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Paper A 20

FOREST AND RANGE MAPPING IN THE HOUSTON AREA WITH ERTS-1 DATA

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ABSTRACT

ERTS-1 data acquired over the Houston area has been analyzed for applications to forest and range mapping. In the field of forestry the Sam Houston National Forest (Texas) was chosen as a test site, (Scene ID 1037-16244). Conventional imagery interpretation as well as computer processing methods were used to make classification maps of timber species, condition and land-use. The results were compared with timber stand maps which were obtained from aircraft imagery and checked in the field. The preliminary investigations show that conventional interpretation techniques indicated an accuracy in classification of 63 percent. The computer-aided interpretations made by a clustering technique gave 70 percent accuracy.

Computer-aided and conventional multispectral analysis techniques were applied to range vegetation type mapping in the gulf coast marsh. Two species of salt marsh grasses were mapped. Aside from their importance for grazing and wildlife habitat, the separation of marshhay cordgrass *(Spartina patens)* and gulf cordgrass *(Spartina spartinae)* locations may be significant in coastal zone management since the natural boundary between the two species approximately marks a change in elevation as small as three inches above sea level. Preliminary results indicate the two types are separable in ERTS-1 MSS data, (Scene ID 1073-16251), both manually and automatically.

1. INTRODUCTION

The ERTS-1 Forest and Range Analysis Teams at the Johnson Space Center (JSC) are investigating the utility of ERTS-1 data for mapping forest and range vegetation types for four study areas in the Houston Area Test Site. This report summarizes preliminary results from two of the study areas, the Sam Houston National Forest Study Site, and the San Bernard Range Study Site.

The authors acknowledge aid and cooperation from personnel of the USDA Forest Service and the U.S. Fish and Wildlife Service in these investigations. Team leaders were G. R. Heath (Forest) and H. D. Parker (Range). Other contributing members of the two analysis teams were: Forest Team - W. A. Kinkel and J. E. Weaver; Range Team - J. M. Disler, E. F. Kan, D. T. Pendleton, A. Simon, and R. S. Trejo.

2. THE FOREST INVESTIGATION

The U.S. Forest Service has a need for forest resource inventory techniques which can be applied over large areas rapidly and with greater efficiency than procedures now used. The ERTS-1 Forest Analysis Team is applying conventional and computerized processing to ERTS-1 data to investigate its potential for forest inventory applications.

For this investigation, an area approximately 7 × 9 kilometers in the Sam Houston National Forest was chosen as the primary study area, because a large amount of data concerning it was available. A secondary area, composed of the west unit of the Raven District, partially surrounds the primary area. The objectives of the study are to determine data, and to learn how the data can be used to make classification maps. The data being used are multispectral scanner (MSS) tapes and imagery from the coverage of August 29, 1973, (Frame 1037-16244).

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Ground truth was a broad classification map of the vegetative cover, and related forest features in the study area. It was constructed from aerial photos and ground inspection

2.1 CONVENTIONAL PROCESSING

To determine the size of areas detected by the sensors, representative features were selected on the ground truth map. Criteria were established for the minimum size of each feature to be evaluated, based on Forest Service management needs. These criteria were 8 hectares (20 acres) for timber types, 15 meters (50 feet) width for streams and right-of-way, and 2 hectares (5 acres) for water impoundments and rural settlements. Features of these minimum sizes, and larger features, were selected for study, and ERTS-1 imagery was analyzed for detection quality. Results were tabulated for all MSS bands, for the Goddard type C color composite, and for a composite made at the Johnson Space Center.

Band 4 (green) was the poorest of the four bands; it provided very little information. Band 5 (red) was the best band for some vegetation types, but it was poor for detecting hardwoods and water bodies. One pine stand for four hectares (10 acres) was observed. In band 6 (IR) hardwoods began to appear and water bodies stood out well, but pine stands were less visible. Band 7 (IR) had similar characteristic showing hardwoods best, but was slightly poorer in general than band 6. However, it revealed the smallest feature seen on ERTS-1 imagery by the Forest Team, a group of one hectare (2 acre) lakes. The composite made at JSC produced the best detection results of all the media examined; the Goddard composite rated midway between bands 6 and 7 (table 1).

Table 1

Media	Features Detected
JSC Composite	21 of 30
Band 5	20 of 30
Band 6	16 of 30
Type C Composite	15 of 30
Band 7	11 of 30
Band 4	4 of 30

Classification mapping by several multispectral enhancement methods is planned but this work is still incomplete. An ocular comparison was performed between ERTS-1 band 7 imagery and aircraft photos. A 9×9 transparency was placed in a rear projection viewer and enlarged to 25X. Then, the various gray levels were delineated onto a transparent medium placed on the screen. These gray levels were compared with ground truth and classifications were assigned which most closely matched the known class. By placing a grid over both maps and by counting points of agreement vs. disagreement, it was determined that the ERTS imagery matched 63 percent of the ground truth classifications.

2.2 COMPUTER PROCESSING

The team plans to classify the study area using a clustering program and a maximum likelihood pattern recognition program. To date, only the clustering analysis is complete.

