avoid some of the back-tracking done on the 2x7-mile test-area analysis.

Attempts were made to convert 9-track ERTS tapes of 1973 ERTS data, to the 7-track format used by an IBM-7094 computer. Numerous bad records were found, so it was decided to re-order tapes from GSFC in seven-track format. Subsequently, seven-track tapes were received at ERIM through other contracts.

An analysis of aircraft multispectral scanner data collected June 8, 1973, over the Eaton County test area was begun. Initial attempts at producing band-ratio images failed as the result of a mis-calibration of a new playback system (see additional discussion under the Soils and Landforms task).

A new program has been developed for detailed, interactive investigation of signatures on the ERTS imagery. The basic purpose of the program is to locate and map any specified combination of voltage ranges in the four ERTS channels, with several output options. This program is currently being used to decipher forest signature for the August 25th, 1972 imagery over the forest test strip (E. Lansing - Rose Lake area). These investigations have revealed that forested areas appear in the Boolean combination of ranges (12-14, channel 5) (17-29, channel 7), with some extraneous materials included. The non-forest materials are being

TABLE I. SUMMARY OF CLASSIFICATION RESULTS

MSU ERTS EATON COUNTY 25AUG72
3 CHANNEL RECOGNITION, .001 REJECTION
12 SIGNATURES

AVERAGES OVER PLOTS OF PERCENTS OF TOTAL NUMBER OF POINTS IN EACH PLOT

	NR. PLOTS	NR. POINT	CORN	SOYBEANS	TREES	SOIL	SENSC. VEG.	POINTS IN CLASS: NOT CLASD	POINTS IN CLASS: RIGHT (OF ALL)	POINTS IN CLASS: WRONG (OF ALL)	POINTS IN CLASS: RIGHT (OF CLASD)	POINTS IN CLASS: WRONG (OF CLASD)	ASS'D FROM OTHER CLASS
CORN	32	444	75.5	0.3	7.1		16.8	.3	75.5	24.2	75.7	24.3	7.6
SOYBEANS	7	51		84.9			6.7	8.4	84.9	6.7	93.2	6.8	2.5
TREES	5	75	11.8		88.2			.0	88.2	11.8	88.2	11.8	2.9
SOIL	5	36				95.0	5.0	.0	95.0	5.0	95.0	5.0	4.0
SENESCENT VE	47	258	9.1	4.5	0.7	7.8	76.8	1.2	76.8	22.1	77.4	22.6	12.4
	96	864						.9	79.9	19.2	80.6	19.4	
AVG. OVER POINTS								1.3	78.5	20.2	79.5	20.5	
AVG. OVER PLOTS								1.2	85.8	13.1	86.8	13.2	
OVER CLAS BY POINT								2.0	84.1	13.9	85.9	14.1	5.9
OVER CLASS BY PLOT													

investigated, along with intersections in channel 4. When the best combination of responses in the four channels has been determined, a map of this signature will be prepared and the accuracy checked.

It should be noted that processing of the Boolean signatures is much less expensive than the conventional maximum likelihood classification, since the computer is being used essentially as a sophisticated densitometer. It also has the advantage that representation of signatures is not limited to linear or quadratic combinations of the channel responses.

Soil and Landforms Task (Task 3)

Computer lineprinter graymaps of June 8, 1973, data from ERTS Bands 5 and 7 were produced for Test Sites III and IV and forwarded for analysis and training set selection. Training and test field annotations on aerial photographs were provided. Identification of these areas in the ERTS data has been delayed until after geometrically corrected version of the ERTS data has been produced. A capability now exists at ERIM to produce data sets which have been rotated and geometrically corrected so that N-S roads are parallel to the printer paper edge on graymaps, skew due to the Earth's rotation is removed, and adjustment to an appropriate (selectable) map scale for line printer maps can be made; the basic along-track scale of ERTS line printer maps is roughly 1:25, 000.

Aircraft multispectral scanner (MSS) data collected over Test Site III on 19 October 1972 were analyzed. Single-band and band-ratio images were produced and subjected to image interpretation. Spectral bands were utilized both to simulate ERTS-1 spectral bands and to investigate the desirability of other bands. Detailed discussion of the procedures employed, examples of the imagery analyzed, and details of the analyses and conclusions are presented in Appendix A.

In summary, the interpretation analysis indicated that significant terrain information is available from band-ratio images which enhance some differences that are not as apparent on single band images. There is at least one instance in which single-band images are as good or better. In addition, the ratio technique may be useful for computer processing to obtain recognition images of large areas at lower cost than with statistical decision rules. The results of this study of aircraft MSS data will be useful for future processing and evaluation of ERTS data for soil and landform studies.

Additionally, the results suggest that some bands other than those currently collected by ERTS (particularly, one or more thermal bands) would be useful in future satellites.

Analysis of aircraft MSS data collected on 8 June 1973 also was begun. As noted under the other tasks, difficulties were encountered in producing imagery like that described above for 19 October 1972.

