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LAND USE CLASSIFICATION AND CHANGE ANALYSIS USING ERTS-1 IMAGERY IN CARETS

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ABSTRACT

Land use detail in the CARETS area obtainable from ERTS exceeds the expectations of the Interagency Steering Committee and the USGS proposed standardized classification, which presents Level I categories for ERTS and Level II for high-altitude aircraft data. Some Levels II and III, in addition to Level I, categories were identified on ERTS data. Significant land use changes totaling 39.2 km^2 in the Norfolk-Portsmouth SMSA were identified and mapped at Level II detail using a combination of procedures employing ERTS and high-altitude aircraft data.

INTRODUCTION

ERTS imagery in the Central Atlantic Regional Ecological Test Site (CARETS) area was examined to determine what categories of land use could be detected, and to what extent land use change could be identified and mapped. The images reported on here are from the ERTS multispectral scanner, taken over the Washington-Baltimore area (E-1080-15192, 11 Oct. 1972, color composite of bands 4, 5, and 7) and over the Norfolk, Virginia area (E-1079-15140, 10 Oct. 1972, color composite of bands 4, 5, and 7; and E-1133-15144, 3 Dec. 1972, color composite of bands 5 and 7).

1. Categories of Land Use

In the discrimination of land use types in the CARETS region, ERTS exceeds the expectations of the 1971 Interagency Steering Committee on Land Use Information and Classification. That Committee presented a two-level land use classification system for use with remote sensing data; a Level I for use with spacecraft data, and a Level II for use with high-altitude aircraft data. Land use data at Levels I and II are useful for regional and statewide land use inventories, and for the needs of

many federal agencies to assist in making land management decisions. Levels III and IV were anticipated as being derivable from medium and low-altitude imagery, respectively, and fulfilling more detailed needs of local agencies for information in support of land use planning, transportation forecasting, and environmental impact statements. The U.S. Geological Survey has published the two-level classification in Geological Survey Circular 671, and is urging that agencies involved with "land use" missions adopt compatible classifications so that standards for the exchange of land use data can be established and costly duplication can be avoided.

In addition to the expected Level I, several categories of Level II land use were obtainable from the ERTS imagery, and even a few from a proposed Level III. Therefore the full potential of ERTS for land use analysis will not be realized if categories for mapping are confined to Level I. Levels I, II, and III categories which were identified on ERTS imagery of the CARETS area are listed in Table 1. Some examples of Level III land use are shown in Figure 1. Proposed Level III categories are listed only for Level I "urban and built-up" lands; however, as ERTS imagery for different seasons becomes available, it is likely that extensions to Level III will be possible also in agricultural, forest, and wetland categories. During the next phases of the ERTS investigations, interaction among investigators and potential users of land use information is recommended, so that similar definitions can be applied to land use types, and exchange of data can be facilitated. The USGS CARETS team will welcome any recommendations concerning the establishment of Level III categories for this region, as determinable from further analysis of ERTS data. Such recommendations will be consolidated by the CARETS team into a proposed Level III classification for CARETS.

2. Identification and Mapping of Land Use Change

To investigate the utility of ERTS data in identifying and mapping significant land use changes, the Norfolk-Portsmouth Standard Metropolitan Statistical Area (SMSA) was selected for detailed analysis. This SMSA serves as the principal sub-region for detailed system tests of procedures for the various subtasks of the CARETS project before applying them to the remainder of the CARETS region (Figure 2).

A UTM-gridded photomosaic was used as a mapping base. Similar mosaics are available for the entire CARETS region, having been

compiled from 1970 NASA RB-57 photography. The data base from which change was to be measured is a Level II land use map at a scale 1:100,000, also compiled from the same 1970 high-altitude aerial photography, and available for the entire CARETS region. A transparency of the 1970 land use map was placed over an enlarged transparency of the color composite of the Norfolk area ERTS image, also at a scale of 1:100,000. After learning some of the principal visual signatures of the various land use types as they appeared on the enlarged ERTS image, a skilled photointerpreter examined each section of the area being mapped, and outlined with pencil all areas that appeared to have changed since 1970. Based on comparison with the data base, and his becoming familiar with the visual signatures of the major land use types as portrayed on the ERTS enlargement, the interpreter indicated the present land use, to a Level II detail if possible, and to Level I if not. Then reference was made to the 1972 ERTS underflight (U-2) photography of the area, to verify whether change had actually occurred, and whether the correct interpretation of that change had been made.

