Paper L 10

GEOGRAPHIC APPLICATIONS OF ERTS-1 DATA TO LANDSCAPE CHANGE

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ABSTRACT

The analysis of landscape change requires large area coverage on a periodic basis in order to analyze aggregate changes over an extended period of time. To date, only the ERTS program can provide this capability. Three avenues of experimentation and analysis are being used in the investigation: (1) a multi-scale sampling procedure utilizing aircraft imagery for ground truth and control, (2) a densitometric and computer analytical experiment for the analysis of gray tone signatures, comparisons and ultimately for landscape change detection and monitoring, and (3) an ERTS image enhancement procedure for the detection and analysis of photomorphic regions.

INTRODUCTION

The ERTS-I capabilities of sensing the same geographic point every 18 days and providing a 13,225 square mile view from each image challenge us to the task of analyzing landscape change from a regional perspective. The investigation focuses on the East Tennessee Test Site, a 20,000 square mile region in which landscape change elements such as forest alterations, strip mines, highway construction, urban-suburban growth, and cyclic seasonal changes in agriculture are being analyzed (Figure 1). Two test sites of smaller dimensions are being intensively studied within the larger test region. The Knoxville Test Site, an 11 x 21 mile area which encompasses the city of Knoxville and the western portion of Knox County, is being investigated for landscape change associated with urban growth. A second smaller test site on the Cumberland Plateau is being monitored for forest alterations and landform disturbances associated with surface strip mining for coal. Unfortunately, the humid East is not the most ideal region for landscape change analysis because the high percentage of cloud cover has reduced the number of useable satellite observations to three for our study area since August.

Three avenues of experimentation and analysis are being used in the investigation: (1) a multi-stage, multi-scale sampling procedure, (2) a densitometric and computer analytical experiment, and (3) an image enhancement procedure.

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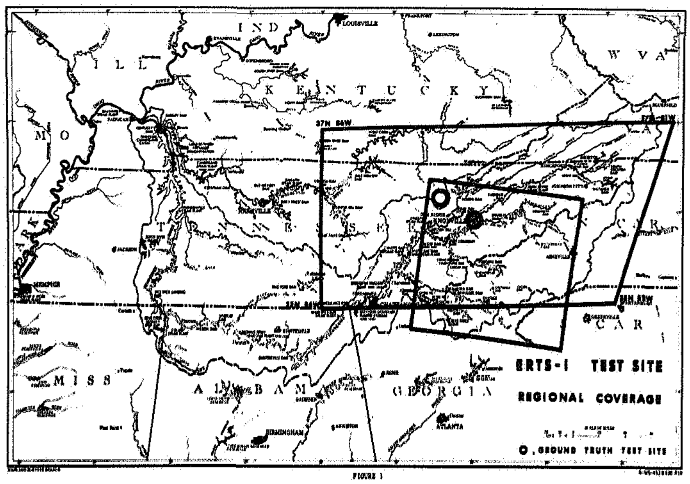

Figure 1 - The East Tennessee Test Site with a representative ERTS frame for scale.

The multi-stage sampling experiment has involved the generation and analysis of low altitude imagery flown from 10,000' in June-August, high altitude aircraft imagery from a NASA RB-57 overflight at 60,000' in April, and the ERTS-I imagery since August. Primarily designed as a source for ground truth data, the aircraft imagery has proven its value in establishing a control base for comparisons with the ERTS imagery.

The intermediate scale imagery from the April RB-57 overflight has been most useful for control. Figure 2 of the Cumberland Plateau Test Site illustrates in a negative print the nature of strip mine scars on the landscape for this area. At this scale one can see not only the modified land surface but also the internal characteristics of the surface mines. Note the extent of cleared, stripped land and the forested area at the bottom of the image for this observation in April. Now, in Figure 3 viewing the same area from an enhanced ERTS image for October 15, one can detect a distinct increase in dark tones indicating cleared land in the area that had been forested in April. This represents a significant landscape change.