Plans for Tasks 1, 2, and 3

The ends of both the subcontract period and the available funds are approaching. We expect to be able to complete analysis of the August 25, 1972 data for the

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APPENDIX A

ANALYSIS OF SUPPORTING AIRCRAFT DATA FOR THE ERTS SOILS AND LANDFORMS TASK

Aircraft MSS data were collected in support of the ERTS soils and landforms task, for several reasons. The most obvious reason is that they provide terrain imagery with finer spatial resolution in the same spectral regions as ERTS MSS data. This fact allows the relating of specific terrain conditions and spatial features, which may not be interpretable or discernable in the ERTS imagery alone, to the ERTS-recorded data. As such, the aircraft data serve as an important type of "ground truth" for initial processing and subsequent evaluation of the satellite data for applications to pedology and geomorphology.

Secondly, techniques for processing ERTS data are easily tested using complimentary aircraft MSS data because procedures for handling and analyzing the aircraft data are long established, and the analog format of the aircraft data is compatible with the high-speed analog computer facility used for processing these data.

Finally, while we are principally concerned with ERTS-1 MSS data, we should develop an awareness for the relative value of collecting and processing of spectral data at wavelengths other than the current four ERTS-1 bands. In particular, we believe that the addition of one or more thermal IR bands to the spectral ranges recorded by satellite sensors (e.g., the original ERTS-B plan and SKYLAB) will be useful for future soil and landform studies. The ERIM-M7 multispectral scanner, used to collect the supporting aircraft data, synchronously recorded twelve spectral bands -- including two thermal infrared bands. The results of ratio processing and analysis of these data are illustrated and summarized below.

Aircraft Data Collection and Processing

Twelve bands of multispectral scanner data were collected at an altitude of 5000 feet over the E. Lansing soil-and-landform test site (Site #III) on October 19, 1972. The 20-mile north-south flightline crossed the Michigan State University (MSU) campus, agricultural research farms, and several different soil and landform features to the north of East Lansing. The multispectral data included one band in the ultraviolet (0.33 - 0.38 μm), six bands in the visible (0.41 - 0.70 μm), three bands in the near infrared (0.67 - 2.6 μm), and two bands in the thermal infrared (8.0 - 10.7 μm) spectral ranges. All of these data are of good quality, although several small portions of the flightline were obscured by cloud shadows at the time of data collection. Seventy-millimeter false-color (Kodak 2443) and color (Kodak SO 397) photographs and nine-inch black-and-white (Kodak 2403) photographs also were collected at the time of the flight. The multispectral data subsequently were machine processed using the ERIM-analog computer facility (SPARC) for scene enhancement of terrain features.

Of the several types of multispectral data processing routinely implemented at ERIM (Euclidean distance and likelihood ratio recognition, level-slicing, band combining, and ratioing) ratio processing was used with these data. Ratio processing is essentially a scene enhancement technique whereby image contrasts are intensified on the basis of relative differences in the spectral contrasts of terrain features recorded in two or more bands. In other words, the aim is to obtain a new terrain image which shows differences between features of interest better than any of the original single-band images alone. The technique consists of electronically dividing the signals of one data channel (spectral band) by those of another, after reference to the signals from internal scanner calibration sources. Where ratio values are consistently distinct for various classes, one can produce recognition maps by assigning scene elements, with values falling in specific ratio intervals, to the appropriate classes.

Ground Conditions

Results of the ratio processing of aircraft multispectral data are illustrated with images of a four-square-mile area showing the MSU experimental farms -- just south of the campus area. The area of interest is bounded on the north by Mt. Hope Rd., on the south by Jolly Rd., on the east by Hagadorn Rd., and on the west by College Rd. This 2 mile by 1.5 mile area serves as the site for many on-going agricultural and land use projects conducted by the staff and students at MSU. For our purposes, the area is of interest because it provides a variety of surface terrain conditions and known treatments at the time of data collection. (This area represents only a tenth of the total area recorded on this flightline.)

Figure 1 is a schematic drawing of the major fields and their uses at the time of aircraft data collection. Most of the area was either pasture or harvested corn. The pasture vegetation was brown, and the deciduous woodlots were reddish-brown and yellow by this time of year. Little or no fall plowing had been done, although complete harvesting of the corn crop for silage left these fields substantially bare of vegetation and crop residues. The only major green crop was a 40-acre field (#24) which contained a 10-inch growth of seedling alfalfa and brome grass.

