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IN SITU SPECTRORADIOMETRIC QUANTIFICATION OF ERTS DATA

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ABSTRACT

The task of correlating in situ spectral reflectance measurements with ERTS imagery has commenced. A method of additive color analysis of a single multispectral band taken on different dates indicates that ERTS-1 bulk images have sufficient spatial and spectral fidelity to show indications of the presence of soil moisture in desert playas and changes in soil moisture with time. The chain of causality between soil moisture, in situ spectral reflectance, and ERTS multispectral scanner image density remains to be established during the subsequent phases of this study.

1. INTRODUCTION

This project was undertaken by Long Island University to establish the relationship between in situ spectral reflectance measurements and the photometric characteristics of ERTS-1 multispectral scanner imagery. All imagery of the test site at Willcox Playa, Arizona, which was received was cloud free; however, clouds obscured a test site at Prescott National Forest, Arizona, where in situ spectral reflectance measurements were being obtained during the 27 September-2 November 1972 period of ERTS-1 image acquisition.

A "first look" analysis of the imagery was performed using a multispectral color viewer. The additive color analysis revealed the existence of significant spectral reflectivity differences in the Willcox Playa between 27 September and 2 November 1972. A time sequence analysis of the 600-700 nm (red) band was performed for the ERTS-1 acquisition dates of 27 September, 14 October, and 2 November 1972. This method of time sequence analysis permitted the association of differences in soil moisture over time with the color of the multispectral display. ERTS-1 bulk images were found of sufficient spatial fidelity to allow good image registration of the image of the Willcox Playa.

2.1 PRESCOTT, ARIZONA - COPPER BASIN

The Copper Basin lies to the east of Prescott and contains a wide variety of soil types and vegetation. The tree species which predominate are juniper, manzanita, and pine. They grow in regions containing pyrite, diorite, limestone, and shale. The Spectral Data telespectroradiometer was used to measure the reflectance spectra of the pine species. A group of sixty targets was used, with each set consisting of three scans. The three scans were averaged and the envelope of all pine species reflectance is shown in Figure 1. Although the amplitude of the curves differs, the basic distribution of the data is consistent. It was anticipated that stands of these pine trees could be differentiated from the other vegetation

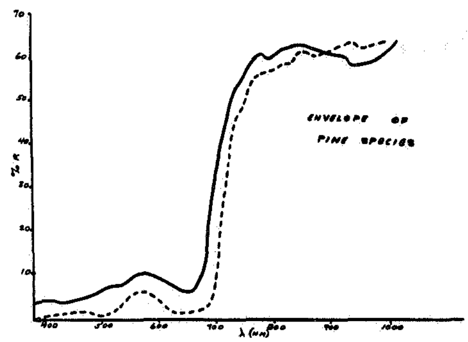

Figure 1. Envelope of spectral distribution of sixty samples pine species, in Copper Creek region, Arizona.

seen on ERTS-A imagery. However, the only frame of ERTS imagery which has been received contains a cloud directly over the test site. Simultaneous with the measurement of the spectra, a low-altitude flight was made over the Copper Basin area. Two sets of filters were used on the Spectral Data Model 10 multispectral camera: a broad band set approximating those on ERTS-A and a narrow band set consisting of two visible and two near-infrared bands. The multispectral low-altitude color composite results, which simulated true color or Ektachrome film, show no differentiation between the juniper, manzanita, and pine trees. The simulation of Ektachrome Infrared film does not discriminate between the species either. Figure 2 is a map of the pine trees (represented as dots) and the juniper-manzanita areas (represented as crossed areas) for a small region along Copper Creek. This map corresponds to the multispectral additive color imagery analyzed. Synthesizing the narrow band imagery by projecting the two visible bands as blue and red and the near-infrared band as green shows a distinct difference between pine trees and the other two species.

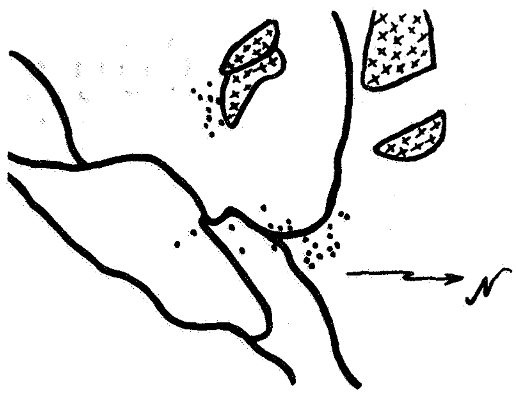

Figure 2. Ground truth of pine versus juniper-manzanita trees in Copper Basin.

Pine trees are displayed as a vivid yellow, while juniper and manzanita are green. The low-altitude imagery was analyzed using the Spectral Data Model 64 viewer; the composite imagery was photographed off the viewer screen.