As shown in figure 1, which illustrates the printout of a 24-cluster map, the symbol 1 is most prevalent. It forms a pattern which most closely approximates the pine category in the ground truth. The pattern produced by the symbol 7 appears most often where hardwoods are found. It was observed that certain combinations of symbols seemed to fall in patterns which represented other classifications. For example, wherever there was a site prepared for pine regeneration the symbols 2, 4, 7, and 8 appeared together, with the 2's predominating. Using this method, the team worked up a code of symbols and combinations of symbols which represented the ground truth classes, and provided a set of symbol signatures for each class. Others have used this technique of interpreting cluster combinations and are finding it useful.

The resulting printout map was then converted to the base map scale and made into a line drawing. A computation of the agreement between the clusters and ground truth yielded 70 percent agreement. It must be emphasized that for forest classification, clustering analysis is an experimental technique that is still under study; its analysis role is not yet defined.

The tape produced from the clustering program was then film-recorded on a Data Analysis Station and subjected to the same comparative analysis as the printer map. Since combinations of symbols could not be represented by a single color on the film map, agreement was only 60 percent, 10 percent less than the results of the printout map analysis.

The team's next step will be to attempt extension of these analyses to a secondary study area, with less ground truth.

2.3 SUMMARY

The preliminary results in this report may be summarized as follows: (1) forest feature visibility in ERTS-1 imagery was very good, (2) the ocular imagery interpretation technique was not an efficient method for analyzing ERTS data on forest classification, becuase of its low (63%) agreement with ground truth, and the time it required, and (3) the clustering technique appears promising, but it needs further testing and refinement.

3. THE RANGE INVESTIGATION

The ERTS-1 Range Analysis Team is investigating the utility of ERTS-1 data for mapping range vegetation types on the San Bernard Site, west of the San Bernard River outlet on the Texas Gulf Coast. Conventional and computer-aided processing techniques are being applied to the data set acquired by the satellite on October 4, 1972 (Scene 1073-16251).

The San Bernard Site, about 370 km^2 in area, is typical of much of the gulf coastal marsh in Texas and Louisiana. The objective of this investigation is to determine the accuracy with which the two major vegetation zones in the marsh could be distinguished with ERTS-1 data. The zone nearest the water, at about 0-2 inches above mean sea level is characterized by marshhay cordgrass *(Spartina patens)*. Frequently inundated by gulf water, it is often referred to as "wetlands". Adjacent and slightly higher is the gulf cordgrass *(Spartina spartinae)* zone. Both types produce large amounts of livestock forage and provide unique habitat for numerous wildlife forms.

The likelihood of future increases in the demand for both grazing and recreation in the marsh creates a need for information on the amount and distribution of vegetation resources which has heretofore been unavailable over large areas. If ERTS-1 data can provide such inventory information, it may be a valuable tool for the high intensity management of the resource which this increased demand will require in the future. Another potential benefit which may drive from separation of the two marshgrass zones, is the mapping of boundaries between the lower (wetland) areas normally subject to inundation, and the drier portions of the marsh. This type of information would be valuable for planning any development in the marsh.

Ground truth for the investigation was a vegetation type map, constructed from aircraft photography and ground inspection of the area. The boundary between the two vegetation types was clearly visible in late Spring color infrared aircraft photos. The San Bernard Site was divided into two areas, one for training and reference, the other for testing. All image enhancements and computer training were done by reference to imagery of the training area; later ERTS data evaluations will be based on results in the test area.

3.1 CONVENTIONAL PROCESSING

Conventional processing involved construction of color composites, enhanced by reference to the training area, to display the boundaries between the two zones.

Two examples of the color composites from conventional processing are shown in figures 2 and 3. Figure 2 was constructed on a multi-channel film viewer from portions of 9.5 inch ERTS-1 images in bands 4, 5, and 7. Figure 3 was generated from the same imagery on an additive color viewer/printer. In both images, the dotted lines indicate vegetation boundaries from ground truth.

A quantitative measure of the precision with which the type boundaries were located will be obtained by planimetering the areas interpreted in each type.

3.2 COMPUTER PROCESSING

As in the forest study, initial computer classification of the San Bernard data was done by clustering. By reference to a vegetation type map of the training area, the clusters were combined such that the boundary between the two vegetation zones was approximated in the output cluster map, which was color-coded and filmed, (fig. 4). The cluster combinations were:

water - 3 shades of blue - 3 clusters
woodland - brown - 1 cluster
marshhay cordgrass zone - yellow - 2 clusters
gulf cordgrass zone - green - 3 clusters
unclassified - white - 3 clusters

The clusters coded white (unclassified) were found to be non-vegetated features including beaches, spoil banks from dredging, and urban areas, including the city of Freeport, Texas.

In recent work to correlate individual clusters with specific ground phenomena, confusion was observed between vegetation in the marshhay cordgrass zone, and burned portions of the gulf cordgrass zone; both were included in the same cluster. In a subsequent clustering run, this confusion was eliminated, but the burned areas were clustered with water (see fig. 5). Apparently, water, burned gulf cordgrass areas, and the marshhay cordgrass zone were multispectrally quite similar. Additional data, acquired after regrowth has occurred on the burns, is expected to reduce or eliminate this confusion.

