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TERRAIN CLASSIFICATION MAPS OF YELLOWSTONE NATIONAL PARK

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ABSTRACT

A cooperative ERTS-1 investigation involving U. S. Geological Survey, National Park Service, and Environmental Research Institute of Michigan (ERIM) personnel has as its goal the preparation of terrain classification maps for the entire Yellowstone National Park. Excellent coverage of the park was obtained on 6 August 1972 (Frame 1015-17404).

Preliminary terrain classification maps have been prepared at ERIM by applying multispectral pattern recognition techniques to ERTS-MSS digital taped data. Training sets for the study were selected by Dr. H. Smedes and Mr. Ralph Root (a Colorado State University student assisting Dr. Smedes). The color coded terrain maps will be presented and discussed. The discussion will include qualitative and quantitative accuracy estimates and discussion of processing techniques.

1. INTRODUCTION

Since 1967, the staff of the Environmental Research Institute of Michigan (ERIM) and Dr. Harry Smedes of U. S. G. S., Denver have explored the use of remote sensing in Yellowstone National Park. Recently, National Park Service personnel and students at Colorado State University have joined the team.

Processed aircraft multispectral scanner data showed great promise for classifying important terrain categories in Yellowstone National Park. The goal of the ERTS-1 experiment now underway was to prepare terrain classification maps of the entire Yellowstone National Park using ERTS-1 MSS data. These data are to be machine processed by software currently available at ERIM. Training set selection and map verification are being done by Dr. Smedes and the students, while the National Park Service, the final users of the product, assisted in the definition of classes to be mapped.

2. PROGRESS TO DATE

Yellowstone National Park was covered in a number of ERTS-1 passes in August and September 1972. While many of the data sets were usable, the 6 August data set (frame 1015-17404) was clearly superior. No cloud cover is apparent over any portion of the park, and all channels of data (in imagery form) were free of artifacts. This data set was selected for analysis (Figure 1).

While routine digital formatting operations were carried out at ERIM, Dr. Smedes and students began an intensive ground effort to define training set categories. The training sets fall into five distinct cover classes -- 1) water, 2) exposed rock of various types, 3) grasslands of varying degrees of cover, 4) coniferous forest with different degrees of cover and different substrata, and 5) lowland/marsh vegetation areas. Several separate samples were selected for each of the cover classes. The locations of these samples were phoned to ERIM. We then performed signature extraction and analysed the signatures.

The signature analysis revealed that a number of different classes could be separated. We then decided, as a preliminary step to prepare a five category terrain classification map. The results of this map, we felt, would give us a basis for evaluating the success of more detailed mapping efforts to follow. Before preparing the recognition map, two analysis steps were performed. First, the individual signatures comprising each of the five classes were combined to yield five category inclusive, composite "super signatures", accounting for geographical and componential variability within each class. Then, optimum channels for classification were determined. The results of this step are shown in Table I below. The average probability of misclassification is an estimate of the percentage of points which will be incorrectly classified on the recognition map. Channel 2 (MSS-5) proved to be the single best channel. The combination 2, 4, 3 proved to be only slightly worse than using all four bands in the spectral classification process.

We decided to use all four bands in the spectral classification process. The recognition map was prepared on the ERIM 7094 computer. A color coded presentation was chosen portraying water in blue, rock and soil areas in red, and various vegetation classes in green (See Figure 2).

TABLE I

AVERAGE PROBABILITIES OF MISCLASSIFICATION
FOR FIVE CATEGORY RECOGNITION

Channels	Average Probability of Misclassification
2	.086
2,4	.031
2,4,3	.028
2,4,3,1	.027

3. FIVE CATEGORY RECOGNITION ANALYSIS

Recognition processing resulted in the entire scene being classified into the generalized vegetation communities and physical landscape features described elsewhere. Quantitative estimation of recognition accuracy are not yet available, but comparison of observable boundary features, e.g., lakeshore perimeters, timberline and forest-grassland ecotones, indicate high correlation with image occurrence on topographic maps and aerial photography.