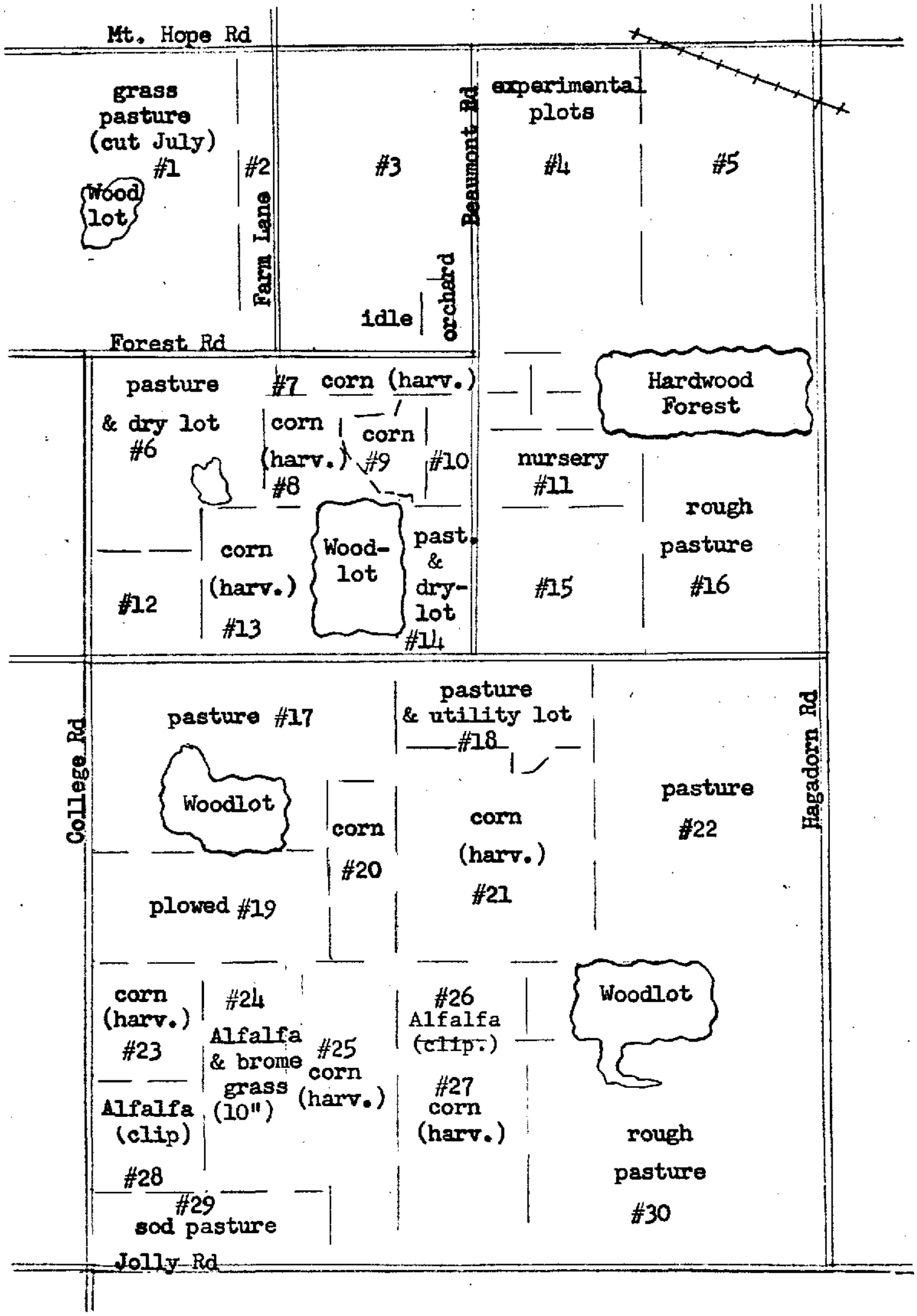


FIGURE 1. Field conditions for the MSU experimental farms at the time of the ERIM aircraft over-flights, October 19, 1972.

The experimental farms were used to determine the significance of the contrasting tones of each of the multispectral single-band and ratio images. Each major field is numbered for subsequent reference in this report -- numbers are consecutive from left to right, beginning at the upper left and ending at the lower right. Conclusions concerning the contrasts displayed in each of the images were then applied to other portions of the flightline and were field-checked when weather conditions permitted in early Spring, 1973.

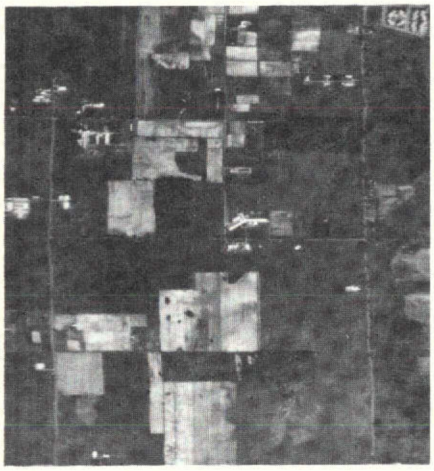
Processing Results

The major objective in processing was to use the aircraft data to simulate the appearance of the terrain in the four ERTS-1 MSS bands; another was to examine data at non-ERTS wavelengths.

The approach taken here was to produce a variety of single-band and ratio images, and study them as an image interpreter, determining which combinations produced distinctive tones for the various categories of soil and vegetation cover. Care must be taken in comparing magnitudes of image contrast, because the operator controls film exposure during image production, usually attempting to utilize the full linear range of the film's characteristic curve.

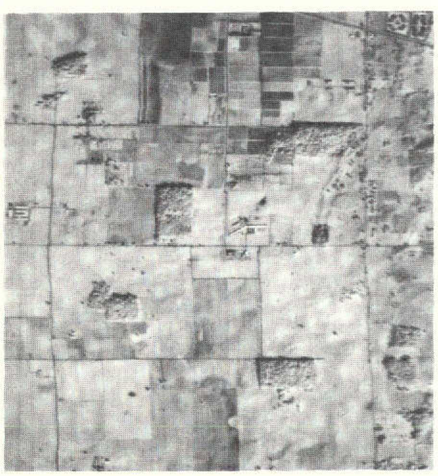
Figure 2 shows four aircraft images spectrally similar to the ERTS bands. Correspondence of these images and ERTS data is not exact, owing to some differences in the spectral ranges recorded, different atmospheric effects, and the much finer spatial detail of aircraft images; but they nevertheless represent a useful approximation to the appearance of the terrain in ERTS-1 bands.

