N73-29928

Paper A 21

APPLICATION OF ERTS-1 DATA TO ANALYSIS OF AGRICULTURAL CROPS AND FORESTS IN MICHIGAN

Gene R. Safir, Wayne L. Myers, *Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan;* William A. Malila, James P. Morgenstern, *Environmental Research Institute of Michigan, Ann Arbor, Michigan*

ABSTRACT

The results reported are based on analysis of ERTS Frame 1033-15580 collected over southwestern Lower Michigan on August 25, 1972. Major agricultural crops such as corn and soybeans were approaching maturity at this data and forest canopies were dense.

Extensive ground truth information was gathered by detailed field study of test strips. This detailed information was supplemented over larger areas by interpretation of RB-57 and C-47 photography and MSS imagery. The U.S.D.A.-A.S.C.S. also cooperated by providing information on crops from their records.

Recognition processing of ERTS-1 MSS data was carried out on a digital computer. Fields and forest stands were selected as training sets and test areas. Aerial imagery was essential for locating the positions of these selected areas on ERTS digital tapes.

The recognition process was successful for each type of vegetation which had a dense green canopy such as forests, corn, and soybeans. Bare soil was also recognizable as a category. However recognition of species was difficult in senescing or senescent vegetation. Since the accuracy of recognition depends on stage of growth, optimum times for collecting data will vary from one crop to the next.

Accurate computer recognition of crops from satellite data will be useful in operational surveys as the first stage in a multistage sampling process.

Michigan Agricultural Experiment Station, Journal Article 6315

Introduction

Michigan State University (MSU) in cooperation with the Environmental Research Institute of Michigan (ERIM) began a program in the summer of 1972 to test the usefulness of ERTS-1 satellite data for monitoring and managing crops and forests in Michigan. Specifically, the objectives included: (1) verification that major agricultural crops and forest types can be identified from ERTS-1 data; (2) development, application, and testing for accuracy of multispectral techniques for crop and forest acreage estimation in Michigan; (3) correlation of variations in signatures from space with ground truth data.

In addition to the scientists directly involved in analysis of the data, a team of cooperators has been assembled to evaluate the operational utility of the results which emanate from the project. This team includes members of state, federal, and local agricultural and natural resource agencies.

Data analysis to date has been confined to ERTS frame E-1033-15[illegible] (August 25, 1972) as a result of the inclement weather conditions which prevailed throughout most of Michigan's 1972 growing season following the launch of ERTS-1.

Ground Truth Information

Direct field observation and 35-mm photography were the main sources of ground truth information for the analysis of agricultural crops. Specifically, biological parameters such as plant height, row direction and width, percent ground cover, stage of growth, corn tassel color, and disease incidence were estimated and recorded for numerous selected fields in the test area. Since forest cover changes less rapidly than agricultural crops, the primary source of information for forests was photointerpretation of RB-57 and C-47 underflight imagery. The photointerpretive work was supplemented by collection of data on the ground as necessary. The RB-57 and C-47 imagery was also extremely useful for analysis of agricultural crops. In addition to the field and underflight data, cooperators in both the United States Department of Agriculture, Agricultural Stabilization and Conservation Service (U. S. D. A. -A. S. C. S.) and the Forest Service have contributed to the pool of ground truth information. The A. S. C. S. efforts produced a set of annotated copies of enlarged airphotos showing the location and nature of vegetation types on the holdings of landowners who subscribe to A. S. [illegible] programs.

M. S. S. Digital Analysis - Methods

Digital tape data for frame 1033-15580, were screened for quality by preliminary processing on the ERIM digital computers. They were found to exhibit the same problem present in a set of tapes for the same frame received by ERIM under another contract. The problem is that reproduced signals from one of six detector elements which generate the MSS data in ERTS band 6 (0.7-0.8 μm) are faulty. Thus, anomalous data are present for band 6 in every sixth line of data; otherwise, the data appear to be satisfactory. This problem complicates signature extraction and data analysis. In particular, recognition processing for the work described here was restricted to three channels.

The primary test sites (in Eaton Co., Michigan) were located within the digital data, and line-printer gray maps were produced for all ERTS bands. The gray maps for ERTS band 5 were used to locate selected training and test plots of known ground cover. The RB-57 and C-47 underflight imagery was essential for correctly locating these plots, which were then designated by line and point number to the computer for extraction of signal statistics. In the selection of training sets. care was taken to avoid boundary points. Fifty-eight plots were designated and ERTS signal statistics were extracted for eight types of ground cover. These statistics were subjected to cluster analysis, and the results were used to select several plots for combination to form recognition signatures. The plots which were not used directly for specifying signatures became "test" sets for evaluating the accuracy of recognition. Eighteen additional test plots were then selected and included in the analysis.

Recognition maps were produced for an intensive test area in Eaton Co., Michigan. Recognition runs were based on the three good ERTS channels using several different sets of parameters. First, twelve recognition signatures were used and maps were produced with different rejection threshold levels. That is, each observation was classified as belonging to one of the recognition signatures and then tested to see if it was unlikely enough to be rejected and categorized as belonging to none of the classes considered. Next, seven recognition signatures were used; the seven recognition signatures included combinations of the pairs of signatures used for several classes in the twelve signature runs.

