1973NASSP.327....F

Paper A 26

IDENTIFICATION AND MAPPING OF SOILS, VEGETATION, AND WATER RESOURCES OF LYNN COUNTY, TEXAS BY COMPUTER ANALYSIS OF ERTS MSS DATA

Marion F. Baumgardner, Steven J. Kristof, James A. Henderson, *Laboratory for Applications of Remote Sensing, Purdue University, West Lafayette, Indiana 47907*

ABSTRACT

A 2,360 km^2 test site was selected to assess the utility of ERTS MSS data for mapping and monitoring soil, vegetation, and water resources. Using computer-implemented overlay techniques, ERTS MSS data obtained on three different dates were analyzed. Temporal changes in vegetation and water supply in Lynn County were identified and mapped. Ground observation and aircraft underflight data were used as training and test sets for the computer-implemented analysis of the ERTS data.

Features which were identified include row crops, unimproved and improved rangelands, bare soils, hydrologic features, and gross geologic and soils features. Results suggest that these techniques may be used to identify drought and other crop stress conditions, crops damaged by hailstorms, areas of active wind erosion, crops species, and soils patterns. The ultimate goal is to provide better yield predictions and more efficient management of agricultural resources.

1. INTRODUCTION

This paper presents the results of the analysis and interpretation of ERTS MSS data obtained over Lynn County, Texas. The test site was chosen because it embodies a variety of problems associated with the development and management of agricultural resources in the Southern Great Plains. It is one of ten counties in a larger ERTS test site centering around Lubbock, Texas.

Description of Test Site

Lynn County is a part of the High Plains lying south of the Canadian River. Known as the Llano Estacado, it is

Provided by the NASA Astrophysics Data System

1973NASSP.327....F

essentially a plateau, bounded on the north, east, and west by prominent escarpments rising from stream-eroded lower lands. On the south it merges physiographically with the Edwards Plateau.

The plains surface is quite flat and, except for a few canyons, is devoid of topographic features. The surface slope is southeast averaging 1 1/2 to 2 meters per kilometer. Canyon erosion is gradually reducing the total area of the Llano by slow retreat of the bounding escarpments. Stream drainage of the Llano surface is imperfectly developed. There are only a few widely-spaced minor valleys. These valleys typically have alluviated and unchanneled floors and are almost devoid of tributaries. Only during rare periods of excessive rainfall does water flow through the Llano valleys.

The most remarkable topographic and hydrologic characteristics of the Llano are the great number of shallow depressions, ranging in size from a few hectares to more than 15 km^2. These "prairie potholes", "playas", or "salinas" accumulate drainage from local watershed areas that range in area from less than 100 hectares to several hundreds of hectares. Most of the playas contain ephemeral, fresh to alkaline water during part of the year. The form of the depressions varies, with topography of the bottom and sides depending on the character of the formations in which the depressions are formed. Water loss from the playas is by evaporation and seepage towards recharge of the water table.

The principal income of Lynn County is derived from agriculture and ranching. The major problems associated with the development and management of the agricultural and rangeland resources of the county are drought, wind erosion, hailstorms, soil productivity, and invasion of rangelands by mesquite (Prosopis glandulosa and Strombocarpa odorata). The purpose of this study is to examine the utility of ERTS MSS data in identifying, characterizing and mapping the soil, vegetation and water resources in this semiarid region. Successful application of remote sensing and machine-processing techniques to arid and semiarid land management problems will provide valuable new tools for the one-third of the world's lands lying in arid-semiarid regions.

2. DATA ACQUISITION AND ANALYSIS

Ground Observation Data Collection

Ground observation data for Lynn County were collected by residents of the area. Six Lynn County farmers who were interested in cooperating in this experiment were requested

Provided by the NASA Astrophysics Data System

1973NASSP.327....F

to make ground observations along segments (6-10 kilometers) of county roads at the time of each ERTS overpass. Fields along each segment were numbered and information on crop type, crop conditions, soil conditions, planting pattern, row direction, and ground cover were recorded. These data from segments well distributed over the county were used in selecting training and test areas for the supervised classifications.

Aircraft Underflight Data

On 12 September 1972 an aircraft mission obtained data over the center of Lynn County on a single north-south pass at an altitude of 6,000 m. Color infrared photographs from this mission were very useful in the interpretation of patterns of rangelands shown in the classification from the computer-analysis of ERTS MSS data.

ERTS Data Analyzed

Multispectral scanner data from ERTS passes over Lynn County on 9 October, 14 November, and 2 December 1972 were used in this study.