Microdensitometric and computer techniques are being used to analyze the ERTS imagery for gray tone signatures, comparisons, and ultimately for landscape change detection and monitoring. Using the same strip mine example, let's observe the same patterns of surface configuration on the computerized map (Figure 4). The experiment involves the microdensity scanning of a positive band 5 image in which strip mines appear as light tones against a dark forested

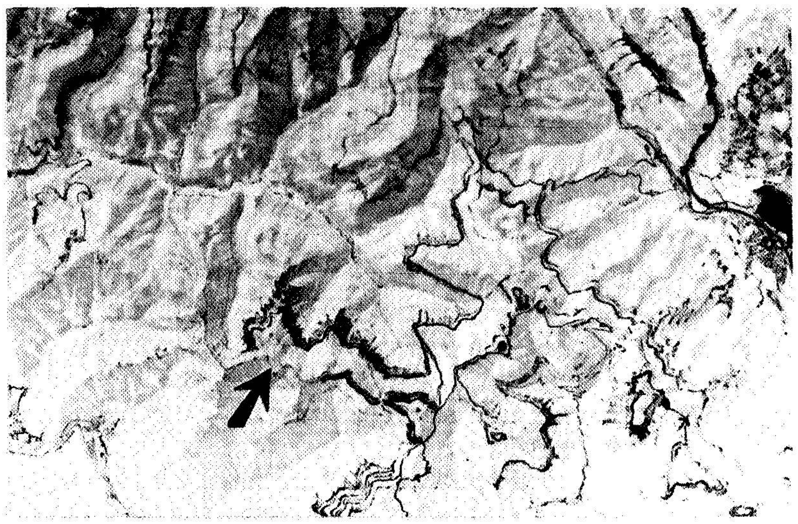

Figure 2 - A portion of an RB-57 image of the Cumberland Plateau illustrating surface mining scars in April, 1972. Note the unmined area indicated by the arrow.

Figure 3 - A portion of an ERTS image of the Cumberland Plateau indicating landscape changes in surface mining scars in October, 1972. Note the mined area shown by the arrow.

background. Gray tone densities are then digitized and computer processed into a computer map and histogram (frequency distribution). By comparing such machine analyzed data from different dates of satellite observations, we can determine if the number of light tones indicating strip mined areas have increased at the expense of dark tones for the same area.

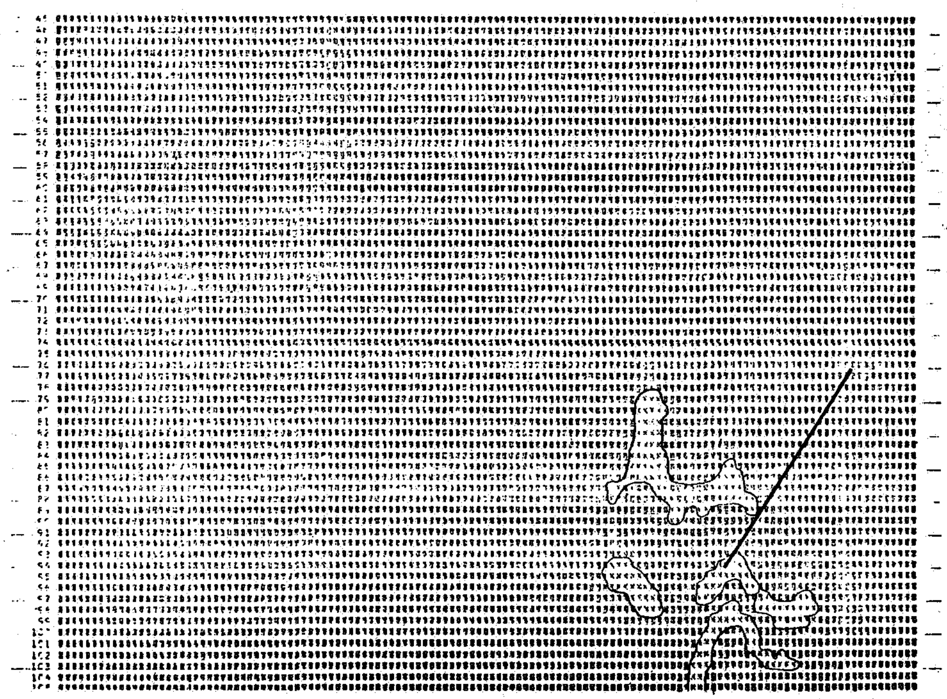

Figure 4 - Microdensity scan displayed in a computer map printout illustrating the same surface mine signatures from an ERTS band 5 image. See figure 3.

Barring extraneous signals from cloud cover, one then should be able to conclude that forest cover has been altered and strip mines have been increasing because of the increased frequency of light toned signatures.

Comparisons between the two histograms in figure 5 with the upper one representing August 22 and the lower one October 15, have resulted in the inverse from the expected. This is because only two relatively clear observations for the strip mined area have been obtained and the atmospherics on August 22 created a serious cloud and haze problem. Given time and more but clearer observations, these problems can be rectified.

