LARS Technical Report ~~022278~~ 061671

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1978

10259-1-X

Reprinted From

PROCEEDINGS of the SEVENTH INTERNATIONAL SYMPOSIUM on REMOTE SENSING OF ENVIRONMENT

17-21 May 1971

Sponsored by

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THE EFFECT OF CULTURAL PRACTICES ON MULTISPECTRAL RESPONSE FROM SURFACE SOIL

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ABSTRACT

Computer-implemented maps which display various soil parameters, such as organic-matter content, texture, color, and soil type, have proved that a high correlation exists between multispectral scanner data and ground observations when the soil is non-vegetated and uniformly cultivated. However, when a variety of tillage methods or cropping patterns exists in a field being mapped by multispectral pattern recognition techniques, the problem of delineating soil boundaries is greatly confounded. Cultural practices, such as plowing and disking, and the amount and kind of vegetative cover affect the multispectral response of surface soils. An attempt was made to eliminate the significance of these effects.

1. DATA COLLECTION

The University of Michigan optical-mechanical scanner system obtained data on May 6 and July 1, 1970, over a flightline which included a 54 hectare test site in Tippecanoe County, Indiana. Reflectance data in the spectral range from 0.40 to 1.8 micrometers were obtained. Panchromatic aerial photographs of the test site were taken in coincidence with the May 6 and July 1 flights (Figures 1 and 2).

The soils in the test site are Mollisols formed under tall prairie grasses. Three soil types are present: Chalmers silty clay loam, Raub silt loam, and Dana silt loam. All three are members of a drainage catena that includes the well-drained Dana, the somewhat poorly drained Raub, and the very poorly drained Chalmers. Relief was the primary soil-forming factor which caused the three soils to be different. Chalmers tends to occupy low-lying positions and Dana occurs on the higher, sloping areas. A soil type map was prepared for the test site using conventional soil surveying techniques with a panchromatic aerial photograph as a base map (Figure 3).

A variety of cultural practices existed on the two scanning dates. On May 6, 1970, a large portion of the test site had been fall-disked and a considerable amount of corn stover lay on the surface (Figure 1). A smaller portion at the southern end of the test site had received a subsequent disking which incorporated most of the organic residue into the soil, leaving very little residue on the surface. The photograph shows corn stalks washed into the depressional areas. A partial ground cover of soybean and corn seedlings was present at the time of the July 1, 1970, flight although this is not readily apparent from the aerial photograph (Figure 2).

2. DATA ANALYSIS

A computer clustering program (5) was used to generate a "map" of three soil spectral classes from the July 1, 1970, multispectral scanner data. The clustering program utilized a process of iteration to minimize the Euclidean distance between relative radiance vectors and the "cluster center" for a given class (assuming that normally distributed spectral classes exist). Class selection was non-supervised, that is, training vectors were not provided as computer input in the clustering program. Output of the clustering program was a set of training vectors used to

The work described was funded in part under NASA Grant #NGL 15-005-112.

train the computer to divide the test site into a number of soil spectral classes (4). The spectrally "mapped" soil classes and the three soil types of the conventional soil map show very similar patterns (Figures 3 and 4). The clustering technique appeared able to separate soil spectral classes despite the partial ground cover of soybeans and corn and the absence of ground soil type observations to train the computer.

The clustering technique was then used to classify four levels of spectral response from the May 6, 1970, multispectral scanner data. In the resulting spectral map, most of the recently-disked area was thresholded out and appeared as a blank (Figure 5). This process eliminates surface features which are unlikely to be in a particular class and thus, in effect, cuts off the tails of the probability distribution curve used for identifying the spectral classes for surface features.

The relatively low reflective response of the recently disked portion of the field probably caused this area to be thresholded. In an attempt to discern soil spectral classes within the recently-disked area, the clustering program was used once again, only this time the clustered area was limited to the recently-disked strip. In the resulting display, the recently-disked strip was divided into four spectral classes and the remainder of the test area was thresholded out (Figure 6). Although neither illustration (Figures 5 and 6) represents an actual soil-type map, patterns can be seen which undoubtedly are representative of the existing soil properties. The effect of tillage practices on radiance properties of the soil surface can be partially eliminated in delineating general soil patterns.

