

Conference on
Machine Processing of
Remotely Sensed Data

October 16 - 18, 1973

The Laboratory for Applications of
Remote Sensing

Purdue University
West Lafayette
Indiana

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MAPPING SOIL ASSOCIATIONS USING ERTS MSS DATA

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I. ABSTRACT

Multispectral imagery from ERTS was compared to a soil association map of Tippecanoe County, Indiana, based on a conventional field survey. Three methods of processing single and multiple wavelength bands were applied to imagery collected on three dates. Correction of geometric distortions in computer-processed imagery was investigated. Four to six groupings of soil associations could be delineated on ERTS imagery. Some associations were more readily delineated using visible wavelengths, some more readily delineated using infrared wavelengths. In general, MSS band 7 was found to give more soils information than MSS band 5. Imagery of single wavelength bands displayed on a television type display system gave greater contrast than photographically processed imagery. Computer processing and display of information from multiple bands is believed to be superior to using single ERTS bands. The present study failed to confirm this hypothesis, primarily because of the combinations of overpass dates, processing methods, and display methods. Computer compatible multispectral data which had geometric distortions removed was superior to distorted data.

II. INTRODUCTION

Preparation of conventional soil maps presently requires a soil scientist to traverse the landscape, examining the soil at intervals, and recording his observations on a suitable map base, usually an aerial photograph. These detailed soil and landscape evaluations usually result in detailed soil survey maps, such as those presently being produced by the National Cooperative Soil Survey (local, state, and federal governments cooperating). The Soil Conservation Service of USDA is involved in continued production of such maps on a county by county basis. Producing such a map for a county may take from four to eight years depending on the size of the county, the complexity of the soils of the area, and many other factors.

Previous researchers have reported relationships between physical and chemical characteristics and their multispectral reflectance properties (3, 5). Multispectral imagery from aircraft and spacecraft has been found useful in various types of soils studies (1, 2, 4, 6, 7, 8, 10). Multispectral imagery is expected to be particularly informative when processed by computerized multivariate statistical procedures. Future use of such procedures in detailed or in generalized surveys seems at this time to be quite feasible. However, techniques for processing multispectral data in a manner which will make it most useful for such purposes are yet to be developed.

This paper deals primarily with one phase of research applying remote sensing

technology to soil survey problems, that of generalized soil mapping as opposed to detailed soil mapping. Effects of several methods of processing multispectral scanner (MSS) data collected by the Earth Resources Technology Satellite (ERTS) are discussed, and types of generalized soils information which was obtained for a single county in Indiana are given.

A soil association is a grouping of soils which occur in areal proximity to one another, that is, it is a generalization of the soils which occur in an area. A soil association map can be made from a detailed soil map by conventional means. Each soil association will generally contain a few major soils and several minor soils in a pattern that is characteristic although not strictly uniform. The soils within any one association are likely to differ from each other in some or many properties. For example, they may differ in slope, soil depth, stoniness, or natural drainage. Therefore, a soil association map does not show the kind of soil at any particular place but rather patterns of soils in each of which there are several different kinds of soils. Usually a soil association is named for the major soil series which occur in that association. The major soils of one association will quite often be present in another association but in a different pattern.

The study took place in Tippecanoe County, Indiana. This county is located within the Tipton till plain physiographic region which is part of the Central Lowland Province. Glacial drift covers the bedrock to depths ranging from a few feet to more than 300 feet. The underlying bedrock consisting of flint, shale, sandstone, and limestone of the Mississippian Period, is exposed as rock terraces in the Wabash Valley and on the upland in the western part of the county. Shale of the New Albany Formation of the Devonian Period is exposed as rock terraces in the northeastern part of the county. There are four physiographic land types occurring in Tippecanoe County. These are the bottomlands which are alluvial deposits, the terraces and outwash plains, the uplands, and the dune sands which are wind deposited sands. Most of the area of the county is considered as uplands. The Wabash River forms a major drainage through the county resulting in significant acreages of bottomland soils. Terraces and outwash plains occur in the central portion of the county, and dune sands occur along the Wabash River in very small amounts.

Thirteen soil associations (Figure 1) are mapped in the county, but only nine major associations were considered in this study.