The "verified" changes were mapped on a separate overlay, along with "false"changes, or changes which the ERTS imagery suggested, but which did not actually occur. Area measurements of each of the categories of land use change were made by dot grid planimeter, and the results totaled for the SMSA. The area measurement and tabulation will be done automatically when the land use data base is digitized and change mapping extended to the remainder of CARETS. Examples of the photomosaic, Level II land use map, ERTS image, and change map for a portion of the test site (South Norfolk vicinity) are shown in Figures 4 through 7. Figure 3 depicts the location of the South Norfolk site within the Norfolk-Portsmouth SMSA.

Results of the 1970-72 change analysis are summarized as follows:

Area analyzed (SMSA total)	1911 km^2
Total aircraft-verified land use change, Level I	36.2 km^2
ERTS-identified land use change, Level I	26.5 km^2
Percent of Level I change identified with ERTS	73.2 %
Total aircraft-verified land use change, Level II	39.2 km^2
ERTS-identified land use change, Level II	22.4 km^2
Percent of Level II change identified with ERTS	57.3 %
"False" change (erroneously indicated by ERTS)	64.3 km^2

The results are consistent with a previous study, which measured Level I land use change for the Norfolk-Portsmouth SMSA averaging 16.7 km^2 per year for the period 1959-1970. The comparable figure for the 1970-1972 period is 18.1 km^2 per year. Preliminary examination by the staff of the Southeastern Virginia Planning District Commission indicates that these results might serve to satisfy portions of a U.S. Department of Transportation (DOT) requirement for 1970-1972 land use change data for revised transport demand forecasting. Conventional land use survey costs for the DOT requirement will be compared with costs using the ERTS-aircraft data analysis method: 32 photointerpreter man-hours (including learning period with ERTS imagery) plus film and drafting materials for change mapping and verification in a fast-growing metropolitan area of 1911 km^2 (739 square miles).

Almost all of the "false change" turned out to be bare fields which in the October and December ERTS imagery had a bright appearance similar to urban areas. Data from the growing seasons would surely alleviate this problem. The results of the change analysis are considered to be highly promising--even without the sophisticated signature determination which is possible with ERTS MSS data, a high proportion of Level I and II land use change was detected and identified correctly with ERTS.

SUMMARY AND ACKNOWLEDGMENT

Based on the encouraging results of this preliminary analysis, the next phases of the investigation will extend coverage to the remainder of the CARETS area. Uniform land use data sets from both ERTS and aircraft sources will be compared and tested for environmental impact applications. Formal user evaluation by key state agencies and other potential users will be obtained. This report and the entire USGS CARETS project is the result of a team effort; staff geographers who have contributed to this effort as members of the team include William B. Mitchell, Ivan Hardin, Peter DeForth, Harry F. Lins, Jr., Katherine Fitzpatrick, and Ken McGinty. Their continued support is gratefully acknowledged.

Table 1. Land Use Categories Identified on ERTS Imagery in CARETS. Numbering System From Geological Survey Circular 671.