MSS Digital Analysis - Results

Recognition results were analyzed for the 76 identified plots. The overall results of the first-look analysis of recognition are summarized in Table 1 for five cover classes (corn, soybeans, trees, senescent vegetation, and soils). As noted earlier, only three ERTS channels were used (4, 5 and 7). The values in Table 1 represent averages of percentages computed separately for each plot analyzed. The overall average percentage of correct classification (for test sets) is over 83%. The average percentage error is 10%, with 16% being Type 1 (i. e., missed classification, including not classified) errors and 4% being Type II (i. e., incorrect classification) errors. If "not classified" points are excluded from the computation, the overall average is nearly 85% correct.

Recognition percentages are high for those vegetation classes that had mature and uniform canopies at the time the data were collected (Aug. 25th). Corn, soybeans, and trees (forest) met this criterion, and were classified accurately. The class of senescent or senescing vegetation included observations from field beans, wheat stubble, and grass. These canopies were characterized by non-uniform distributions of dead and dying vegetation along with patches of more healthy vegetation. For example, field beans had matured and had begun senescing, while soybeans and corn were more vigorous. Also, wheat stubble fields were dry and brown except for some that had been seeded to alfalfa or red clover; the latter fields had patches of green growth among the stubble. The wide variability within these vegetation types at this time of year makes it difficult to classify them accurately. Alfalfa is a crop that is harvested repeatedly at irregular intervals throughout the growing season, and plots of it can appear very different, depending on their conditions at the time of observation. One vigorous alfalfa was included initially and accurately recognized. A lack of test plots, for which the exact condition at the time of the ERTS-1 pass is known, caused us to omit alfalfa as a class from the reported analysis. Bare soil was distinctive and accurately recognized.

Thus, the first-look analysis for computer recognition within boundaries of selected plots shows a good capability for differentiating each type of vegetation that has a dense green canopy, with bare soil also being recognizable as a category. The next step in the analysis of computer recognition is a more critical evaluation of accuracy by cover type for all resolution elements in selected portions of the frame.

Element-by-Element Analysis for Forest Cover

Figure 1 is a portion of the gray map for ERTS band 5 in Chester and Roxand Townships of Eaton County, Michigan with major roads delineated. An RB-57 color infrared photo was used to transfer the locations of the forests to the gray map, and the elements that fall within the forest area are shown by heavy dots in Figure 1. Figure 1 is conservative in that most doubtful border elements were not designated as "forest". Figure 2 is a computer recognition map for the same area. Heavy dots have been superimposed on the elements which were correctly classified as "trees" (forest). The forest elements which were not recognized as such by the computer (Type 1 error) are indicated with a heavy square having a white center. Type II errors (incorrectly classified as "trees") are indicated by triangles. The Type I error for forests on this portion of the frame is approximately 40%. An examination of Figure 2 shows that most of these errors take place in border elements. For the most part, these border elements were classified as corn. The remaining Type I errors are mostly accounted for by areas in which the forest canopy is sparse. The Type II errors are only about 3%.

Since the original "trees" training sets were located in the center of dense woodlots, the misclassification of sparsely stocked areas is not too surprising. An examination of the likelihood for the misclassified elements showed a very low probability of classification under the "trees" signature. Use of separate training sets and subresolution element analysis are being investigated as possible means of improving recognition in sparse forests. The current classification would give a reasonable estimate of the acreage that is suitable for woodlot management, but would give an underestimate for total acreage of forest.

Summary

Computer analysis of ERTS-1 data provided good recognition of vegetation classes that had mature and uniform canopies at the time when the data were collected. Bare soil was also recognized accurately. Classification was extremely difficult for senescent vegetation which was characterized by non-uniform distribution of dead and dying vegetation along with patches of more healthy vegetation. Since the accuracy of classification depends on the stage of growth, optimum times for collecting data will vary from one crop to the next. However, the optimum for recognizing each crop is yet to be determined. This bears further study, especially for field beans since Michigan is the leading producer of this crop in the United States.

TABLE I. SUMMARY OF RECOGNITION RESULTS ON A PLOT-BY-PLOT BASIS FOR 76 PLOTS, ERTS FRAME 1033-15580, 3 CHANNELS (ERTS 6 EXCLUDED), 0.001 PROBABILITY OF REJECTION

A.

			Average Percentage of Class'Plots Assigned to Listed Recognition Signature						
Class	No. Plots	No. Points	Corn	Soy	Alf	Tree	Senesc Bean	Grass	Soil
Corn	21	481	84.27	0.55	0.13	9.85	3.85	1.35	0
Soy	10	115	1.00	89.40	2.30	2.59	2.61	0	0
Trees	12	358	11.00	3.80	0	84.50	0.20	0.50	0
Senesc	16	306	16.30	6.55	7.15	0	54.30	8.23	6.53
Soils	4	56	0	0	0	0	0	0	97.62
TOTALS	76	1416							

B.

