LAND USE MAPPING AND CHANGE DETECTION USING ERTS IMAGERY IN MONTGOMERY COUNTY, ALABAMA

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ABSTRACT

The feasibility of using remotely sensed data from ERTS-I for mapping land use and detecting land use change was investigated. Land use information was gathered from 1964 air photo mosaics and from 1972 ERTS data. The 1964 data provided the basis for comparison with ERTS-I imagery. From this comparison, urban sprawl was quite evident for the city of Montgomery. A significant trend from forestland to agricultural was also discovered. The development of main traffic arteries between 1964 and 1972 was a vital factor in the development of some of the urban centers. Even though certain problems in interpreting and correlating land use data from ERTS imagery were encountered, it has been demonstrated that remotely sensed data from ERTS is useful for inventorying land use and detecting land use change.

INTRODUCTION

The University of Alabama, in conjunction with the Alabama Geological Survey, and the George C. Marshall Spaceflight Center, is conducting a vigorous program to determine the feasibility of using remotely sensed data from ERTS-I for (1) mapping land use and land use change, (2) the inventory and management of natural resources, and (3) the improvement of environmental quality in Alabama.

This paper documents an initial study utilizing ERTS-I imagery to determine its applicability to mapping land use and detecting land use change. Good quality, cloud-free ERTS imagery covering most of the state of Alabama was acquired October 15-18 on the satellites fifth pass over the area. Montgomery County, located in the central portion of the State was selected for the initial study primarily because of the large number of first level land use categories represented and also because of the city of Montgomery, the state capitol, which, it was expected, would demonstrate urban growth detectable by ERTS-I.

LAND USE INTERPRETATION AND MAPPING

Land use was mapped for Montgomery county from two types of imagery, conventional air photo mosaics at a scale of 1:63,360 and ERTS imagery. The process of mapping land use from photo mosaics was begun prior to receiving

Original photography may be purchased from:
EROS Data Center
and Dakota Avenue
Sioux Falls, SD 57198

ERTS data. The digital land use data was compiled for each square kilometer, based on six general land use categories considered compatible with satellite resolutions, namely: urban, agricultural, forestland, water, barren land, and non-forested wetland. These correspond to the latest classification scheme proposed by the U. S. Government Inter-Agency Steering Committee on Land Use Information and classification.

The digitized land use data for Montgomery county, compiled from 1964 air photo mosaics and termed "historic" data, provided the basis for comparison with and analysis of ERTS-I imagery. By storing the historic data in computer format, it was possible to generate maps of per cent of land use per square kilometer for a specific category or maps of dominant land use per square kilometer. The latter proved to be best suited for comparison to ERTS data to determine change; the former, however, was especially helpful in spectral analysis of ERTS imagery.

Land use information was extracted from ERTS imagery in much the same manner as from the air photo mosaics, except that instead of estimating what per cent of each square kilometer was occupied by each of the six land use categories, only dominant land use per square kilometer was recorded. An acetate mylar grid was prepared to overlay the ERTS images; the grid cell size corresponded to the image scale of 1: 1,000,000; hence, each square millimeter represented one square kilometer which facilitated rapid comparison with the historic data. Positioning the grid on the ERTS image to correspond to the correct UTM coordinates for that area and using a lighted magnifying glass and light table to view the scene, each cell was color coded as follows:

red	urban
brown	agricultural
green	forested
blue	water
black	barren land
orange	non-forrested wetland

Black and white positive prints corresponding to all four spectral bands were used as well as a color composite image of the Montgomery scene at the same scale. Spectral bands six and seven (near infrared) were first examined under the grid to determine the location of prominent lakes and streams. This initial step was necessary in order to forgo the possibility of classifying a lake or reservoir as some other form of land use when viewing bands four and five (visible bands). After color coding the appropriate cells dominated by water bodies, the grid was applied to the same scene in bands four (green) and five (red). Cultural features were especially prominent on band four even down to secondary roads inside the city of Montgomery itself. Spectral band five displayed agricultural and forestland patterns extremely well.

To aid in interpretation of ERTS-I imagery, an I^2S Mini-Addcol color additive viewer was used to produce color composites of the Montgomery scene.

Use of this instrument enabled features such as small towns, roads, and rock outcroppings that otherwise faded into the background to be distinguished. Varying the light intensity and filter combinations made it possible to highlight features of interest, whether cultural or physical.

Certain interpretation difficulties were encountered resulting from both errors in interpretation by the analyst and constraints in scale and resolution imposed by the ERTS imagery. As might be expected, large areas of homogeneous land use were easily recognized for both time periods and land use categories covering as little as 5% of a square kilometer could be readily interpreted on the 1964 air mosaics. No such detail could be extracted from the ERTS scenes however, thus dictating dominant land use per square kilometer.