2.2 WILLCOX PLAYA, ARIZONA

The Willcox dry lake consists of a flat, shallow clay type surface which much of the time is hard and cracked due to the great evaporation which occurs during the heat of the day. The Playa is subject to a wide change of environmental conditions. That is, periodic heavy rainstorms wash down soil from outlying regions, thereby flooding parts of its surface. Its boundaries alter with time; windstorms blow loose gravel and sand, depositing it in other areas which did not contain that soil base. Because of its dynamics, Willcox Playa was chosen for spectral analysis of its soils and multispectral image analysis of changes in spectral distribution within the area as a function of time. Figure 3 shows the general terrain of the dry lake bed. The area is approximately ten miles square and is surrounded by elevations up to 7500 feet; an alluvial fan exists to the west. Surface cracking appeared in the test sites which were measured. In addition to the large truck-mounted telespectroradiometer, a smaller unit measured the reflectance close to the surface. Both types of data were obtained at two stations, the averages of which are shown in Figure 4. Within the accuracy of the

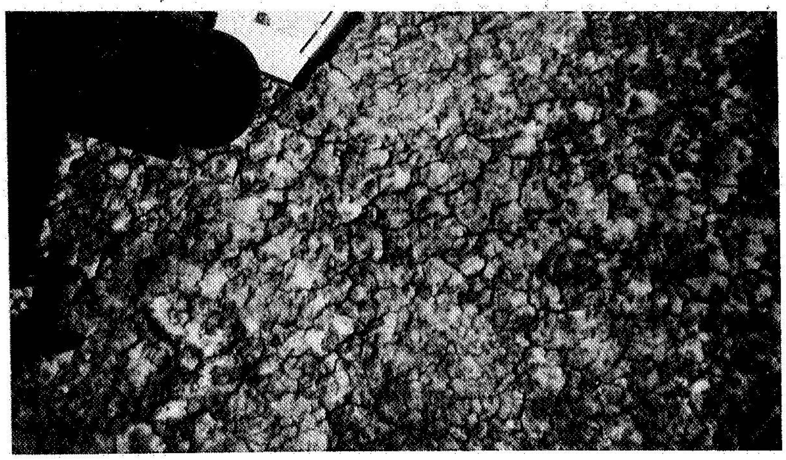

Figure 3. Close-up of the surface of the northwest portion of Willcox Playa when dry.

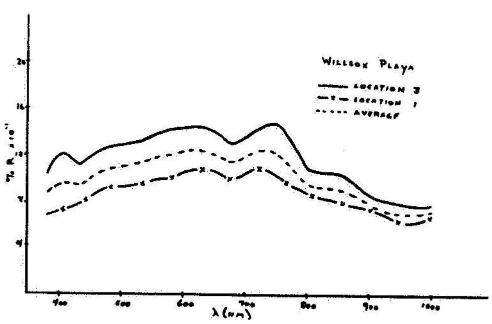

Figure 4. Soil reflectance at two locations in Willcox Playa.

telespectroradiometer (2 1/2% in the visible range and 5% in the near-infrared) it is apparent that the soil reflectance distribution is almost the same. The average is shown as the center curve. However, the brightness of the two locations differs and this has been attributed to the presence of the moisture which existed in location #   at the time of measurement. Apparently this moisture did little to bias the reflectance data in the red region which had previously been suggested. Within four days of obtaining these measurements, the ERTS-A satellite made a pass over the Willcox area. Figure 5 shows a black-and-white composite of that frame with the entire portion of the dry lake achromatic or essentailly the same shade of gray. Neither the multispectral composite simulation of true color (the green band projected as cyan and the red band projected as red) nor the simulation of Ektachrome Infrared (the green band projected as blue, the red band as green, and the near-infrared band as red) showed any visible signs of reflectance change between September 27, October 14, and November 2. A distinct change in brightness did exist between the individual data, but the color remained the same. It was concluded, therefore, that changes in the soil moisture conditions were too small to be seen in a conventional multispectral composite for any given overflight. However, the dynamics of soil moisture were studied

Figure 5. Black-and-white multispectral composite of ERTS-A image over Willcox Playa, September 27, 1972.

on a temporal basis using the NASA release band 5 positives for September 27, October 14, and November 2. The Playa itself was located in a different position of the frame for each date so that only the intersect of the three images was recombined in additive color. The September 27 band 5 was projected as blue, the October 17 band 5 as green, and the November 2 band 5 as red. Ordinarily the colors in a multispectral display are indicative of reflectance differences which exist as a function of wavelength. However, the vivid color differences which were seen in the time sequential multi-spectral photo represented reflectance changes in the red spectral region as a function of time. The colors within and surrounding the Playa may be interpreted as follows:

-- A colorless shade of white or gray indicates no change in surface moisture content between 27 September and 2 November 1972.

-- Yellow indicates areas where a decrease in soil moisture occurred between 27 September and 14 October and little change from 14 October to 2 November.

-- Orange also indicates a decrease in soil moisture between 27 September and 14 October, coupled with a reduced rate of decrease to 2 November.

-- Cyan or red are areas where moisture changed little between 27 September and 14 October, then increased greatly by 2 November.

-- Red indicates areas where surface water did not change between 27 September and 14 October, then decreased between 14 October and 2 November.

-- Green indicates a reduction in surface moisture from 27 September to 14 October and an increase between 14 October and 2 November.

-- Blue indicates the opposite effect from those areas that appear yellow; i.e., surface moisture increases between 27 September and 14 October with no change between 14 October and 2 November.

3. CONCLUSIONS

ERTS-1 bulk multispectral scanner imagery, when recombined in a single additive color presentation, show color differences which are related to spectral reflectance changes of desert dry lakes (Playas). When the same bands acquired at different times are reconstituted in color, changes in reflectance at the same wavelengths with time are shown as colors.