The Raub-Ragsdale association [73] occurs on nearly level landscapes. The somewhat poorly drained, silty Raub and the very poorly drained, silty Ragsdale are formed from wind blown silts and glacial till. The Sidell and Parr soils [89] occur on sloping landscapes and are well drained. Both were formed from wind blown silts and glacial till, but the Sidell is silty in texture and the Parr is loamy in texture. The Odell-Chalmers association [88] consists of nearly level soils which are somewhat poorly and very poorly drained, respectively. These three associations comprise the prairie soils, which are high in organic matter content and have very dark surface colors.

The Miami-Russell-Fincastle association [81] consists of soils formed under forest vegetation. This association consists of the sloping, well drained, loamy Miami in glacial till and the silty Russell in wind blown silts and glacial till, and the nearly level, somewhat poorly drained silty Fincastle in wind blown silts and glacial till. These soils are lighter in color than the prairie soils and are lower in organic matter content.

The Elston-Wea [16], Ockley-Westland [36], and Ockley-Fox [38] associations consist of nearly level, well drained, loamy soils on outwash sand and gravel and occur near the Wabash River.

The Genesee-Shoals-Eel association [4] consists of nearly level alluvial soils. The Hennepin-Rodman association [90] consists of the steep, well drained, loamy Hennepin and the excessively drained, shallow, sandy Rodman. Both the Genesee-Shoals-Eel and the Hennepin-Rodman associations are found only in near proximity to major and minor drainageways.

The cultural and natural vegetation of the county is affected to some extent by the soils on which it occurs. A large portion of the county is in cultivated agriculture with a significant amount of wooded area being present primarily along

major and minor drainageways. The major crops of the area are corn and soybeans.

III. PROCEDURES

ERTS multispectral scanner data were processed both photographically and on an IBM 360 Model 67 computer using the LARSYS software system. This software system consists of a set of computer programs which permit multivariate analyses in addition to single wavelength band histogramming to be performed on multispectral data in computer compatible tape format. After the multispectral data were photographically processed or analyzed on the computer the results were output in image format. For the computer analysis this step employed a digital display system* or a line printer. Spectral differences in the images were represented by using gray level tones or various symbols on a line printer. These resulting images were then compared with a soil association map of the county. Images were evaluated in terms of boundaries between one or more soil associations that could be delineated using manual photointerpretation techniques. This technique was used because the spectral characteristics within a soil association were often very heterogeneous. In several cases the heterogeneity arose from cropping patterns in which rectangular fields were apparent.

IV. RESULTS AND DISCUSSION

In evaluating the maps (Figures 2, 3, and 4) visual interpretation is most useful. Two soil areas can be distinguished if the boundary between them is apparent, and this technique relies heavily on spatial information. An example of this is seen in Figure 3. The Elston-Wea [16] area in the left-center area of the figure is readily distinguished from the areas around it by visual observation. It exhibits a checked pattern of light and dark fields, in contrast to the predominately light patterns surrounding it.

Boundaries between the Raub-Ragsdale [73], Odell-Chalmers [88], and Sidell-Parr [89] associations could not be distinguished well on any of the imagery. Boundaries between these three associations and the adjacent Miami-Russell-Fincastle [81] association could be distinguished very well, especially on the histogrammed data (Figure 3).

Soils of the Elston-Wea [16], Ockley-Westland [36], and Ockley-Fox [38] associations could not be distinguished well from one another on the imagery. However, boundaries between these associations and the Miami-Russell-Fincastle [81] and Sidell-Parr [89] associations were readily apparent in most instances where they occurred.

Soils of the Genesee-Shoals-Eel [4] association could usually be delineated in MSS band 5 (not shown). This was possible in part because of their relationship to drainageways and to the Hennepin-Rodman [90] association, which was often wooded.

Figure 4 indicates a predominance of dark soils in the southwest part of the county. This fact is verified by the soil association map, but the general orientation of soil patterns appears to be in a northwest-southeast direction on the ERTS imagery (Figures 2 and 4). This overview gives additional soils information, the utility and interpretation of which must be further investigated.