Cleared land near Montgomery was recognized as such on the air photo mosaics, but could not be distinguished from the urban area on the smaller scale ERTS scenes. Familiarity with the area however, indicated that the bare land in the 1964 data had been cleared for single and multiple family dwellings and had since been developed thus corroborating that area's having been classified urban on the ERTS scene.

In addition to the I^2S viewer, additional large scale photos (1: 20,000) and U.S.G.S. topographic maps offered supplemental information as an aid in interpretation.

COMPARISON AND CHANGE DETECTION

Upon completion of land use mapping for both time periods (1964 and present), an analytical comparison program was initiated for the purpose of detecting land use change in Montgomery county.

From the computerized 1964 land use data, it was possible to generate a map denoting dominant land use per kilometer. This printout was then color coded to facilitate comparison with land use information derived from ERTS.

From Fig. 1, it is obvious that the metropolitan Montgomery area has experienced considerable growth in the past nine years. It should be mentioned that although a large number of barren land categories would be expected in an area undergoing rapid urban sprawl, barren land was not distinguishable from urban and was thus included in the urban category. This is not altogether in error, for there is usually a very short time period between clearing of land in or near a city and construction on that site.

Other cities are shown to have experienced growth also; and this growth was detectable by comparing 1964 data with that obtained from ERTS-I (Fig. 1). For example, the town of Ramer in southern Montgomery county dominated only one square kilometer in 1964, but now dominates three square kilimeters. Likewise, the small towns of Mount Meigs and Merry in the northeastern part of the county which were not even recorded as dominant in 1964, each dominated one square kilometer in 1972 according to ERTS-I.

The construction of main highways had a marked influence on the growth of the urban areas. As can be seen on Fig. 2, in 1964, many sections of main roads were either under construction or only in the proposed stage (dashed lines). By 1972, however, imagery from ERTS indicated that these roads were in use and that other roads not proposed in 1964 had been built such as the completion of the northern portion of the ring-road around the city of Montgomery (Fig. 2). There seems to be good correlation between road construction and urban growth both in Montgomery and in the small towns of Mount Meigs and Merry, mentioned previously, which are thought to have benefited directly from the completion, by 1972, of I-85 which runs eastward from the inner Montgomery city area. I-65, proposed but not yet under construction according to 1964 air photos, runs southwesterly out of Montgomery and is now open to traffic. I-65 was very prominent on MSS-5 and is thought to have accounted for a part of the urban growth in that area. Some small urban developments were visible along the new major traffic arteries described above, but did not occupy a major portion of the grid cell in which it occurred and was thus absorbed in the more dominant use and hence, not mapped.

The dominant transition in rural land use in Montgomery county was from forest to agricultural (Fig. 1, 2). Forests still lined the Catoma Creek which flows from southeast Montgomery county to its confluence with the Alabama River in the northwest. Asthetic appeal of these forests along the Catoma may have been partly responsible for the apparent growth of the urbanized fringe of the city of Montgomery in that direction.

Two square kilometers within the bounds of the city of Montgomery were dominated by forestland.

These correspond to parks and areas of widely spaced single family dwellings.

PROBLEMS ENCOUNTERED

Besides detecting actual land use change, the comparison of 1964 data with that derived from ERTS (Fig. 1, 2) may indicate change in a cell where no change has in fact occurred. Because of the low resolution of the ERTS images, small areas of individual land use were grouped into larger homogeneous land use areas and classified according to the dominent form, thus falsely indicating that a change in land use had occurred. Dubious land use changes, such as agricultural to forestland, were probably due to just such an event. Despite the apparent misinterpretation of land use and change detection in some instances, it has been shown that ERTS imagery is capable both of extracting land use information and monitoring land use changes in the rural and urban environment.

FUTURE PHASES OF THE STUDY

Now that the coding of "historic" land use data (from air photo mosaics, 1:63,360) has been completed for all 67 counties in Alabama and the data computerized, future efforts will concentrate on updating the information utilizing remotely sensed data from ERTS-I. The extraction of land use data from ERTS imagery will provide the information needed for change assessment and will, in itself, serve as an "historic" data base with which to compare subsequent ERTS coverage. Once the color coded land use information has been digitized and stored in a computer, timely land use maps can be generated for any category or combination of categories. Furthermore, with both "historic" and ERTS-derived land use information in computer storage, comparison of the two data bases can be performed internally, thus automating the process of change detection. Ultimately, the analysis of ERTS imagery will be extended to the rest of Alabama for comparison with existing land use information.

In conjunction with the land use phase of the Alabama ERTS project, the correlation of water quality parameters with ERTS imagery will be investigated by the establishment of four to seven data collection platforms (DCP's) within the Warrior River basin. The DCP's will telemeter information concerning water temperature, turbidity, pH, and flow rate to ERTS as it passes overhead where it will be combined with corresponding spectral data and relayed back to Earth.

