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THE USE OF AIS DATA FOR IDENTIFYING AND MAPPING CALCAREOUS SOILS IN WESTERN NEBRASKA

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ABSTRACT

The identification of calcareous soils, through unique spectral responses of the vegetation to the chemical nature of calcareous soils, can improve the accuracy of delineating the boundaries of soil mapping units over conventional field techniques. The objective of this experiment is to evaluate the use of the Airborne Imaging Spectrometer (AIS) in the identification and delineation of calcareous soils in the western Sandhills of Nebraska. Based upon statistical differences found in separating the spectral curves below 1.3 microns, calcareous and non-calcareous soils may be identified by differences in species of vegetation. Additional work is needed to identify biogeochemical differences between the two soils.

Conventional methods for the identification of homogeneous soil mapping units rely upon selective soil sampling and landscape interpretation. While the former approach is a relatively quantitative method, the latter is dependent upon the soil surveyor's experience to accurately identify the boundaries of a soil unit (i.e., a qualitative judgement). The mapper relies upon his ability to separate soils, partly based on geobotanical observations and limited biogeochemical analysis.

Aerial reconnaisance techniques have historically assisted in delineating soil boundaries based on the ability to distinguish between relatively homogeneous vegetation communities and the identification of changes in the topography. However, subtle changes in vegetation are not always apparent on panchromatic or color-infrared aerial photography because of spectral limitations found in the visible and near-infrared portions of the electromagnetic spectrum. These variations in vegetation may be attributed to many factors, such as differences in species, moisture availability or content of the vegetation, or chemical stress.

The purpose of this experiment is to undertake a preliminary examination of the feasibility of using the Airborne Imaging Spectrometer in the identification and delineation of calcareous soils in the western Sandhills of Nebraska.

MATERIALS AND METHODOLOGY

Two soil series were selected for this experiment (Map 1). An Els-Tryon complex, 0 to 3% slopes, was selected as the non-calcareous soil, and a Els calcareous-Wildhorse fine sands, 0 to 3% slopes, to represent the calcareous soils. Both locations are similar in range site and type of vegetative cover (e.g., short meadow grass). These soils were identified and mapped by the Soil Conservation Service recently, and laboratory data on the chemical and mineralogical composition of the soils were not available at the time of this study.

A flight by the Airborne Imaging Spectrometer was made over the study site on August 6, 1984, at approximately noon. The sky at the time of the flight was free from clouds or apparent atmospheric haze. Spectral data were collected under the "rock" mode (GPOS 1-4) and were obtained at a spatial resolution of approximately ten meters.

Processing of the spectral data collected by the scanner was initially made on a Harris 700 computer, with an IBM/PC microcomputer used to analyze data subsets and generate graphics. Statistical analysis was made through the Statistical Analysis System (SAS) software on an IBM 3081 mainframe computer. All software, except for the multivariate statistical programs, were developed and implemented locally at the University of Nebraska-Lincoln.

Six locations (pixels) were selected for an area covered by the Els-Tryon complex (non-calcareous) soils, and three locations to represent the Els calcareous-Wildhorse fine sands (Figure 1). All one hundred and twenty-eight channels were extracted for each of the nine samples. The raw data were used for all analyses and were not adjusted for atmospheric corrections.

Cluster analysis was used to test for statistical separation ($p < .05$) between the two training sites to insure that spectral differences were present. Dimension reduction of the one hundred and twenty-eight channels was accomplished after the cluster analysis through a t-test ($p < .05$).

RESULTS

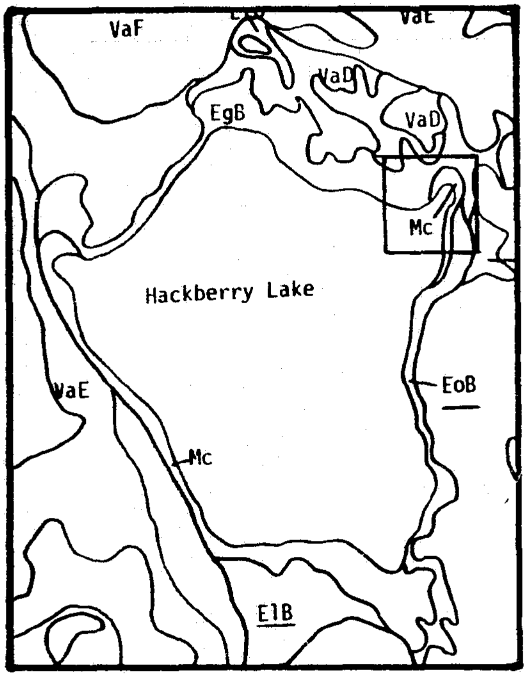
Figure 2 shows the spectral curves for the average of the six pixels from the non-calcareous soil and the three pixels from the calcareous soil. Except for channels one through fifteen (1150.7 - 1288.8 nm), the curves are almost superimposed upon one another.

FASTCLUS, from the SAS cluster analysis set of programs, verified that the two locations contained spectral curves which were more similar within the training sites than between the two training sites.

With this test of separatability providing evidence that the two test sites are probably spectrally distinct from one another, T-TEST was used to reduce the number of dimensions down to those wavelengths which explained statistically where the greatest difference between the two sets (locations) of spectral curves occurred.

According to the results obtained from the t-test, channels one through fifteen (1150.8 - 1288.8 nm), thirty-three (1448.4 - 1457.6 nm), eighty-one (1892.0 - 1901.3 nm), and one hundred and six (2127.2 - 2136.5 nm) were statistically different between the calcareous and non-calcareous soils. Figure 3 shows the same curves as were shown in Figure 2 except for the removal of the curve segments which were determined to be statistically similar to one another.