Summary of Percentages (Averaged Over Plots)

Class	No. Plots	No. Points	Not Clas'd	Correctly Assigned To Class	Incorrect. Assigned To Class	Average Error	Correct Excluding Not Clas'd
Corn	21	481	0	84.27	7.29	11.51	84.27
Soy	10	115	2.10	89.40	.50	6.55	91.31
Trees	12	358	0	84.50	3.66	9.58	84.66
Senesc	19	340	0.94	62.53	2.59	20.03	63.12
Soils	14	122	2.38	97.62	2.00	2.19	100.00
Averaged Over Five Classes			1.08	83.66	0.61	9.97	84.67

Figure 1. Channel 5 gray map for portions of Chester and Roxand Townships in Eaton County, Michigan showing actual locations of woodlots (●) and roads (⟵⟶).

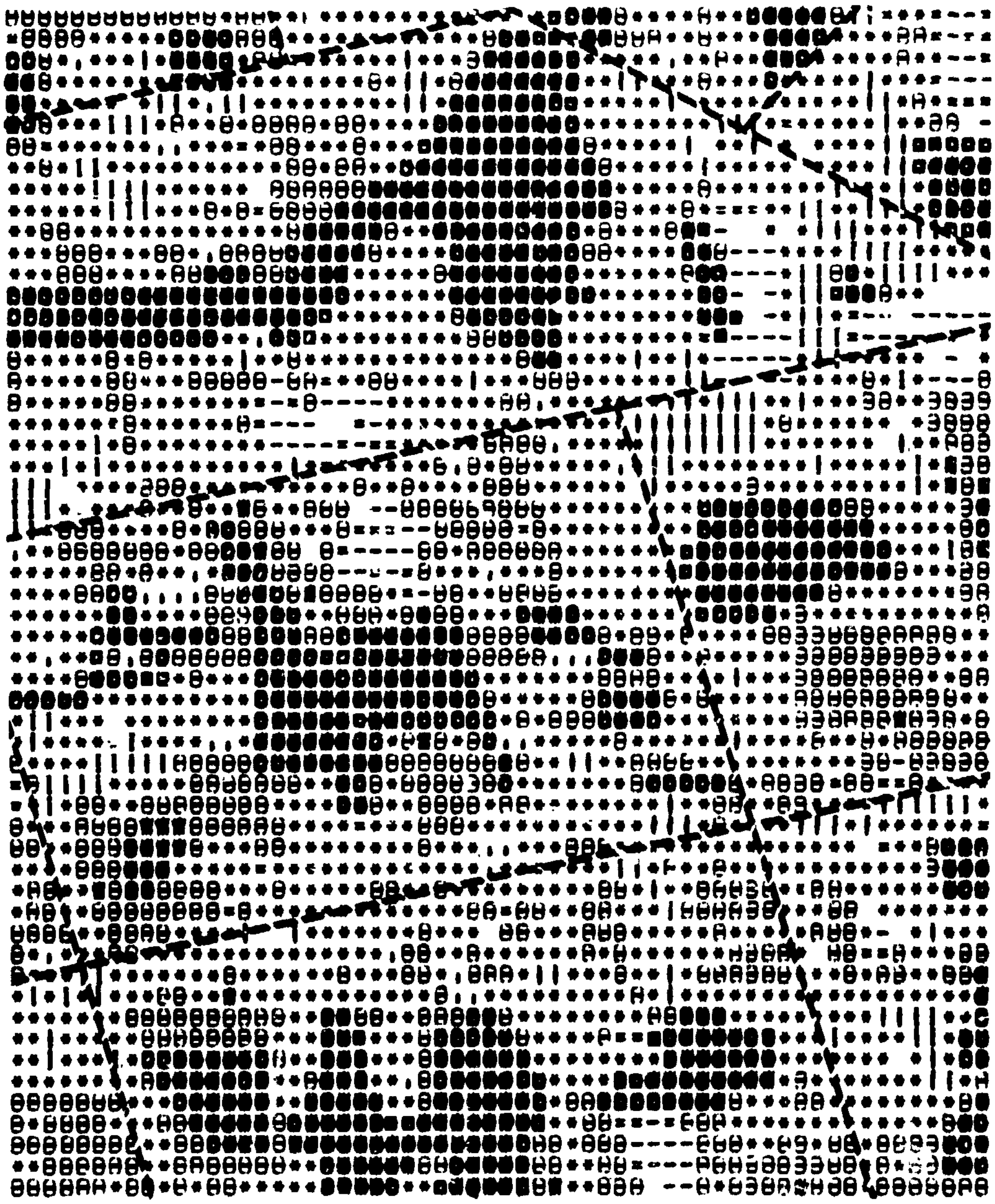

Figure 2. Computer recognition map showing correctly and incorrectly classified elements associated with forest cover; ● indicates correctly classified forest areas, ■ indicates forest areas misclassified, and ▼ indicates non-forest areas classified as forests.