3. SUMMARY AND CONCLUSIONS

At the time of the July flight, the soil surface covered by soybean canopy did not exceed twenty-five percent. This amount of cover posed no problem in delineating soil patterns from computer-implemented analysis of multispectral scanner data. In the soils studied where distinct light and dark patterns often distinguish the members of a drainage catena, gross soil patterns can probably be delineated from multispectral scanner data unless vegetative ground cover is almost complete. Even with partial ground cover, computer-implemented spectral mapping of soils can be done with the proper selection of pattern recognition algorithms.

Tillage practices appear to alter greatly the spectral radiance of surface soil. When areas of identical or similar tillage practices can be isolated and classified separately, a useful map of certain soil properties can be produced. In the case of the May 6, 1970, data for the test area, the computer display could possibly be used to illustrate the surface drainage features of the field.

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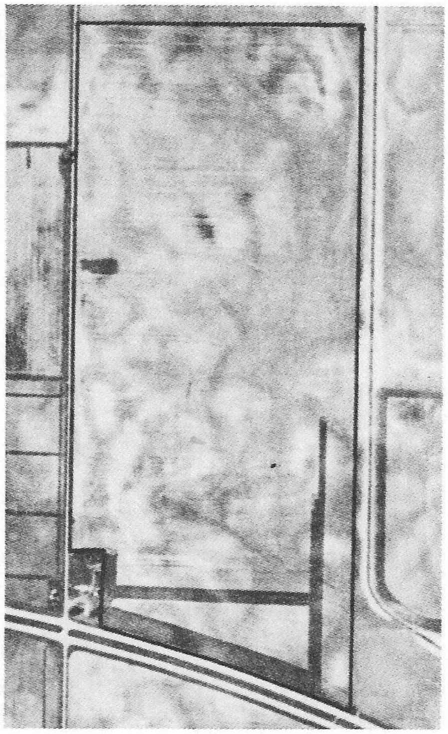

FIGURE 1. PANCHROMATIC AERIAL PHOTOGRAPH OF TEST SITE: May 6, 1970. The test site had been fall-disked and a partial residue of cornstalks was present in the depressional areas. The dark toned area had been disked shortly before this date.

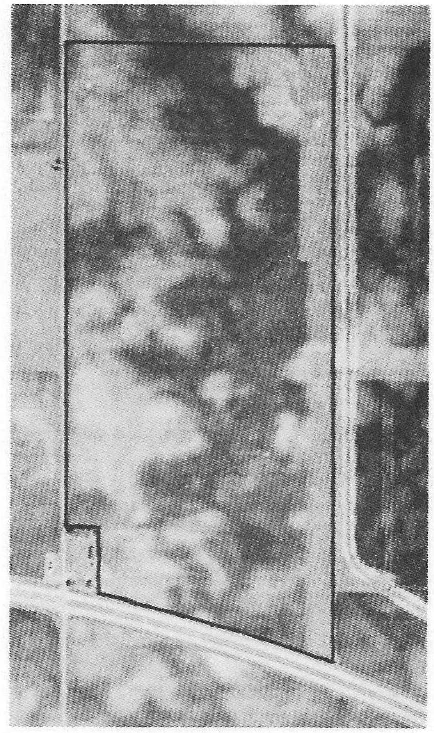

FIGURE 2. PANCHROMATIC AERIAL PHOTOGRAPH OF TEST SITE: July 1, 1970. A partial ground cover of corn and soybeans existed. Note that dark and light soil patterns show very well in spite of the ground cover.

