N74-34733

(E74-10733) A STUDY FOR THE APPLICATION OF REMOTE SENSING DATA TO LAND USE PLANNING ON THE MISSISSIPPI GULF COAST Final Report, Sep. 1972 - (Mississippi State Univ.) 60 p HC $4.25 CSCL 08B

Unclas
G3/13 00733

FINAL REPORT

NAS5-21817

# "A STUDY FOR THE APPLICATION OF REMOTE SENSING DATA TO LAND USE PLANNING ON THE MISSISSIPPI GULF COAST

F. M. Ingels

September 19, 1972-August 19, 1974

Submitted To:

Goddard Space Flight Center
Greenbelt, Maryland 20771

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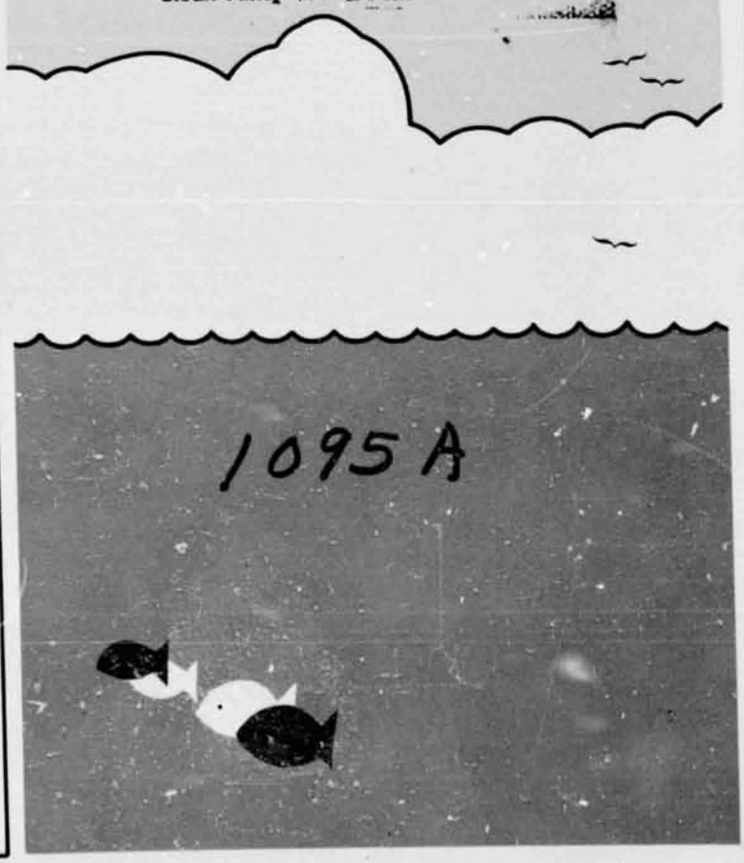

# A STUDY FOR THE APPLICATION OF REMOTE SENSING DATA TO LAND USE PLANNING ON THE MISSISSIPPI GULF COAST

NAS5-21817

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A Final Report

September 1972 - August 1974

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# I. INTRODUCTION

Much discussion has been generated about the relative merits of the ERTS satellite data for application to Land Use Classification, Urban and Rural Planning and various other related applications.

Many have sought to eulogize the ERTS system and many have sought to downgrade the ERTS system.

This study was initiated without either of these objectives in mind. Rather, this study has as its objective the comparison of ERTS-1 data with data from existing land use studies of a three county area of the Mississippi Gulf Coast.

Several factors existed to create a situation in which ERTS-1 data could be fairly compared to existing techniques and some conclusions drawn based on comparable situations.

These factors were primarily as follows:

A. A land use classification map of a four county area along the Mississippi Gulf Coast had just been completed as ERTS was being launched. This existing map had been constructed using the standard techniques of the day; that is, aerial photography and on site inspection by personnel. Thus the study had available a data base that was created by the most up to date methods. (This map was developed by the Gulf Coast Regional Planning Commission.[1])

B. The area in question had undergone significant damage due to Hurricane Camille and the necessary rebuilding, plus the normal expansion of this area, meant that a reasonable amount of change would result in a year's period. This would enable one to make a judgment of the usefulness of ERTS data for monitoring change in land use.