The two images recorded in the visible wavelengths (0.50 - 0.60 and 0.62 - 0.70 μm) appear similar to each other and show marked contrasts between light-toned bare fields (harvested corn) and roads, and the much darker vegetated areas. The two near-IR images (0.67 - 0.92 and 1.0 - 1.4 μm), which also appear similar to each other, show much less contrast between different fields, with wooded areas appearing distinctive on the basis of rough image texture. Variable tones associated with bare fields are seen in each of the images (for examples, fields 21, 25 and 27) but are more difficult to discriminate in the near-IR images due to the similarity of vegetation tones. Dark areas in bare fields correspond to more poorly drained soils than light areas -- probably due to higher concentrations of organic matter and moisture in the surface horizon. This drainage-contrast is reversed for the pasture areas -- where the more poorly-drained areas appear lighter in tone than the dryer areas (see pastures, #22 and #30). This reversal of contrast also holds for two alfalfa fields (#26 and #28) which had been clipped the previous August.

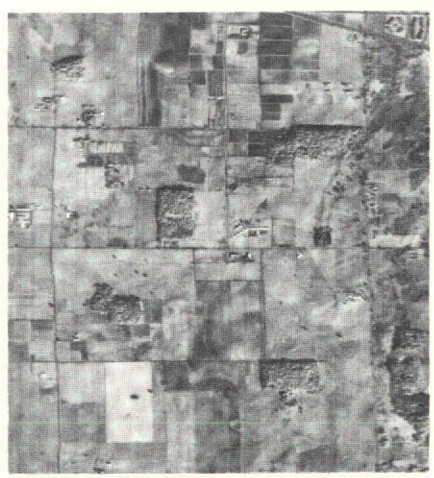


(a) 0.50-0.60 μm

(b) 0.62-0.70 μm



(c) 0.67-0.92 μm



(d) 1.0-1.4 μm

FIGURE 2. SIMULATION OF FOUR ERTS-1 SPECTRAL BANDS USING AIRCRAFT MULTISPECTRAL DATA. East Lansing Test Site. Altitude 5000 ft. October 19, 1972.

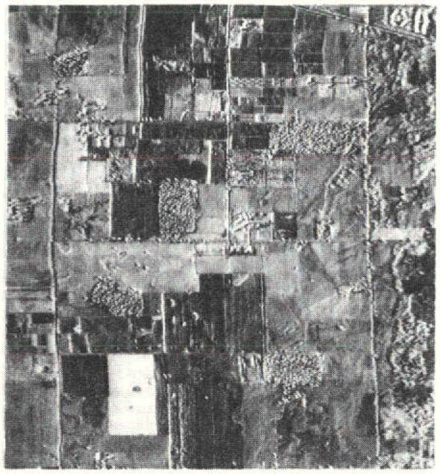
The herbaceous vegetation of these poorly-drained low areas probably remained greener than the dryer areas -- accounting for their notably lighter appearance in the near-IR bands.

In Figure 3 are shown four of the six non-redundant ratio images possible using these simulated ERTS-1 spectral bands. Each shows contrasts which are distinct from the original images. For example in image 3a, simulating ERTS 4/5, bare fields appear uniformly dark in tone, in spite of the fact that the bare field areas of the two original bands (1a and 1b) whow considerable tone variation. This same ratio image shows a variety of tones associated with woodlot and field vegetation. Reasons for the vegetation tonal variations are not all known, but slight mis-registration of the two original bands during the ratio image playback caused the "edge enhancement" effect which makes the deciduous woodlots appear "coarse-textured" and the drainage pattern more obvious (field #16).

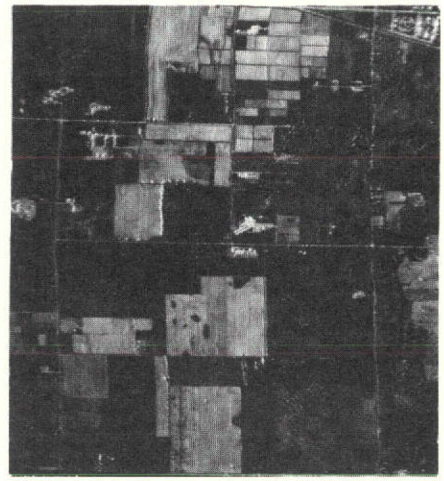
A very light appearing field contains green seedling vegetation (#24), in contrast to the bare soil (dark) and pasture vegetation (medium) present in most of the other cultivated fields. This separation of green seedling from pasture vegetation is not obvious in the original images or in any of the subsequent ratio images, but may be significant for early detection of late summer or fall planted crops, e.g., winter wheat.

The ratio images simulating ERTS 5/6 and 5/7 (Figures 3b and 3c, respectively) appear similar to each other in the tone and pattern of landscape features. In both images, the bare fields appear light in tone and the vegetated areas dark. Some indication of harvesting direction can be discerned within the bare (harvested corn) fields, but there is insufficient tone contrast to show differences within the vegetated areas. The similarity of these two images indicates that there is relatively little spectral difference between the 0.67 - 0.92 µm and 1.0 - 1.4 µm bands used in the denominators of ratio images 3b and 3c, respectively; Figure 3d, the ratio of these two bands, confirms this fact, as discussed in the next paragraph.