Clear water bodies were effectively recognized and drainage patterns are quite evident. Occasional blue symbols marking the presence of streams or rivers aids in separating grass covered ridgetops from valleys. Further definition of drainage patterns could undoubtedly be achieved locally by mapping every digital resolution element, rather than every other element as we have done here.

Cultural features and hydrogeothermal areas dominated by stone construction, pavement and large expanses of sparse vegetation are solidly recognized in the <u>light rock</u> category. High density visitor use areas such as Thumb-Grant Village, Fishing Bridge and Canyon Village are easily distinguished. Additionally, well known sites of thermal activity including the upper, lower, and Norris Geyser Basins are also fully delineated. Perhaps even more significant, many of the smaller centers of hydrogeothermal activity are detectable; Sulphur, Vermillion and Pelican Springs and Brimstone Basin are all observable ringing Yellowstone Lake.

The rugged, exposed slopes of the Gallatin, Beartooth and Absaroka Ranges are appropriately identified as <u>light rock</u>. At lower altitudes, large exposures and rock outcrops in the Grand Canyon of the Yellowstone and Lamar and lower Yellowstone River Valleys are accurately depicted. As indication of potential future mapping detail, sand bars framing the upper Yellowstone River meanders are recognized.

Lowland meadows and wetlands characterizing the lake margins and many of the valleys also help to emphasize the drainage system, and begin to reveal the ecological structure of the non-forested landscape when their occurrence is contrasted with that of the grass-sage community.

Dominating the upper slopes of valleys up to the forest edge and again beyond timberline, the grass-sage community is most apparent in the upper Yellowstone and Lamar River Valleys and Pitchstone Plateau.

Future recognition efforts will concentrate on separating environmentally significant sub-categories within these basic cover types. Spectral analysis of data located on transects oriented along vegetation cover type and altitudinal continua is expected to reveal the feasibility of this objective. Particularly, we wish to investigate individual forest species recognition, separation of different densities of coniferous forest cover and detection of forest types on different substrates.

4. SIGNIFICANT RESULTS

Several significant results have resulted from this investigation:

1. Accurate five category terrain classification maps have been made through computer processing of ERTS-1 multispectral scanner data collected over Yellowstone National Park in August 1972.

2. The five categories recognized were exposed rock and soil, water, coniferous forest, grass-sage vegetation, and lowland grassy vegetation.

3. Further analysis is expected to yield maps with improved detail in the five general categories above.

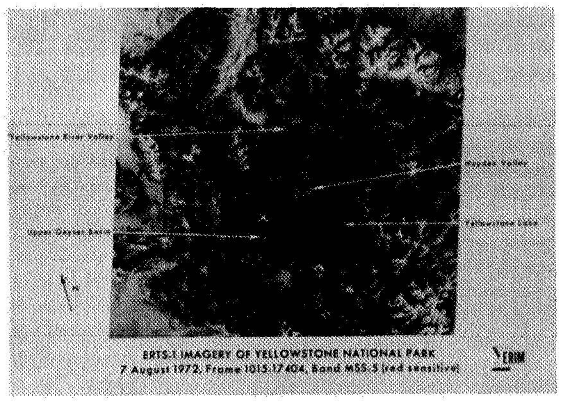

Figure 1
Yellowstone National Park Imagery

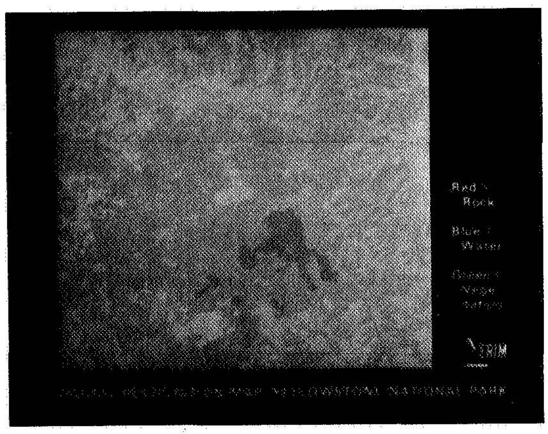

Figure 2
Yellowstone National Park Recognition Map