The cluster statistics generated by the clustering program were input to a maximum likelihood classification program, to obtain a supervised classification with a classification threshold of 0.95 (fig. 5). The map produced was generally very similar to the cluster map, as expected. However, the large number of unclassified (white) data points suggests that the cluster distributions were not as tight as they may appear in the cluster map. Additional classifications, using other threshold values and statistics of conventional training fields, have produced classifications very similar to the map in figure 5. That result, and the similarity of the cluster map to the vegetation zone boundaries from ground truth, indicates that the groups of clusters constructed did provide a reasonable match with the vegetation zones.

4. DISCUSSION

Both the forest and range investigators encountered difficulty in relating clusters to specific ground features. With the exception of large, homogeneous features such as water and tree stands, the vegetation types did not occur in single clusters when the clustering program was allowed to run to stable conditions (i.e., when all splitting and re-combining was complete). Two approaches were taken, and are continuing, to solve this problem.

The first approach, illustrated in these results (fig. 4) was to let the program run to stability, but then combine clusters such that one or more are represented by the same symbol (color). The other approach was to constrain the program to generation of only a few clusters with the expectation that only those features of greatest multispectral contrast will be clustered, and further, that those few clusters will coincide with vegetation type boundaries. The first trial of this technique on the San Bernard Site appeared to work well (fig. 5). The program successfully made the distinction between the two vegetation zones without manipulation by the investigators.

Although quantitative evaluations of all techniques must yet be completed, it appears the computer classifications were superior to the conventional image enhancements for delineating the boundaries. This difference is not believed due to more accurate classifications, however. Rather, the superior resolution achieved in the final analysis products from computer classification rendered the vegetation type boundaries more distinct.

In summary, both conventional and computer-aided processing techniques have been used successfully to distinguish between the two marsh vegetation zones. Although a quantitative comparison of the precision of each technique must yet be made, it appears that ERTS-1 data is capable of providing the needed vegetation inventory information in wetland areas along the Texas coast.

COMPUTER PRINTOUT
CLUSTER CLASSIFICATION FOREST STUDY AREA

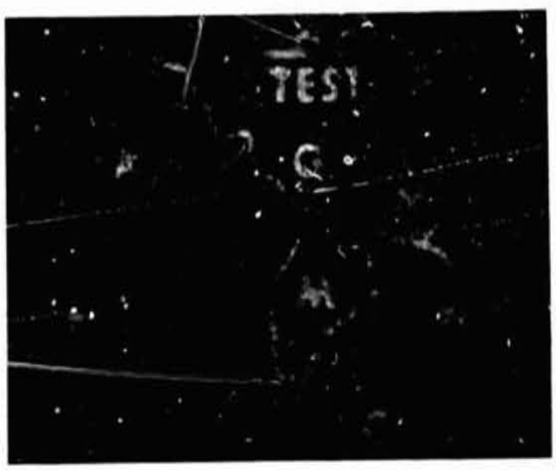

Figure 2 - Multichannel film viewer (electronic) enhancement showing marshhay cordgrass zone (M) and the Gulf cordgrass zone (G), in the training and testing areas. Dotted lines indicate zone boundaries from ground truth. Water areas (W) and offshore clouds (C) are also indicated.

Figure 3 - Additive color viewer (optical) enhancement. (See legend in Figure 2.)

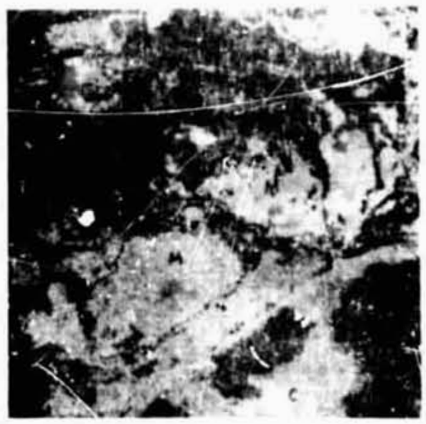

Figure 4 - Cluster map constructed by combining clusters manually. (See legend in Figure 2.)

Figure 5 - Cluster map generated entirely automatically. (See legend in Figure 2.)

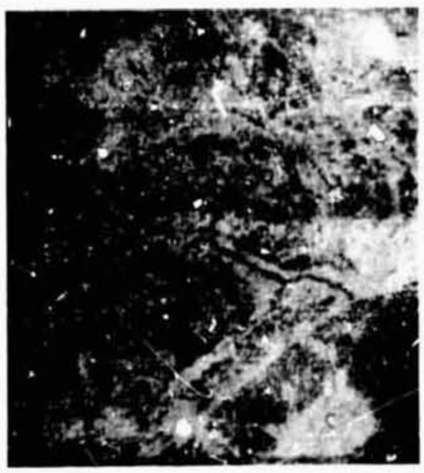

Figure 6 - Supervised classification map; threshold level was 0.95 for all classes. (See legend in figure 2.)