V. CONCLUSIONS

Correction of geometric distortions in ERTS MSS data in computer-compatible format was very useful for comparing spectral images and soil associations. Images of individual MSS bands gave soils information both when processed photographically and when processed by computer (histogramming) and displayed on a

*The Digital Image Display System receives an image from a System/360 computer, stores this data in a video buffer, and displays the image in a raster scanning mode on a standard television screen. An interactive capability to edit, annotate, or modify the image is provided through a light pen and a program function keyboard. An additional photographic copying capability is also provided.

digital display. MSS band 7 provided the most soils information, although MSS band 5 facilitated some separations of soil associations which were not possible using only MSS band 7. Digital display images of single MSS bands provided the greatest contrast of any processing and display method, but were not geometrically corrected. Additionally, complete comparisons of processing methods were not possible because imagery collected on three dates was processed by three different methods (single band photographic, single band computer, and multiple band computer processing).

Four groupings of 13 soil associations were separated using ERTS imagery. Two other groupings of associations were separated whenever they occurred adjacent to spectrally contrasting associations. The ability to distinguish boundaries between soil associations from the ERTS analysis could not be attributed entirely to the surface color of the soils when most of the area was covered with vegetation. Rather, identification of boundaries between soil associations in such cases was possible apparently because of the effects which soils have on vegetation and because of the patterns of soils occurring on the landscape. It was found that more information relating to soil associations could be extracted from imagery obtained in May when much of the county had soil exposed due to cultivation.

It is believed that a more effective method of processing ERTS MSS data for soil survey uses can be developed by combining the best features of the methods reported here. This method would consist of an unsupervised classification using multiple wavelength bands. Data should be collected when the maximum amount of nonvegetated soil is present. Multiple ERTS passes would provide more information than a single pass. Results would be output in geometrically corrected format on the digital display and photographed in color or black and white.

In addition to and of more importance than the agreement found between ERTS imagery and mapped soil associations, the processed ERTS imagery provided new soils information not shown on the standard soil association map. Results indicated that computer-processed ERTS imagery can provide useful supplementary information to persons producing conventional soil survey maps, both for generalized and more intensive mapping.

VI. REFERENCES

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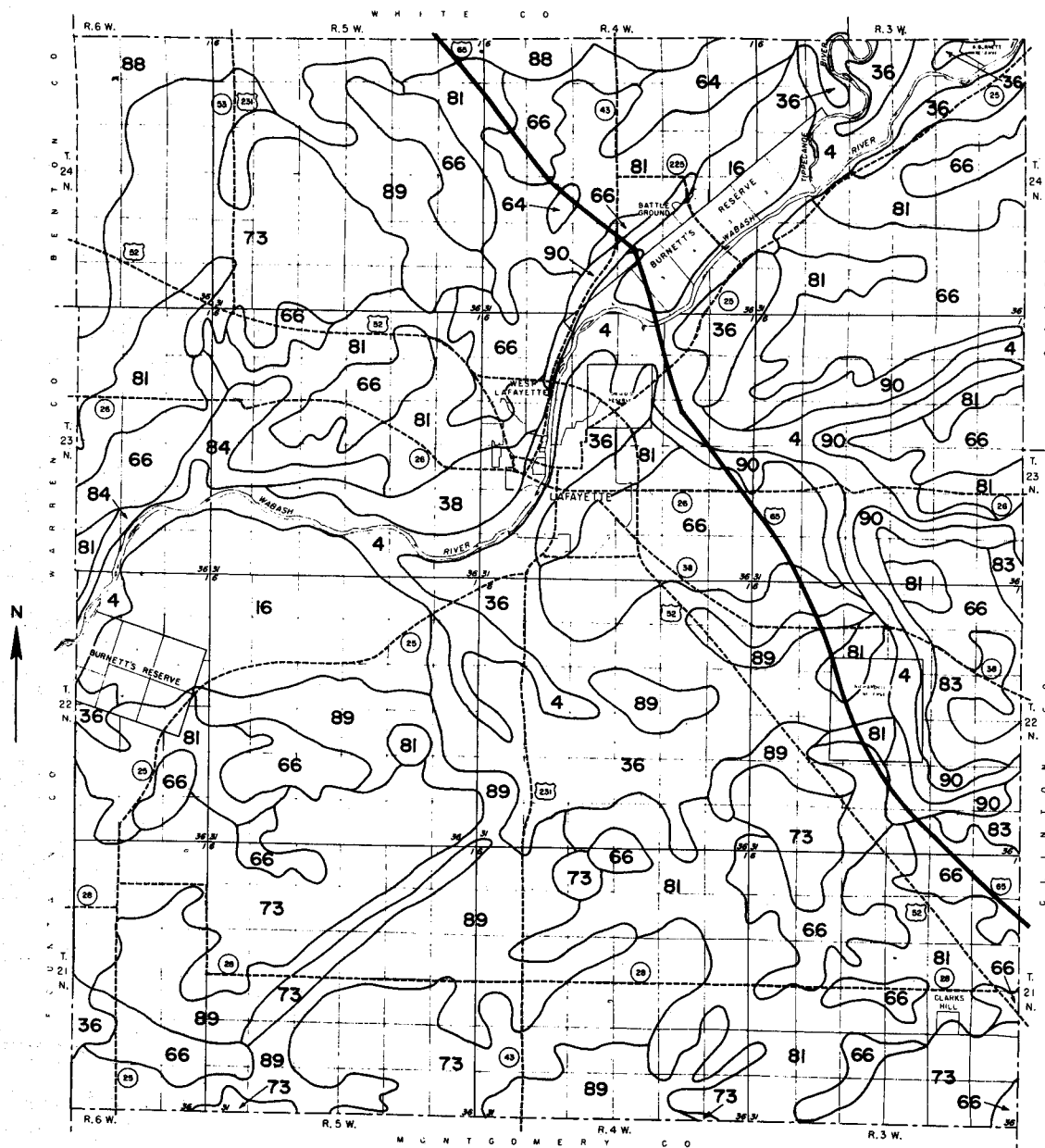