C. The availability of the NASA-MTF-ERL facility and personnel gave the study the ability to produce a land use classification map using the satellite data by purely automated means--a computer generated data map. Thus we would be capable of comparing a standard

technique data map system with a newly automated technique utilizing satellite data and computer processing.

The study was organized into three phases:

A. Data Management--A systematic analysis of the receiving MSS photographs to determine the statistics of site coverage, cloud coverage problems, data losses, etc. A determination of the system reliability insofar as receiving data on a specific area of land for a specific period of time.

B. An Interview Program--The discussion with potential users of such data of the relative merits and the data base differences. This phase also included some education of potential users as to the existence of the ERTS system and data.

C. Data Analysis Techniques--A study of the methods used to produce the computer generated maps.

The final report will discuss each phase of the study in sequence and will present a discussion of the results and conclusions drawn by both the investigators and the agencies interviewed.

Some recommendations based upon the results of the study are offered in hopes that future data products would be tailored to the needs of the user.

## II. DATA MANAGEMENT

Data for this study is received from two sources. Listings of all available ERTS-1 frames and photographic copies of some of these frames are received directly from NASA-Goddard Space Flight Center. Copies of 70 mm negatives and 9.5+ inch positive transparencies are received for each of the 4 MSS sensors for any ERTS-1 frame which: (1) depicts any of the area enclosed by the rectangle having corners located at:31° 05' N, 90° 00' W; 31° 05' N, 88° 15' W; 30° 00' N, 88° 15' W; 30° 00'N, 90° 00'W; and (2) has a cloud cover not greater than 30%. The second data source for this project is the Earth Resources Lab at NASA/MTF. Refined data products, including computer generated color coded land use maps, are produced by the ERL.

### Processing of NASA/GSFC Data

#### A. Site Coverage Determination

The test site for this project is the three Mississippi counties: Harrison, Hancock and Jackson; which comprise the Mississippi Gulf Coast. A computerized algorithm has been established for identifying all available ERTS-1 frames, that is, all frames appearing in the U.S. Standard Catalogs which view any part of this three county region. The routine also computes the percentage of this area and the percentage of each individual county which is depicted by the ERTS-1 frame.

The computer algorithm proceeds as follows:

1. The principal point coordinates of all frames (within reasonable distance of the test site) are inputted. This coordinate is taken from the U.S. Standard Catalog.

2. Based on a model (formed as the average area covered by early ERTS-1 frames over the Gulf Coast) the perimeters of the frame are estimated. These boundaries are the approximate edges of the projection of the frame onto a plane (called the map plane) which is tangential to the land surface just north of the Gulfport-Biloxi area (89° 00' W, 30° r0' N).

3. The desired site area (usually entire Gulf Coast or single county) is then projected into the same map plane.

4. The computer then determines the area in the plane common to both the site projection and the frame projection. This calculation is accomplished in terms of units approximately equal to 36.9 sq. km. The entire site area is also calculated in terms of the same units and these numbers are then ratioed to yield the percentage of the site included in the particular ERTS-1 frame.

A list of all frames covering any part of the test site, the percentage of the site covered, and other selected items from the Standard Catalog has been made and is given in Table II-2. A check after an entry indicates that photographic data for that frame has been received. Those frames which do cover part of the Gulf Coast and were not received in photographic form have been investigated to ascertain why they were not received. A summary of the results of this investigation is given in Table II-1. The time span involved is for data taken from Cycle I through Cycle 28, or from 1 August 1972 through 17 December 1973.

Table II-1

Accounting of Unreceived data

Cycle I - Before Start of Contract
Cycle II - Cycle XXVIII

| No. frames taken over test site | No. not taken | No. Received | Reason why frames were not received | | |
|---|---|---|---|---|---|
| | | | Clouds | Quality | Unknown |
| 54 | 5 | 18 | 31 | 1 | 4 |