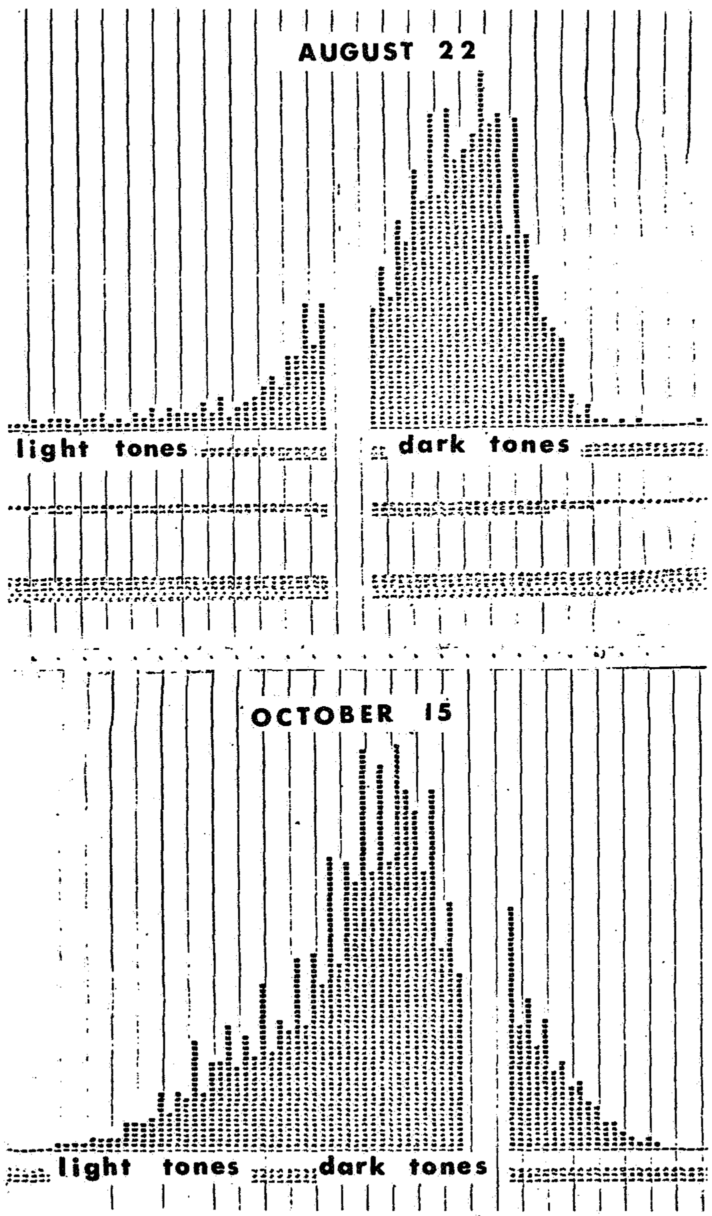

Figure 5 - Histograms of gray tone densities. ERTS band 5 images for August 22 and October 15, 1972.

In addition to this experiment, applications toward earth resources management problems involve the generation of enhanced

ERTS imagery for emphasizing areas of potential and current landscape dynamics. In this regard several photomorphic regions have been under observation.

The Great Smoky Mountains represent a region of cyclic, seasonal change for which natural and not man-made causes predominate. Figure 6, a negative print from band 7, illustrates a temporary landscape change phenomenon of a surficially wetted area on the western, windward slopes of the Smokies. The day preceding this ERTS observation, a frontal disturbance deposited approximately 2"-3" of rainfall on the windward slopes. By comparison, Knoxville, located downslope in the valley received 1.12" of precipitation. The wetted surface shown here in white tones was sufficiently wet to register in tones not unlike the surrounding streams and T.V.A. reservoirs to the north and west. The satellite monitoring of a water-shed such as this indeed has application toward water resources, flood prediction, and a host of other water management problems.