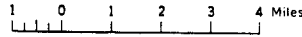
Figure 1. Soil Association Map of Tippecanoe County, Indiana,
Produced by Conventional Procedures Including Field Survey.

(See legend on following page.)

TIPPECANOE COUNTY

General Soil Map

AGRICULTURAL EXPERIMENT STATION AND COOPERATIVE
EXTENSION SERVICE, PURDUE UNIVERSITY; AND THE SOIL
CONSERVATION SERVICE, U.S. DEPARTMENT OF AGRICULTURE



Base map from the Indiana Geological Society

Note: This map is intended for general planning. Each delineation contains soils different from those shown in the legend. For operational planning, use detailed soil maps that may be available in published or unpublished form at the local Soil and Water Conservation District Office.

SOIL ASSOCIATIONS

4. *Genesee-Shoals-Eel*: Nearly level, well drained, loamy Genesee, moderately well drained, loamy Eel, and somewhat poorly drained, loamy Shoals in alluvial deposits.
16. *Elston-Wea*: Nearly level, well drained, loamy soils on outwash sand and gravel.
36. *Ockley-Westland*: Nearly level, well drained, loamy Ockley on outwash sand and gravel.
38. *Ockley-Fox*: Nearly level, well drained, loamy soils on outwash sand and gravel.
64. *Crosby-Brookston*: Nearly level, somewhat poorly drained, clayey Crosby and very poorly drained, loamy Brookston in glacial till.
66. *Fincastle-Ragsdale-Brookston*: Nearly level, somewhat poorly drained, silty Fincastle in wind-blown silts and glacial till, very poorly drained, silty Ragsdale in wind-blown silts and loamy Brookston in glacial till.
73. *Raub-Ragsdale*: Nearly level, somewhat poorly drained, silty Raub in wind-blown silts and glacial till and very poorly drained, silty Ragsdale in wind-blown silts.
81. *Miami-Russell-Fincastle*: Sloping, well drained, loamy Miami in glacial till and silty Russell in wind-blown silts and glacial till and nearly level somewhat poorly drained, silty Fincastle in wind-blown silts and glacial till.
83. *Miami-Crosby*: Sloping, well drained, loamy Miami and nearly level, somewhat poorly drained, clayey Crosby in glacial till.
84. *Miami-Hennepin*: Sloping, well drained, loamy Miami and steep, well drained, shallow, loamy Hennepin in glacial till.
88. *Odell-Chalmers*: Nearly level, somewhat poorly drained, loamy Odell and very poorly drained, loamy Chalmers in glacial till.
89. *Sidell-Parr*: Sloping, well drained, silty Sidell in wind-blown silts and glacial till and loamy Parr in glacial till.
90. *Hennepin-Rodman*: Steep, well drained, shallow, loamy Hennepin in glacial till and excessively drained, shallow, sandy Rodman on sand and gravel.