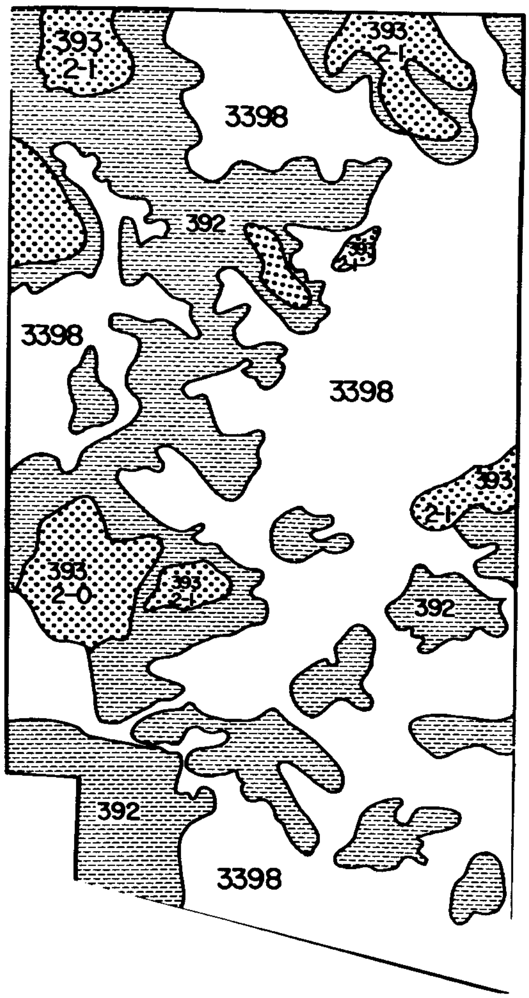

FIGURE 3. SOIL TYPE MAP OF TEST SITE. 3398: Chalmers silty clay loam; 392: Raub silt loam; 393 2-0: Dana silt loam, 2-6% slope; 393 2-1: Dana silt loam, 2-6% slope, moderately eroded.

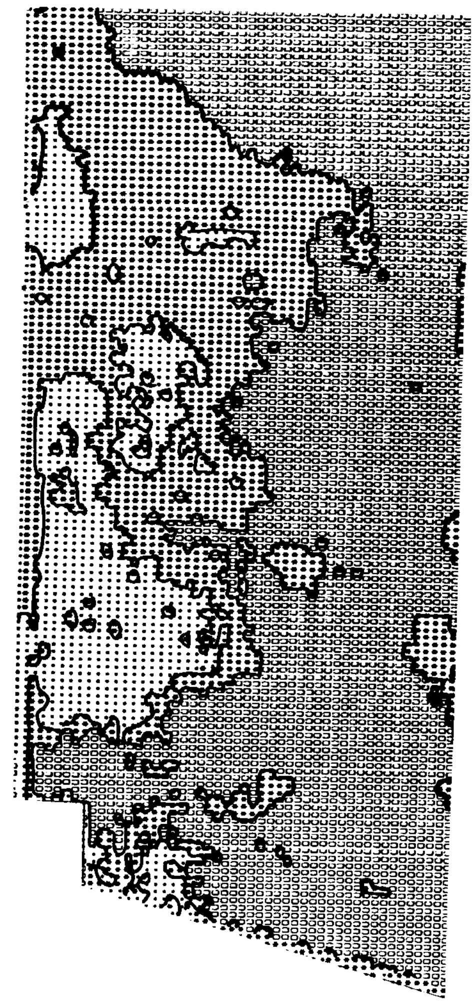

FIGURE 4. COMPUTER GENERATED SOIL SPECTRAL MAP FROM JULY 1, 1970, SCANNER DATA. Note that general soil patterns match fairly well with the conventional soil map of Figure 3.