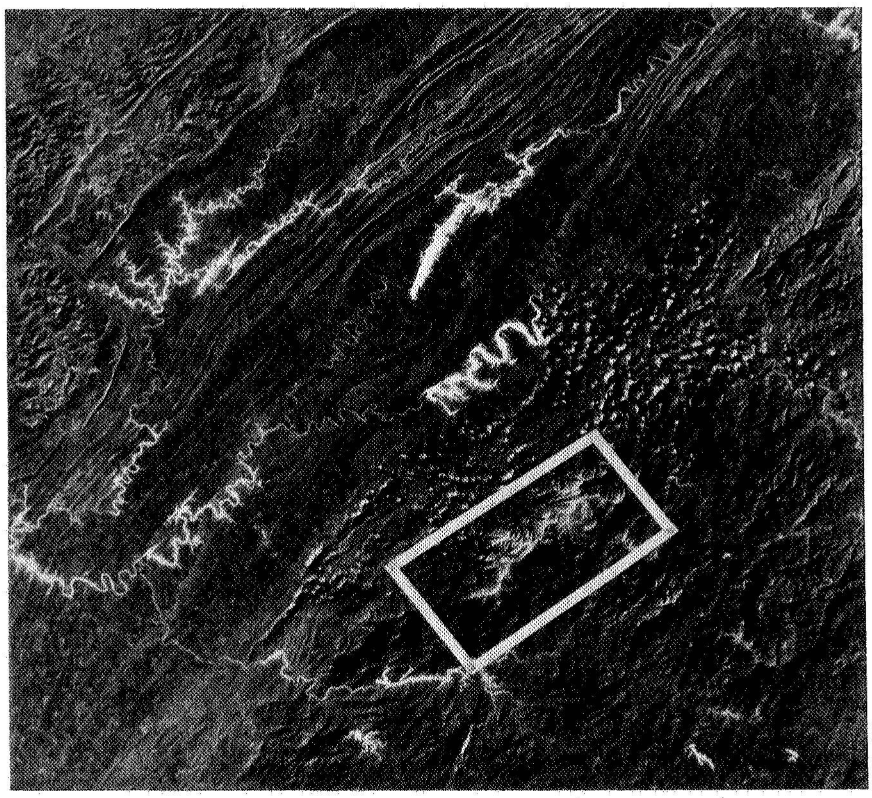

Figure 6 - ERTS band 7 negative print of the East Tennessee Test Site. Note light toned wetted surface on the Great Smoky Mountains.

One of the more humanly responsible photomorphic regions is illustrated by the enhanced band 5 image in figure 7. Using a positive transparency as a negative we have produced a negative print which enhances normally light toned cultured features into dark ones. Reading black on white, one can observe a broad agricultural area in the eastern portion of the Great Valley and the spider web effect of roads and routes leading to Knoxville. The built up area of Knoxville and suburban growth areas to its west appear much sharper on this image than on the normal black and white. The black dots and lines of deepest intensity indicate areas of highest reflectance for band 5 and generally for this area represent areas of cleared earth. Such bare red soil surfaces are best illustrated by the I-81 interstate highway construction in the northeast portion of the image. Westward one can see again the strip mines enhanced as black jagged lines on the Cumberland Plateau.