November, 1971

Figure 1. Legend for Soil Association Map.

<pre> LOCATION: PROJECT: DATE: </pre>	<pre> PROJECT: DATE: </pre>	<pre> LOCATION: PROJECT: DATE: </pre>	<pre> PROJECT: DATE: </pre>
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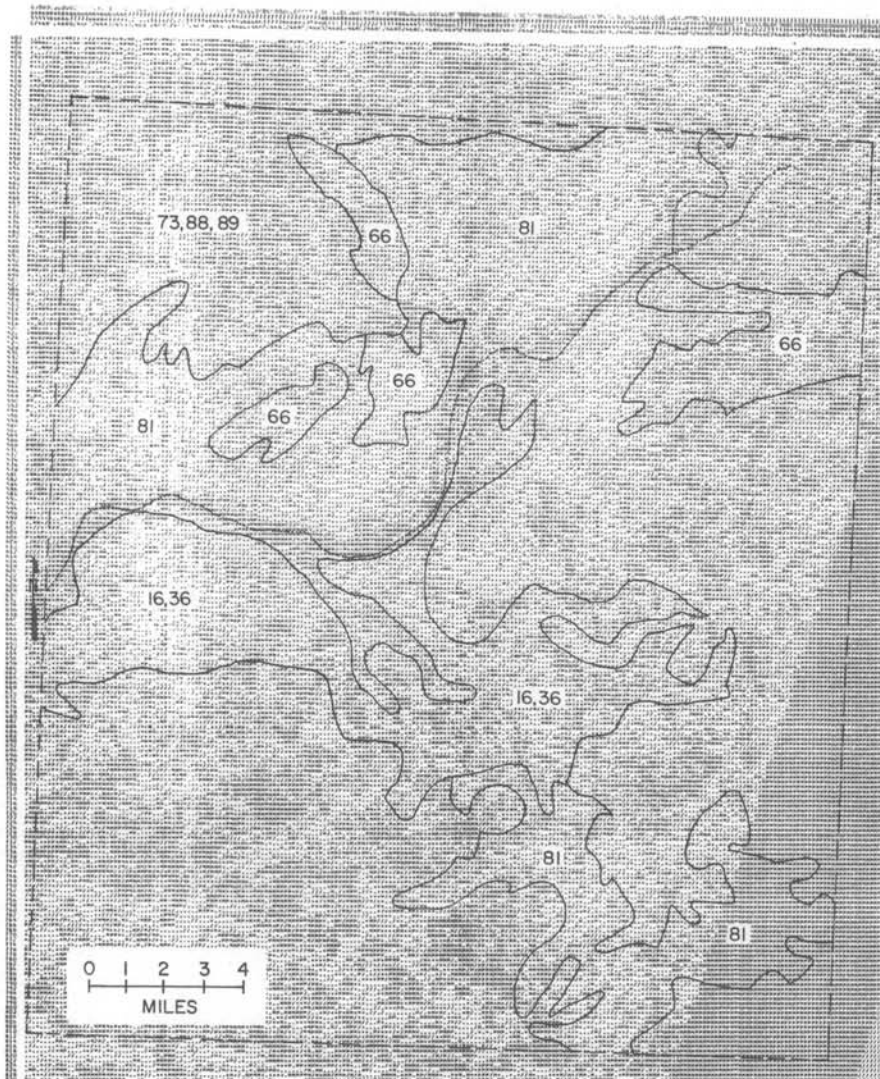


Figure 2. Computer Printout Map of Tippecanoe County Produced from ERTS MSS Bands 5, 6, and 7 and Processed to Give Reasonable Geometric Fidelity. Selected soil boundaries are shown. Data collected November 24, 1972.