Analysis Procedure

The LARSYS software system is a package of computer programs which have been designed to analyze and display remotely sensed multispectral data. Five major processing algorithms were used in this study: (1) CLUSTER, (2) STATISTICS, (3) CLASSIFYPOINTS, (4) PRINTRESULTS, and (5) NEWPHOTO. The CLUSTER processor is an unsupervised classifier that groups data vectors into spectrally distinct classes. Mean vectors and covariance matrices are calculated by the STATISTICS processor and are then used in the CLASSIFYPOINTS processor which performs a maximum likelihood Gaussian classification on a point-by-point basis over the entire area. Results from the analysis are then displayed using: (1) the PRINTRESULTS processor to make alphanumeric maps; and (2) the NEWPHOTO processor to display the results on the Digital Image Display System.

The Digital Image Display System receives an image from a System/360 computer, stores these data in a video buffer, and displays the image in a raster scanning mode on a standard television screen. An interactive capability to edit, annotate, or modify the image is provided through a light pen and a program function keyboard. An additional photographic copying capability is also provided.

Provided by the NASA Astrophysics Data System

1973NASSP.327....F

3. RESULTS AND DISCUSSION

Ground observation data and aircraft underflight photography were used in the analysis and interpretation of the ERTS measurements. Ground observations were made by six cooperating farmers. Each farmer identified crops and described soil and crop conditions in fields on each side of a 10-13 kilometer segment of a county road. Figure 1 (a classification of ERTS data) represents one of the observation segments. "A" is an area of cultivated fields. "B" is an area of rangeland in which the mesquite has been successfully eradicated. Projection of the observation segments on the Digital Image Display System made it possible to identify and locate the address of each ground observation site on the digital MSS data tapes.

A. Soils Resources

Although a large percentage of the land surface of Lynn County was covered with natural vegetation and crop residues at the time of the ERTS overpasses reported herein, broad soils patterns are revealed in the ERTS multispectral data. Figure 2 is an MSS band 2 (0.6-0.7μm) gray scale image of the test site on 14 November. The dark areas along the north and east of the image (A) represent deep moderately permeable loams and clay loams; the small, highly reflective area (B) contains deep permeable fine sands. The highly reflective soils in the southwest and west of the county (C) are deep, moderately permeable fine sandy loams. Results to date suggest that well chosen training sets for the analysis of ERTS MSS data obtained at a time when a maximum percentage of soil is without cover could greatly refine and improve the capability to delineate the soils boundaries of Lynn County.

B. Vegetation Resources

The two major land uses in Lynn County are agriculture and ranching. Of the total agricultural land there is little under irrigation. Approximately 58% of the county was in cotton in 1972. Other cultivated crops include grain sorghum and forage sorghum. Vegetation of rangelands consists primarily of natural grasses and mesquite.

Ground observation data obtained on 9 October were used for training and test sets for the computer-implemented analysis of 9 Oct., 14 Nov., and 2 Dec. ERTS data. Classifications of row crops, pasture, fallow, and water were obtained for each of these dates (Figures 3, 4, and 5). Examination

Provided by the NASA Astrophysics Data System

1973NASSP.327.....F

of these classifications reveals that field boundaries and homogeneity of fields are much better for 9 October. With the use of temporal overlay techniques a classification was obtained using the best combination of four MSS bands from the three dates (9 Oct., 14 Nov., 2 Dec.). The four bands selected to give the best classification of row crops, pasture, fallow, and water were bands 5 (0.6-0.7μm) and 7 (0.8-1.1μm) for 9 Oct. and 14 Nov. (Figure 6).

The highest percent correct recognition was 89.6% for the 9 Oct. classification. The accuracy declined for the 14 Nov. and 2 Dec. data. For the temporal overlay classification (Figure 6) the accuracy approached that of the classification accuracy for the 9 Oct. data.

It was not expected that this late in the growing season temporal overlay would improve classification results. A killing frost early in November, excessive autumn rains, and late summer weed growth contributed to much confusion in classification results from the November and December data. Experience in identification of summer annuals indicates that the most significant contributions of temporal overlay will be made during the active growing season prior to senescence.

C. Water Resources

Since water has very low reflectance in the near infrared wavelengths (ERTS spectral bands 6 and 7), it was easy to separate and map playas and reservoirs containing water. Water was separated spectrally from all other categories for three ERTS overpass dates. It was found that many of the playas containing water on 9 October contained no water on 14 November; many with no water on 14 November had water on 2 December.

Examination of the precipitation records revealed a record high rainfall for August and September. At the time of the 9 October ERTS overpass essentially all playas were full (Figure 7). During the three weeks prior to the 14 November overpass very little rain had fallen in Lynn County. Water in the playas had been partially or completely depleted by evaporation and/or seepage to groundwater recharge. The period from 12 November to 2 December (ERTS overpass) was characterized by cloudy days, high humidity and several light rains. The ERTS data for 2 December reveals water in many playas which had no water in mid-November (Table 1).