Level I	Level II	(Proposed) Level III
1 URBAN AND BUILT UP	11 Residential	Single-family residential
	12 Commercial and services	Retail trade area
	14 Extractive	Sand and gravel pits
	15 Transportation, communication and utilities	Airports Highways Power line rights-of-way
	17 Strip and clustered settlement	
	19 Open and other	
2 AGRICULTURAL	21 Cropland and pasture	
4 FOREST-LAND		
5 WATER	51 Streams and waterways	
	52 Lakes	
	53 Reservoirs	
	54 Bays and estuaries	
6 NON-FORESTED WETLAND	61 Vegetated	
	62 Bare	
7 BARREN LAND	74 Beaches	

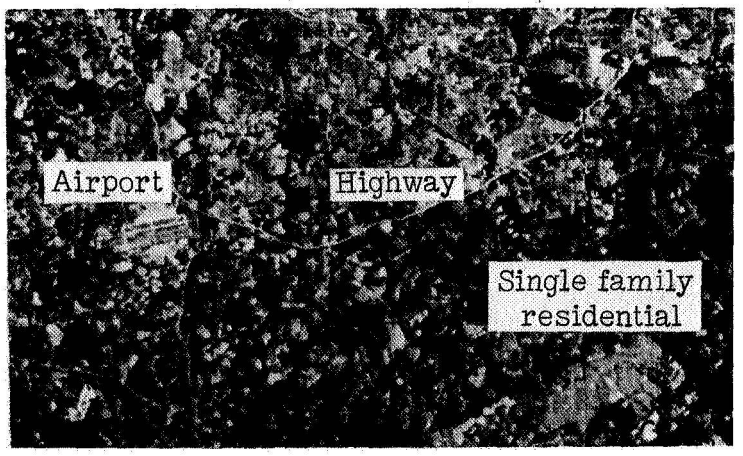

Figure 1. Examples of Level III land use from ERTS image of national capital area (E-1080-15192-5, 11 Oct. 1972).

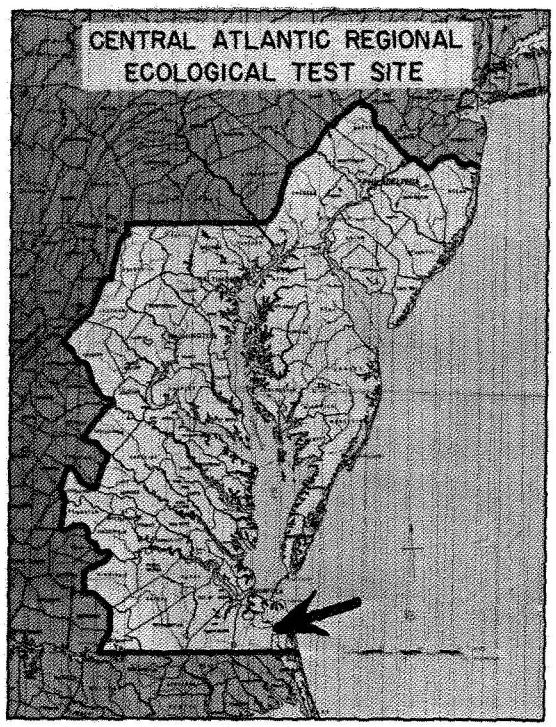

Figure 2. CARETS location map showing Norfolk-Portsmouth Standard Metropolitan Statistical Area (SMSA).

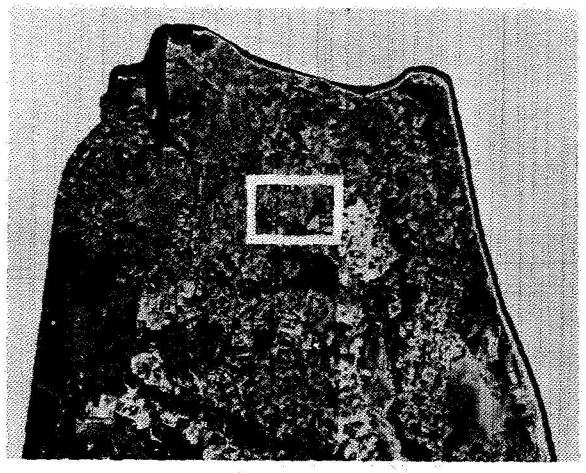

Figure 3. Norfolk-Portsmouth SMSA showing location of South Norfolk test site for ERTS-detected land use change.