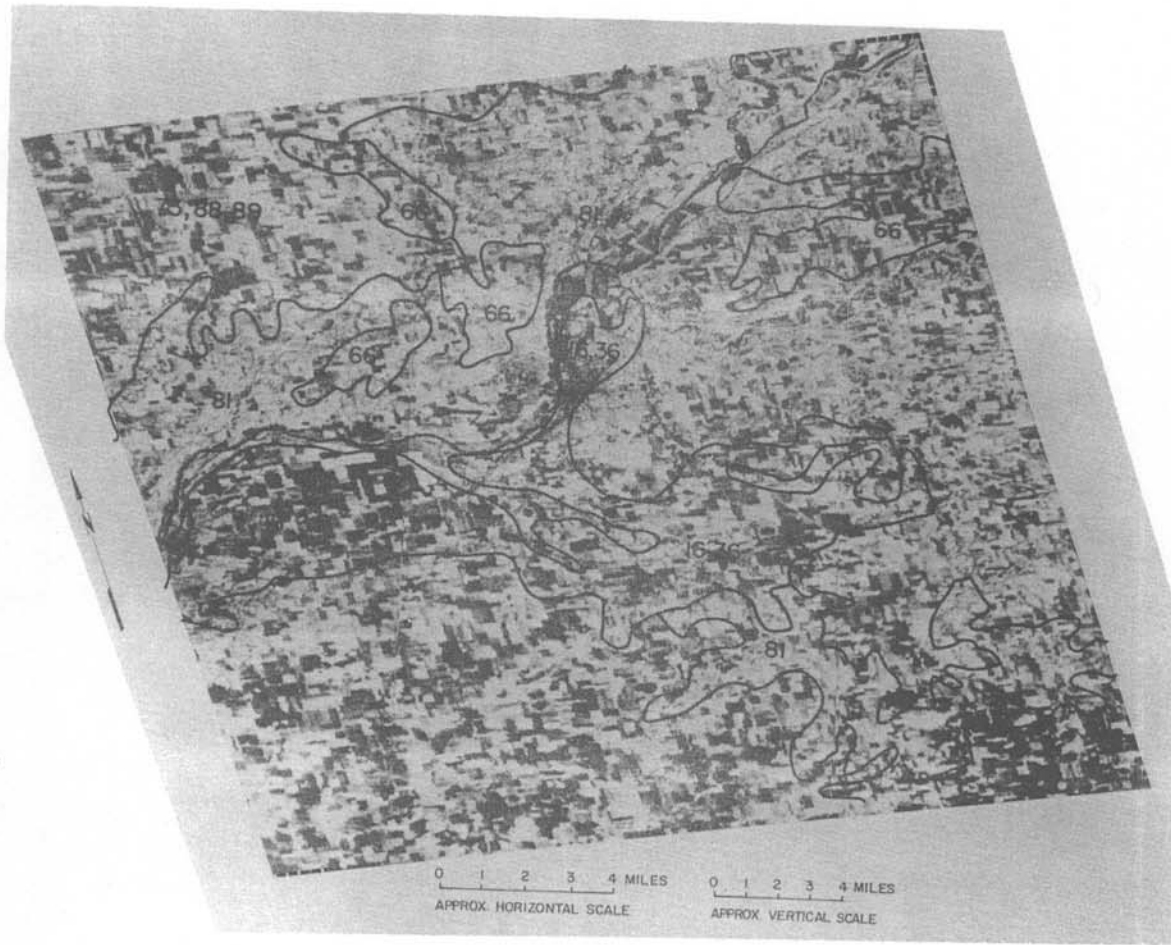


Figure 3. Digital Display Image of Tippecanoe County Produced from ERTS
MSS Band 7. Data collected September 30, 1972.
Image is not geometrically corrected.



Figure 4. Photographically Reproduced ERTS MSS Band 7 Imagery of Data Collected May 4, 1973. Reasonable geometric fidelity is preserved.