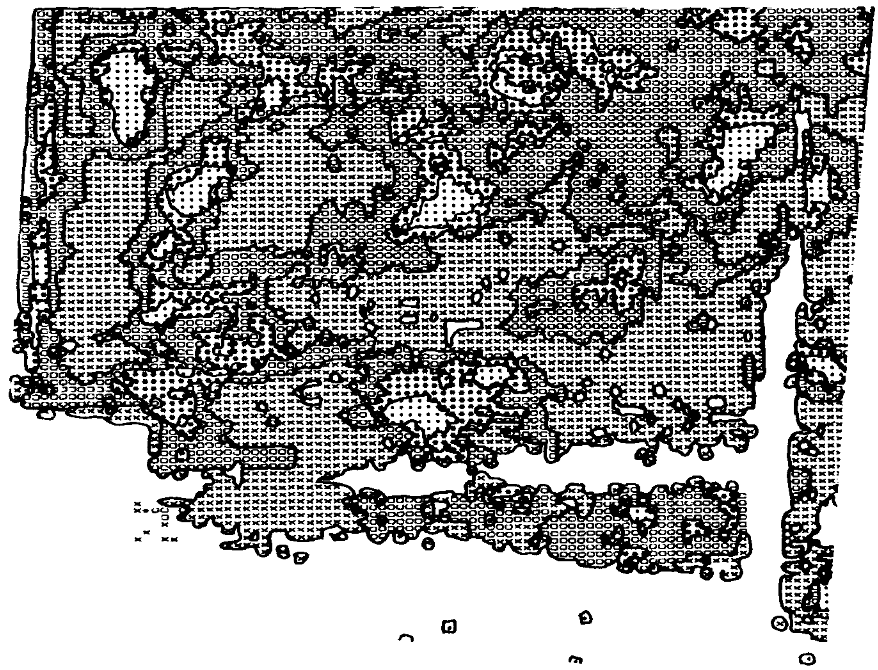

FIGURE 5. SOUTHERN PORTION OF TEST SITE, May 6, 1970, SHOWING SOIL SPECTRAL PATTERNS. Four levels of spectral response are represented. Note that most of the recently-disked area was thresholded out of the classification because of its relatively low reflective response.

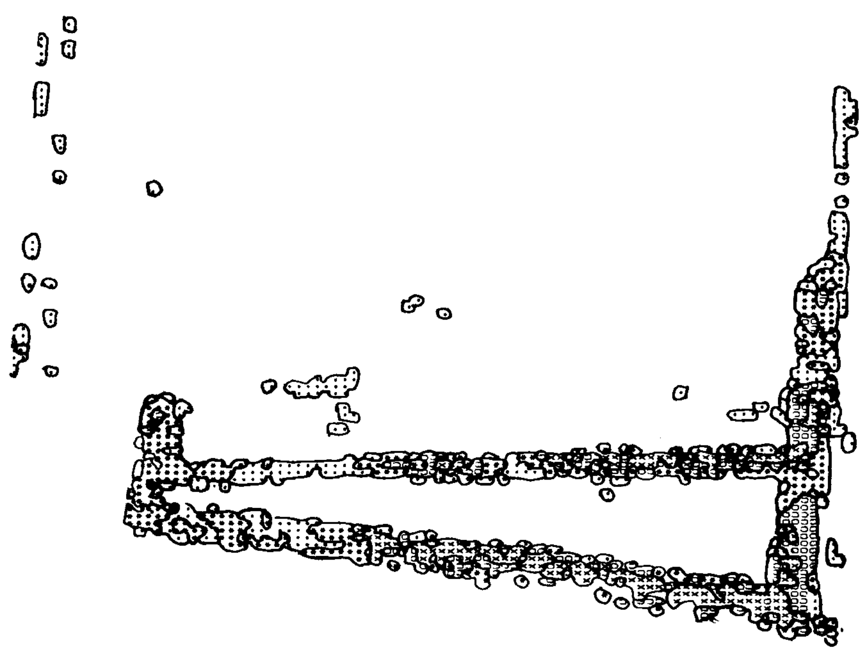

FIGURE 6. SOUTHERN PORTION OF TEST SITE, May 6, 1970: CLASSIFICATION OF RECENTLY-DISKED AREA. By isolation of this area and application of a computer clustering program, four levels of spectral response were discerned in spite of the area's low reflectivity relative to the rest of the test site.