Possible explanation for the observed differences may be found in channels one through fifteen. Empirical evidence has shown that this region in the spectrum is associated with morphological features of vegetation, indicating that the two curves may represent two different types of vegetation (no field data has been collected to confirm this supposition; however, the difference in the pH between the two soils may influence the type of vegetation found at the two



Map 1. Soils map around the study site (boxed area). The calcareous soil in this study is represented by EoB and the non-calcareous soil by EgB.

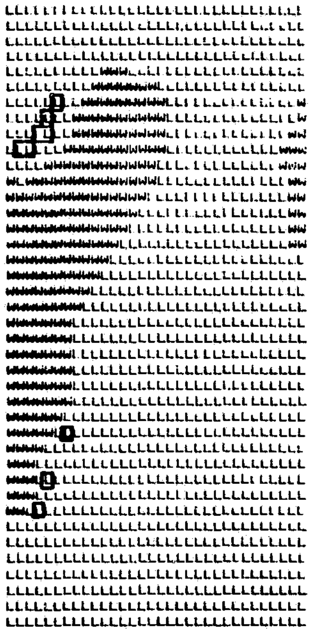


Fig. 1. Location of the sampled pixels (water body corresponds to the upper right inlet of Hackberry Lake in Map 1). L = land surface, W = water

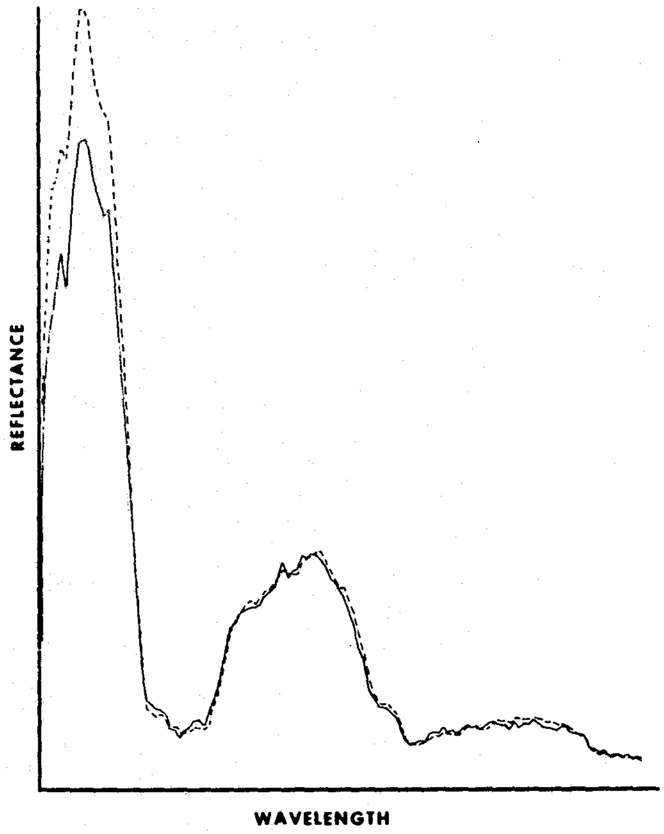


Fig. 2. Averaged spectral curves for non-calcareous soil (dash line) and calcareous soil (solid lines).

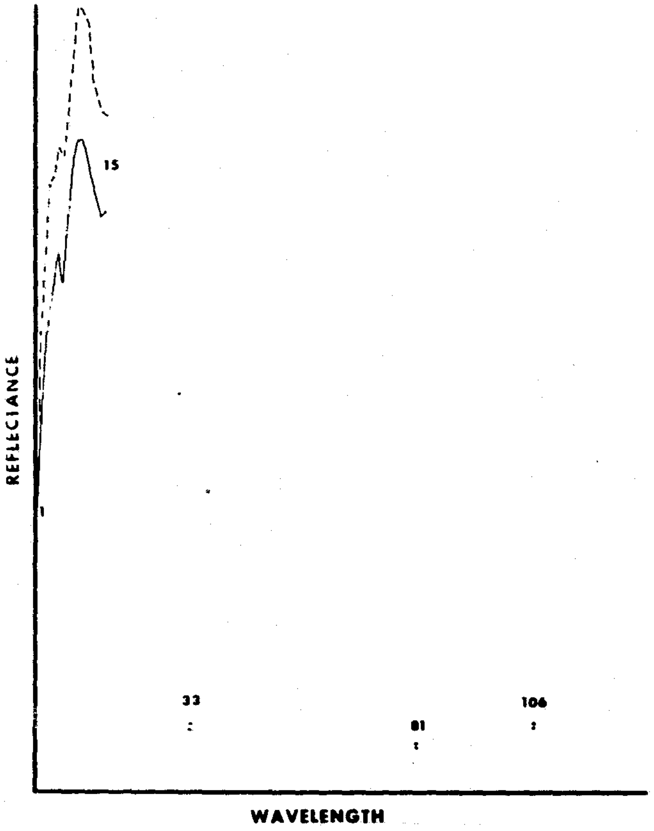


Fig. 3. Figure 2 after running a t-test against the raw spectral data. The line segment and the three discrete points indicate wavelengths where statistical differences occur between the two curves.

sites). Explanation for the effect the three discrete spectral (channels thirty-three, eighty-one, and one hundred and six) has not been investigated at this time.

CONCLUSIONS

With the limited ground truth available at the time of this study, it appears that a separation between a calcareous and a non-calcareous soil can be made based upon geobotanical differences between the two soils is not readily apparent, but may possibly be found in one of the three discrete channels not analyzed in this study. It may also be beneficial to pre-process the raw data to remove atmospheric interferences as well as investigate additional signal processing and statistical techniques.