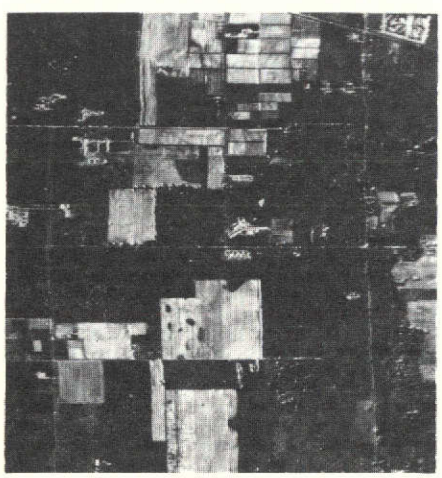
Figure 3d, simulating ERTS 6/7, shows most of the scene with a more-or-less medium grey tone -- with slight variation within or between bare soil and vegetated areas. The two clipped alfalfa fields (#26 and #28) do appear slightly darker than the adjacent fields. Spatial road and field patterns are distinguishable and perhaps a low contrast image like this would serve as a useful base map for recording field observations. The relative lack of contrast in this image indicates that there is little spectral difference in these two near IR bands for these terrain conditions; however, it is observed later (Fig. 6a) that marsh and organic soil areas are more distinctive with this ratio than with any other analyzed.



(a) $\frac{0.50-0.60}{0.62-0.70}\,\mu m$



(b) $\frac{0.62-0.70}{0.67-0.92}\,\mu m$



(c) $\frac{0.62-0.70}{1.0-1.4}\,\mu m$

(d) $\frac{0.67-0.92}{1.0-1.4}\,\mu m$

FIGURE 3. FOUR RATIO IMAGES USING SIMULATED ERTS-1 SPECTRAL BANDS. East Lansing Test Site. Altitude 5000 ft. October 19, 1972.

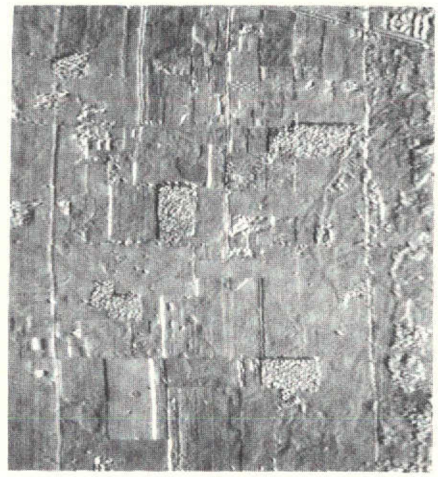
Figure 4 demonstrates ratio images using spectral bands not recorded by ERTS-1. The first two images (4a and 4b) show ratios for bands at ultraviolet and/or visible wavelengths which are spectrally close to each other. Image 4a, ultraviolet over blue-violet, is similar to Image 3a (∿ERTS 4/5) in that bare fields appear dark and vegetated areas are light in tone -- with woodlots distinctively lighter than the herbaceous field vegetation.

Image 4b, yellow-red over deep red, is similar to Image 3d (∿ERTS 6/7) in that there is little tonal contrast for different scene features indicating little spectral variation between these two bands. Slight misregistration of these two bands during playback resulted in the vertical dark and light field edges.

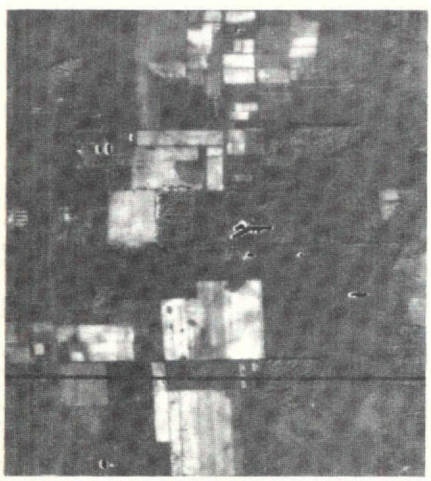
Image 4c presents the ratio of a near-IR band and a thermal-IR band. If ERTS-B were to have a thermal IR band, this type of ratio would be possible using orbital data. The resulting appearance of the image is quite similar to the single-band video images in the visible wavelengths (Images 2a (∿ERTS 4) and 2b (∿ERTS 5) -- bare fields appear relatively light in tone and vegetated areas dark. It was expected, on the basis of previous work, that the addition of the thermal band would help to enhance natural drainage differences between soils -- with poorly drained soils appearing both darker and warmer at mid-day than well drained soils. Well-drained areas in bare fields do appear light in tone and the poorly-drained areas as dark; however, these contrasts do not appear significantly greater than those in single-band Image (2a) for the same fields. Some of the building roofs, which had temperatures considerably higher than the surrounding terrain, appear as saturated "dark spots" on this ratio image.