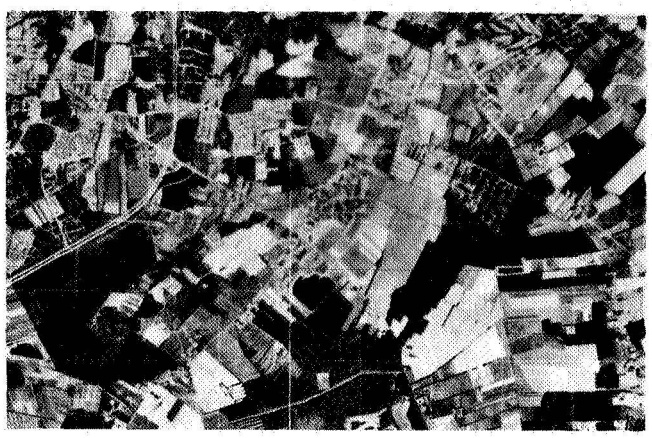

Figure 4. South Norfolk test site: 1970 Photomosaic, photography from NASA/MSC Mission 144. Scale 1:100,000.

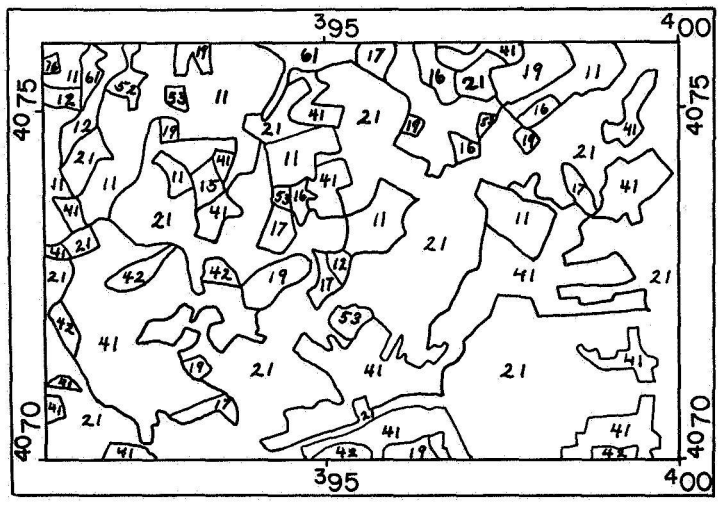

Figure 5. South Norfolk test site: 1970 Level II land use map. Land use categories numbered as in Table 1. Scale 1:100,000.

Figure 6. South Norfolk test site: portion of ERTS MSS image E-1133-15144-5, 3 Dec. 1972, enlarged to a scale of 1:100,000.

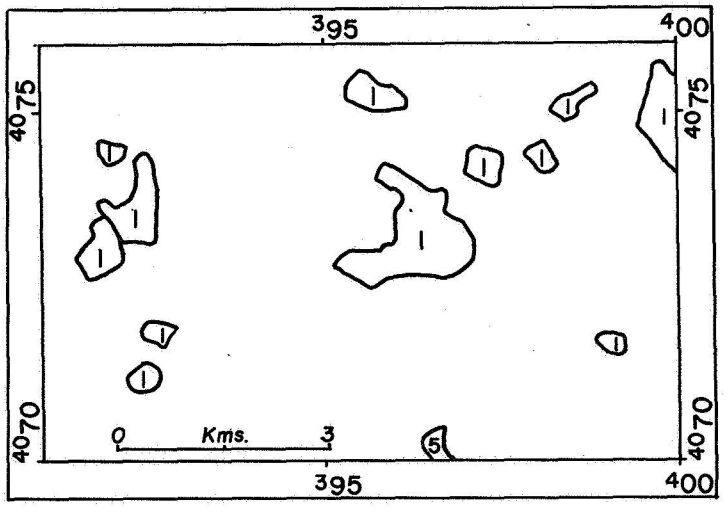

Figure 7. South Norfolk test site: land use change mapped using technique combining ERTS and high-altitude aircraft data. Scale 1:100,000.