D. Temporal Overlay

Temporal overlay capabilities provide a significant

Provided by the NASA Astrophysics Data System

1973NASSP.327.....F

advance in the machine-processing of multispectral scanner data. It is no longer necessary to go through the tedious exercise of locating ground observation sites on the digital data from each ERTS overpass. Once the address of a ground observation site has been located on a digital tape from any ERTS overpass, the overlay technique can be used to locate the same address on a digital tape of MSS data from any other ERTS pass over the same area.

The temporal overlay technique also adds a valuable dimension for identifying and mapping changes in vegetation, water, and other dynamic surface features.

Provided by the NASA Astrophysics Data System

1973NASSP.327.....F

Figure 1. Classification of area around a ground observation site.

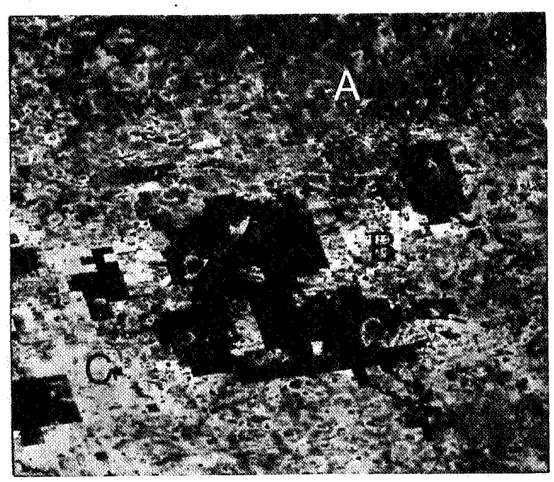

Figure 2. Gray scale image of Lynn County, Texas. ERTS MSS band 5 (o.6-0.7μm),]4 Nov 72.

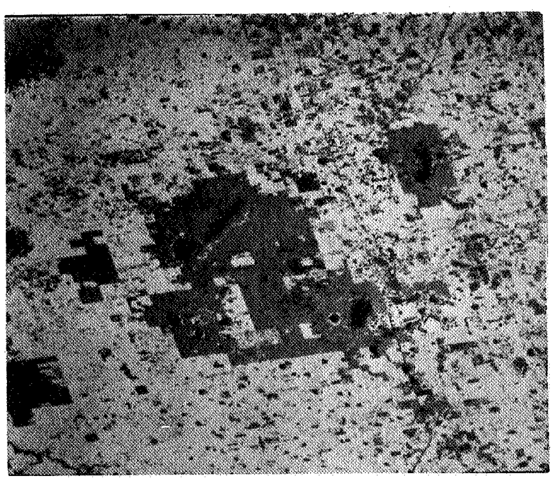

Figure 3. Four spectral classes representing row crops, pasture, fallow, and water. ERTS data-- 9 Oct 72.

Provided by the NASA Astrophysics Data System

1973NASSP.327.....F

Figure 4. Four spectral classes representing row crops, pasture, fallow and water. ERTS data--14 Nov 72.

Figure 5. Four spectral classes representing row crops, pasture, fallow, and water. ERTS data--2 Dec 72.

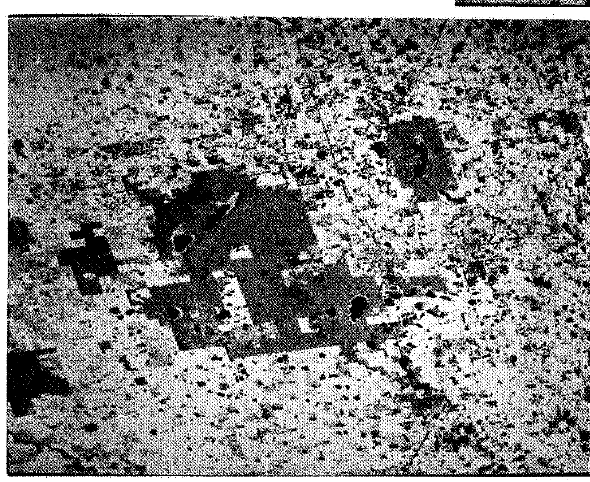

Figure 6. Four spectral classes representing row crops, pasture, fallow, and water. From overlay of ERTS MSS bands 5 and 7 on 9 Oct and 14 Nov 72.

Provided by the NASA Astrophysics Data System

1973NASSP.327.....F

Table 1. Estimated Changes in Water Surface Area.

Date	Points	Hectares
9 Oct.	4374	1924
14 Nov.	3735	1643
2 Dec.	5120	2252

Total Area 197683 Hectares

Figure 7. Two spectral classes representing water and other in Lynn County, Texas. ERTS data--9 Oct 72.

Provided by the NASA Astrophysics Data System