Figure 4d presents a ratio of two thermal infrared bands. Unfortunately, the spatial resolution of these thermal data was considerably coarser than the other spectral bands, degrading the interpretability of the output. In this ratio, the well-drained bare soil areas appear dark while the vegetated areas are light in tone. This ratio is intended to show emissivity differences between different materials in these two thermal bands. In particular, the emissivity of silicate minerals in the 8 - 9.1 μm wavelength interval (so-called "restrahlen band") is lower than in the 9.5 - 11 μm interval. In other words, if silicates are present the apparent blackbody temperature in the 8.0 - 9.1 μm band will be lower than the apparent temperature for the same area imaged in the 8.7 - 10.7 μm range. A ratio of these two bands then shows contrasts (ratio values) related to the relative silicate--non-silicate composition of the surface materials. Since most well-weathered temperate climate soils are primarily composed of silicate minerals, these areas appear darker than the (non-silicate) vegetated areas.

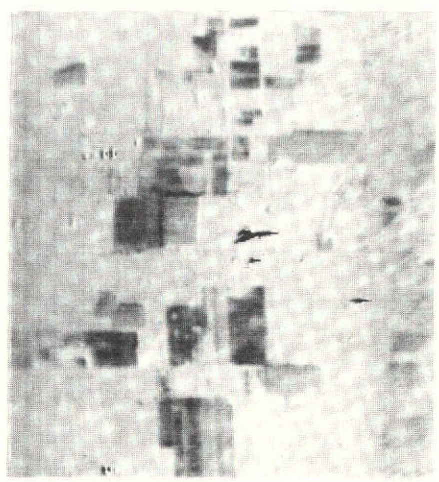
(a) $\frac{0.33\text{-}0.38}{0.41\text{-}0.48}\ \mu m$



(b) $\frac{0.58\text{-}0.64}{0.62\text{-}0.70}\ \mu m$



(c) $\frac{2.0\text{-}2.6}{8.7\text{-}10.7}\ \mu m$



(d) $\frac{8.0\text{-}9.1}{8.7\text{-}10.7}\ \mu m$

FIGURE 4. FOUR RATIO IMAGES USING NON-ERTS-1 SPECTRAL BANDS. East Lansing Test Site. Altitude 5000 ft. October 19, 1972.

It is also noteworthy to point out that in Image 4d most of the bare field areas (dark) have light tone patterns which, in part, correspond to poorly-drained areas -- as noted in Images 2a and 2b. Evidently the occurrence of surface conditions associated with poor drainage (greater organic matter accumulations and higher relative soil moisture) are sufficient to partly mask the emissivity effects of silicate minerals. Here then, we have a method of assessing surface soil drainage which appears to be relatively independent of solar illumination and actual surface temperature.

Extension of Aircraft Results

These results were derived by comparison of images to known field conditions at the MSU experimental farms. To further test the results, we inspected the ratio imagery for other portions of the test site -- specifically a 10-by-2-mile agricultural area north of the City of East Lansing. Although primarily agricultural, this area has a diversity of terrain elements -- including two gravel pits, a small airport, a golf course, and numerous swampy areas.

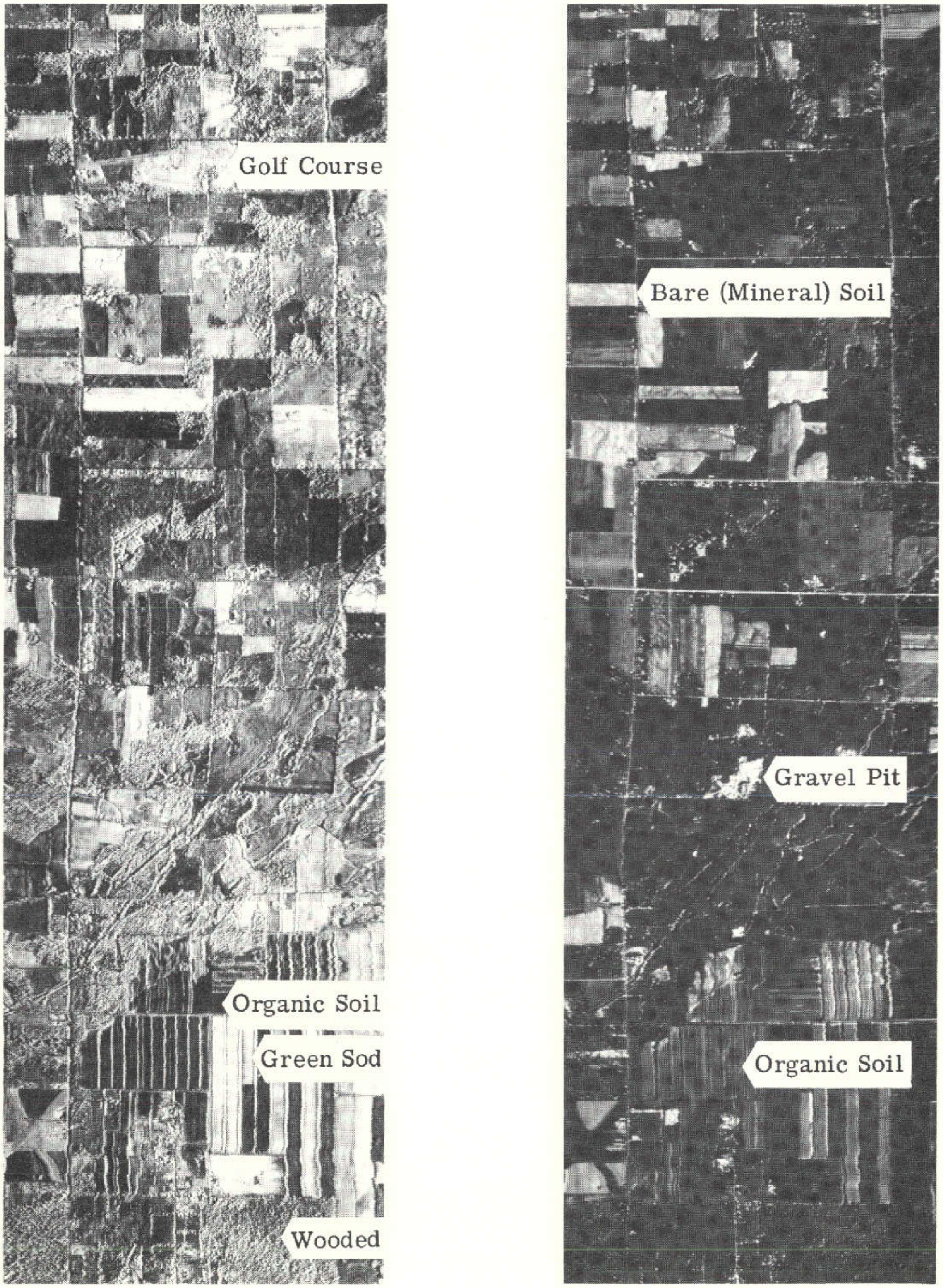
In general, the differing image contrasts which were noted previously for the experimental farms also occurred in this area. These are partially illustrated in Figures 5 and 6. These images show the greatest contrast diversity of the ratioed images for this test area.