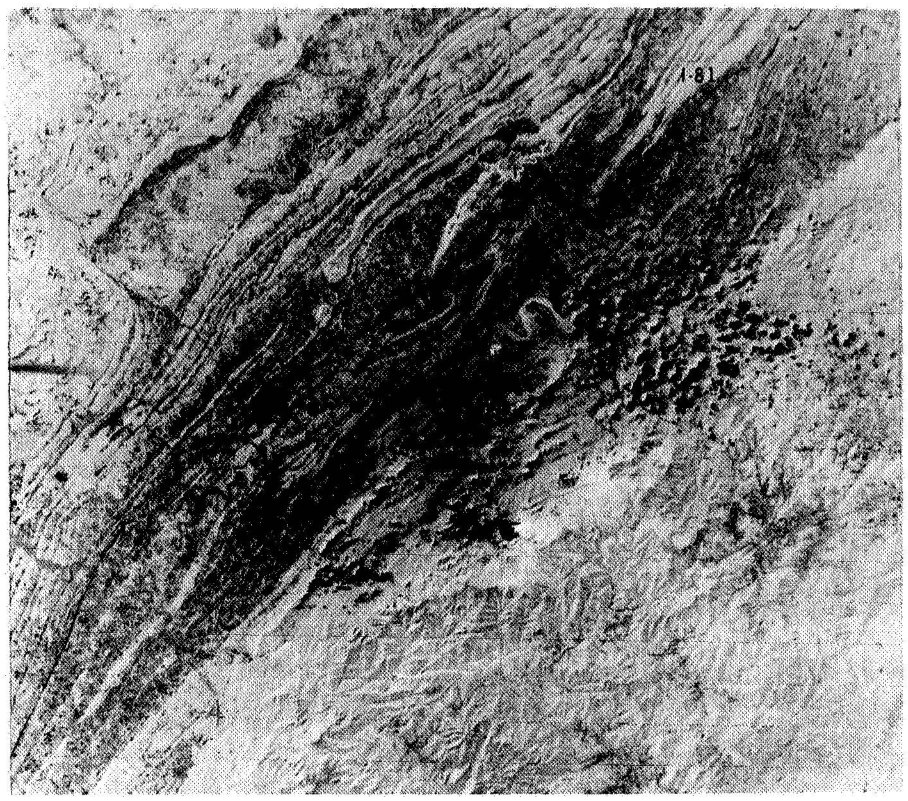

Figure 7 - ERTS band 5 negative print of the East Tennessee Test Site. Note urban and agricultural areas - man-made landscapes - shown in dark tones. Disregard clouds at right.

In each photomorphic region we can determine a certain and separate degree of tonal unity and distinctiveness. More importantly, a management and landuse distinction exists in each region. On a positive print, dark toned rough forested lands indeed represent a different tonal and landuse quality than do light toned, cleared cultural landscapes (Figure 8). Although forested vs cleared land surfaces are understood in detail here on earth, one requires the region-wide view to analyze such regional variations and to express to the general public the importance of such distinctive regions. In many ways, variations like these in tonal quality, reflect variations in earth resources and thus suggest a different set of values and management principles to be applied to each.

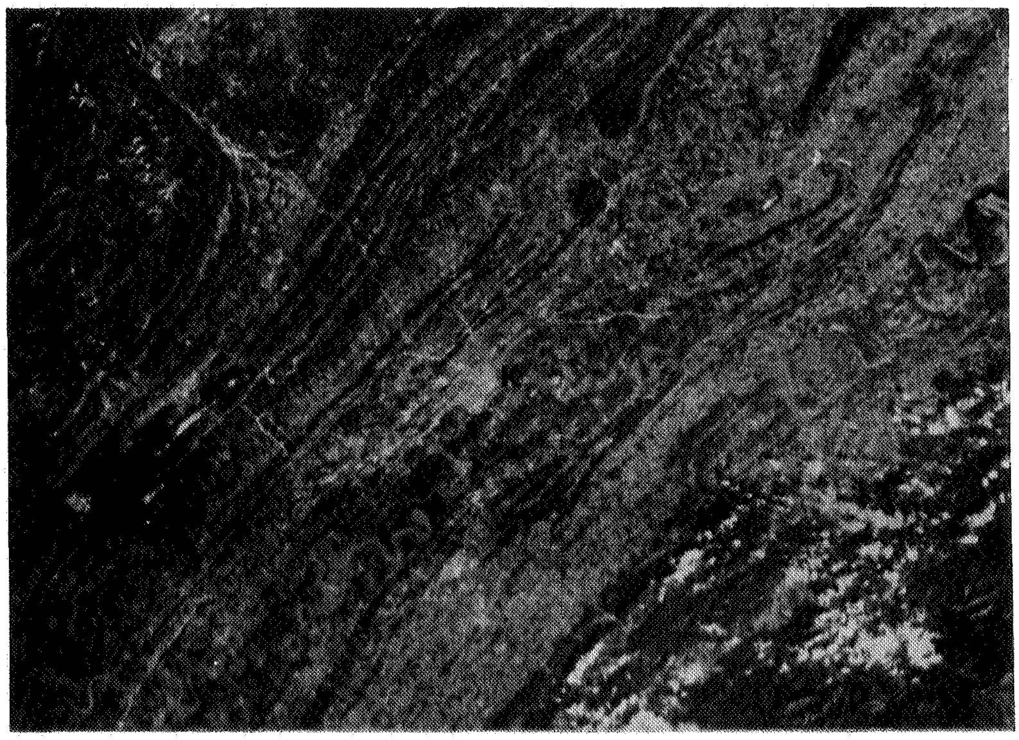

Figure 8 - ERTS band 5 positive print of a portion of the East Tennessee Test Site.

Because man's individual actions in creating landscape change are relatively small on a cell for cell basis, any investigation such as this one requires large area coverage on a periodic basis in order to observe and analyze aggregate changes over an extended period of time. To date, only the ERTS program can provide this capability. The continued analysis of data from ERTS-I and, more importantly, from ERTS-B would insure a success in the analysis of landscape change from a geographic point of view and would be a contribution in the study of man's role in changing the face of the earth.