Also to be investigated is the effect that subsurface geology exerts on land use patterns. The potential of this study was demonstrated in small measure by the agricultural pattern in Crenshaw county (Fig. 3). As can be seen, the amount of agricultural activity decreases sharply south of the contact between the highly eroded and fertile Midway Group Clays to the north and the more rugged and erosion-resistant Wilcox Group sandstones to the south.

CONCLUSIONS

The work thus far performed, part of which is outlined in this paper, indicates that small scale imagery from ERTS-I is a valuable tool in land use inventory and change detection. The accuracy of any interpretive effort, however, is directly proportional to the quality of the imagery being analyzed. Only of late has image quality been acceptible for analysis. If tighter and more consistent control is applied to data processing in the future, ERTS imagery should prove to be useful in a wide array of land use mapping and change detection programs.

REFERENCES

Anderson, J. R., Hardy, E. E. and Roach, J. T., 1972, "A Land-Use Classification System For Use With Remote Sensor Data, Geological Survey Circular 671, Washington, D. C.

Lins, H. F., and Milazzo, V. Z., 1972, "The Use of Small Scale Multi-Band Photography for Detecting Land-Use Change," Proceedings of The 8th International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan.

FIGURE 1: DOMINANT LAND USE PER SQUARE KILOMETER FROM CONVENTIONAL AIR PHOTOS (LEFT) AND FROM ERTS-I IMAGERY (RIGHT)

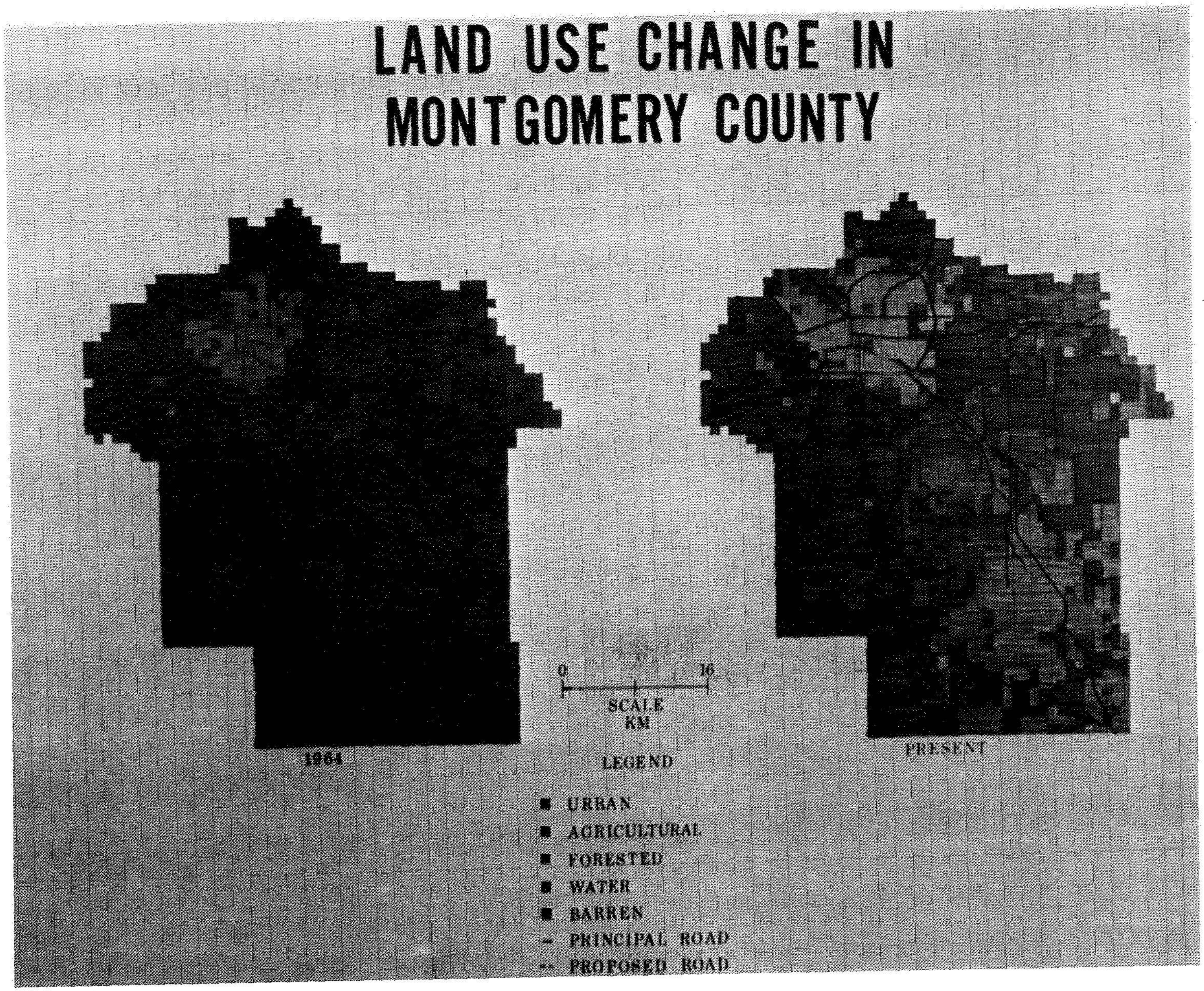

FIGURE 2: THE APPARENT EFFECT OF ROAD CONSTRUCTION ON LAND USE TRENDS[4]