Image 5a shows the enhancement of green vegetation and seedling crop areas with the 0.50-0.60/0.62-0.70 μm ratio. In particular both a golf course and green sod appear very light in tone in contrast to the dark bare soil areas and medium tone of the other woody and herbaceous vegetation. Image 5b (0.62-0.70/1.0-1.4 μm) shows bare mineral soil and gravel pits in very light tones. Note that the organic soil associated with a sod farm in the lower portion of the image has a darker tone than the bare mineral soils. The road network also shows up quite well in this image.

Although generally lacking the contrast which is apparent in the previous two images, Image 6a (0.67-0.92/1.0-1.4 μm) highlights marsh and organic soil areas by their dark tones. In no other image are these scene elements as clearly defined. Image 6b, utilizing non-ERTS bands 0.33-0.38/0.41-0.48 μm, shows wooded areas as light in tone and bare areas as dark. In particular, gravel pits and sandy spots are clearly identifiable by their dark tones.

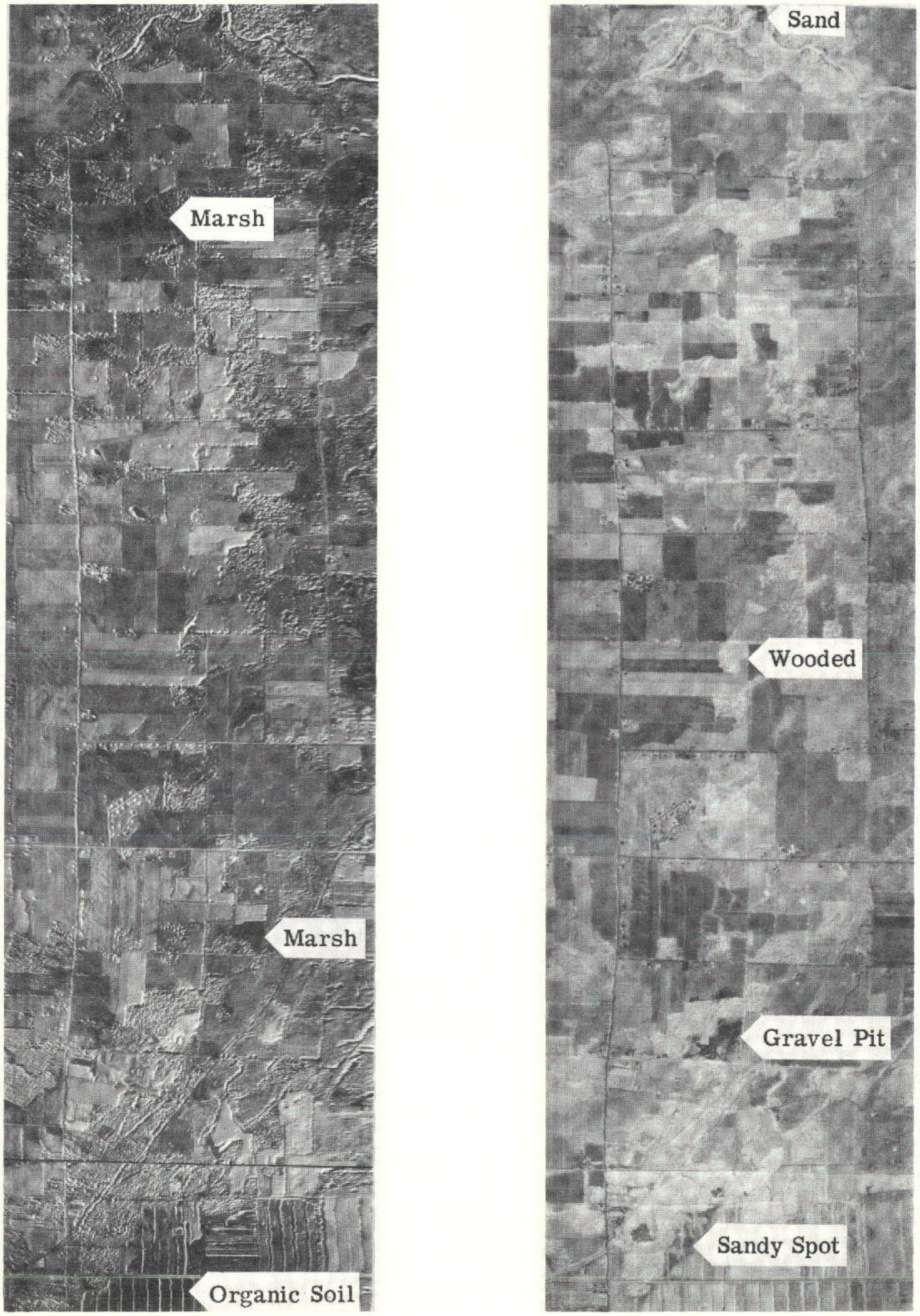
Summary Results

Results of interpreting single-band and band-ratio images of aircraft multispectral data from the East Lansing test site are summarized in Table A.



(a) $\frac{0.50\text{-}0.60}{0.62\text{-}0.70}$ μm   (b) $\frac{0.62\text{-}0.70}{1.0\text{-}1.4}$ μm

FIGURE 5. TWO RATIO IMAGES FOR AREA NORTH OF EAST LANSING, MICHIGAN. Altitude 5000 ft. October 19, 1972.



(a) $\frac{0.67\text{-}0.92}{1.0\text{-}1.4}\ \mu m$

(b) $\frac{0.33\text{-}0.38}{0.41\text{-}0.48}\ \mu m$

FIGURE 6. TWO RATIO IMAGES FOR AREA NORTH OF EAST LANSING, MICHIGAN. Altitude 5000 ft. October 19, 1972.

TABLE A. SUMMARY OF INTERPRETATIONS OF AIRCRAFT MULTISPECTRAL SCANNER SINGLE-BAND AND BAND-RATIO IMAGERY OVER SOILS AND LANDFORMS TEST SITE III, DATA COLLECTED 19 OCTOBER 1972, 5000-FT ALTITUDE

Band Wavelength	Approximate ERTS Band(s)	Identifiable Scene Features
(1) 0.50-0.60 μm	4	roads & most buildings, vegetation & dark soil (mineral & organic), light mineral soil
(2) 0.62-0.70 μm	5	same as (1) above
(3) 0.67-0.92 μm	6	some roads & buildings, wooded areas, other vegetation & mineral soils, organic soils, surface water
(4) 1.0-1.4 μm	7	same as (3) above
(5) $\frac{0.50-0.60}{0.62-0.70}$ μm	4/5	seedling (green) crops, bare soil & crop residue, wooded areas, other vegetation
(6) $\frac{0.62-0.70}{0.67-0.92}$ μm	5/6	bare areas, roads, most green vegetation, other vegetation
(7) $\frac{0.62-0.70}{1.0-1.4}$ μm	5/7	same as (6) above