TABLE II-2

LISTING OF ALL ERTS-1 DATA TAKEN OVER GULF COAST SITE

| Cycle | Date | Frame ID | Cloud Cover | Quality 4567 | Principal Point W Long | Principal Point N Lat | Site Coverage | Data Rcvd |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 Aug 72 | 1014-15555 | 20% | GPFF | 87°59' | 30°34' | 47% | * |
| | 7 Aug 72 | 1015-16013 | 0% | GGGF | 89°26' | 30°34' | 95% | * |
| 2 | 24 Aug 72 | 1032-15555 | 30% | GGGF | 87°58' | 30°38' | 46% | ✓ |
| | 25 Aug 72 | 1033-16012 | 80% | PFPP | 89°08' | 31°33' | 14% | |
| | | 1033-16014 | 50% | G GF | 89°35' | 30°13' | 90% | |
| 3 | 11 Sept 72 | 1050-15560 | 50% | PGPG | 88°06' | 30°17' | 50% | |
| | 12 Sept 72 | 1051-16014 | 20% | GGPG | 89°32' | 30°17' | 93% | ✓ |
| 4 | 29 Sept 72 | 1068-15560 | 50% | GGGG | 88°02' | 30°19' | 45% | |
| | 30 Sept 72 | 1069-16014 | 90% | GGGG | 89°28' | 30°19' | 97% | |
| 5 | 17 Oct 72 | 1086-15562 | 20% | GGGG | 88°05' | 30°17' | 48% | * |
| | 18 Oct 72 | 1087-16020 | 80% | GGGP | 89°31' | 30°17' | 94% | |
| 6 | 5 Nov 72 | 1105-16020 | 50% | GGGG | 89°12' | 31°34' | 12% | |
| | | 1105-16022 | 90% | GGGG | 89°36' | 30°08' | 91% | |
| 7 | 22 Nov 72 | 1122-15565 | 80% | PGGG | 88°10' | 30°16' | 54% | |
| | 23 Nov 72 | 1123-16021 | 100% | GGGG | 89°10' | 31°38' | 6% | |
| | | 1123-16023 | 90% | GGGG | 89°10' | 30°13' | 90% | |
| 8 | 11 Dec 72 | 1141-16023 | 100% | G G | 89°13' | 31°32' | 21% | |
| | | 1141-16023 | 100% | G G | 89°38' | 30°06' | 88% | |
| 9 | 28 Dec 72 | 1158-15564 | 10% | GPPP | 88°05' | 30°18' | 49% | ✓ |
| | 29 Dec 72 | 1159-16022 | 100% | GGGG | 89°29' | 30°18' | 97% | |

*Unknown why not received

TABLE II-2 (Continued)

| Cycle | Date | Frame ID | Cloud Cover | Quality 4567 | Principal Point W Long | Principal Point N lat | Site Coverage | Data Rcvd |
|---|---|---|---|---|---|---|---|---|
| 10 | 15 Jan 73 | 1176-15562 | 10% | GGGG | 87°58' | 30°30' | 49% | ✓ |
| | 16 Jan 73 | 1177-16020 | 0% | GGGG | 89°19' | 30°47' | 98% | ✓ |
| 11 | 2 Feb 73 | 1194-15564 | 10% | GGGG | 88°09' | 30°20' | 54% | ✓ |
| | 3 Feb 73 | 1195-16023 | 0% | GGGG | 89°34' | 30°20' | 89% | ✓ |
| 12 | 20 Feb 73 | 1212-15570 | 60% | GGGG | 88°39' | 30°21' | 59% | |
| | 21 Feb 73 | 1213-16024 | 80% | GGGG | 89°39' | 30°16' | 84% | |
| 13 | 10 Apr 73 | 1230-15571 | 90% | GGGG | 88°17' | 30°22' | 66% | |
| | 11 Apr 73 | 1231-16025 | 80% | GGGG | 89°40' | 30°22' | 79% | |
| 14 | 28 Apr 73 | 1248-15571 | 40% | GGGG | 88°20' | 30°21' | 70% | |
| | 29 Apr 73 | 1249-16025 | 90% | GGGG | 89°47' | 30°21' | 71% | |
| 15 | 15 Mar 73 | 1266-15571 | 30% | GGPG | 88°19' | 30°27' | 71% | * |
| | 16 Mar 73 | 1267-16025 | 90% | GGGG | 89°46' | 30°26' | 70% | |
| 16 | 3 May 73 | 1284-15570 | 40% | GGGG | 88°21' | 30°23' | 73% | |
| | 4 May 73 | 1285-16024 | 0% | GGGG | 89°46' | 30°27' | 70% | ✓ |
| 17 | 21 May 73 | 1302-15560 | 20% | PGGG | 88°23' | 30°25' | 71% | ✓ |
| | 22 May 73 | 1303-16024 | 90% | GGGG | 89°47' | 30°22' | 71% | ✓ |
| 18 | 9 June 73 | 1321-16022 | 30% | GGGG | 39°44' | 30°27' | 73% | ✓ |
| 19 | 27 June 73 | 1339-16021 | 20% | GGGG | 37°46' | 20°23' | 72% | ✓ |
| 20 | 14 July 73 | 1356-15561 | 100% | GGGG | 83°21' | 30°20' | 70% | |
| | 15 July 73 | 1357-16020 | 80% | GGPG | 89°46' | 30°22' | 72% | |