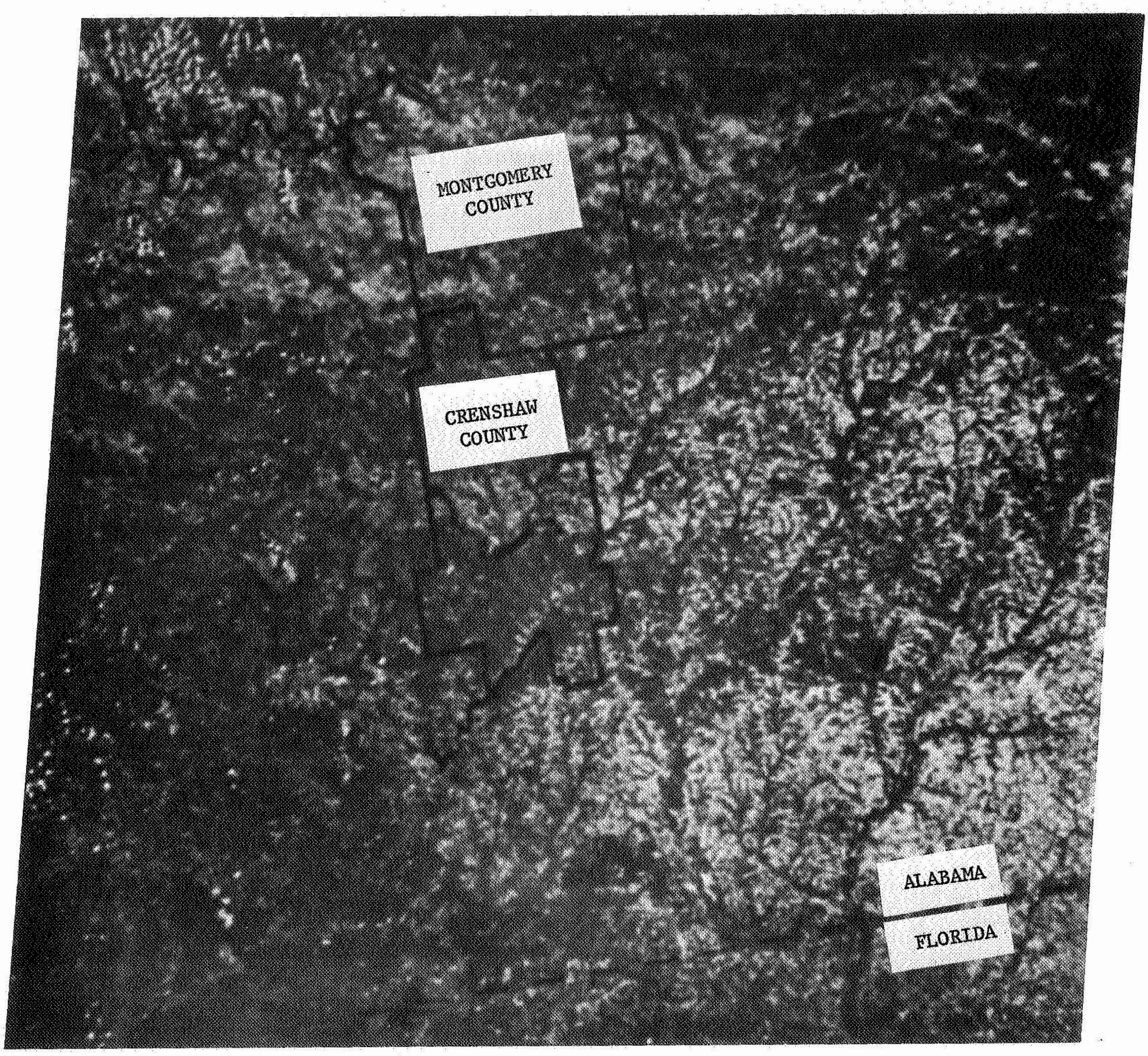

FIGURE 3: MONTGOMERY SCENE (ERTS): THE EFFECT OF SUBSURFACE GEOLOGY ON RURAL AGRICULTURAL PATTERNS AS DETECTED BY ERTS-I