(8) $\frac{0.67-0.92}{1.0-1.4}$ μm	6/7	organic soil & most marsh, other vegetation & soils
(9) $\frac{0.33-0.38}{0.41-0.48}$ μm		bare mineral soil, woody vegetation & surface water, other vegetation & organic soil, exposed sand & gravel
(10) $\frac{0.58-0.64}{0.62-0.70}$ μm		nil
(11) $\frac{2.0-2.6}{8.7-10.7}$ μm		light mineral soil, vegetation & dark soil (mineral & organic)
(12) $\frac{8.0-9.1}{8.7-10.7}$ μm		same as (11) above

Each scene feature or combination of features listed has a distinct image tone which makes it readily distinguishable from the others in that image. The reader is cautioned that the absolute contrasts on the images interpreted were subject to the image playback controls and subsequent photographic processes, a problem in common with conventional photointerpretation.

The most significant differences noted were the distinctive appearance of green vegetation on ratio images approximating ERTS 5/6 and 5/7, the uniqueness of fall seedling crops on the ratio image approximating ERTS 4/5, and the distinctiveness of organic soils in Bands 6 and 7 and organic soils and marsh in Band Ratio 6/7. Thus, it appears that there may be one instance for which single-band images are preferable, while band-ratio images appear preferable for delineating green vegetation and organic-soil/marsh areas.

Significant Results

The results of this investigation of ratioing simulated ERTS spectral bands and several non-ERTS bands (all collected by an airborne multispectral scanner) indicate that significant terrain information is available from band-ratio images. Ratio images, which are based on the relative spectral changes which occur from one band to another, are useful for enhancing differences and aiding the image interpreter in identifying and mapping the distribution of such terrain elements as seedling crops, all bare soil, organic soil, mineral soil, forest and woodlots, and marsh areas. In addition, the ratio technique may be useful for computer processing to obtain recognition images of large areas at lower costs than with statistical decision rules.

The results of this study of ratio processing of aircraft MSS data will be useful for future processing and evaluation of ERTS data for soil and landform studies. Additionally, the results of ratioing spectral bands other than those currently collected by ERTS-1 suggests that some other bands (particularly a thermal band) would be useful in future satellites.