*Unknown why not received

TABLE II-2 (Continued)

| Cycle | Date | Frame ID | Cloud Cover | Quality 4567 | Principal Point W Long | Principal Point N Lat | Site Coverage | Data Rcvd |
|---|---|---|---|---|---|---|---|---|
| 21 | 1 Aug 73 | 1374-15560 | 80% | GGGG | 88°19' | 30°18' | 66% | |
| | 2 Aug 73 | 1375-16014 | 70% | GGGG | 89°44' | 30°18' | 77% | |
| 22 | 20 Aug 73 | 1393-16013 | 0% | GGGG | 89°46' | 30°19' | 73% | * |
| 23 | 6 Sept 73 | 1410-15552 | 100% | PGGG | 88°15' | 30°18' | 61% | |
| | 7 Sept 73 | 1411-16011 | 40% | GGGP | 89°42' | 30°19' | 79% | |
| 24 | 24 Sept 73 | 1428-15550 | 10% | GGGG | 88°11' | 30°23' | 57% | ✓ |
| | 25 Sept 73 | 1429-16004 | 10% | GGGG | 89°38' | 30°21' | 88% | ✓ |
| 25 | 12 Oct 73 | 1446-15543 | 60% | GPGG | 88°08' | 30°25' | 54% | |
| | 13 Oct 73 | 1447-16001 | 70% | PGGP | 89°35' | 30°20' | 88% | |
| 26 | 30 Oct 73 | 1464-15541 | 0% | P-PP | 88°08' | 30°18' | 52% | |
| | 31 Oct 73 | 1465-15595 | 90% | PPGG | 89°32' | 30°19' | 93% | |
| 27 | 17 Nov 73 | 1482-15541 | 10% | GGGG | 88°11' | 30°11' | 53% | ✓ |
| | 18 Nov 73 | 1483-15592 | 10% | PGPG | 89°14' | 31°36' | 5% | ✓ |
| | 18 Nov 73 | 1483-15595 | 10% | PPPG | 89°38' | 30°10' | 88% | ✓ |
| 28 | 5 Dec 73 | 1500-15535 | 0% | GGGP | 88°13' | 30°14' | 56% | * |
| | 6 Dec 73 | 1501-15591 | 0% | GGGG | 89°15' | 31°37' | 4% | ✓ |
| | 6 Dec 73 | 1501-15594 | 20% | GGGG | 89°39' | 30°12' | 85% | ✓ |

*Unknown why not received

B. Visual Analysis

As previously stated, the photographic data which we receive is in the form of 70 mm negatives and 9.5+ inch positive transparencies. The data is checked and logged upon arrival. The negatives are then filed for possible future reproductions, and the frames are plotted on a Mississippi map. These maps showing data locations are then filed giving an easy catalog system for determining if we have data over particular areas of the state.

Visual analysis is then performed on the positive transparency. The data is overlaid on a map drawn to the approximate frame scale (1:1,003,000). It is then easy to check the results of the coverage algorithm and the plot made previously. The map shows only political boundaries of interest and water. The coast line and the various lakes along with the Mississippi River make it easy to locate a frame accurately on the map.

Then an estimate is made of the cloud cover, over the site area only. This cloud cover is often very different than the cloud cover over the entire frame due to the proximity of the Gulf.

Next, all four sensor's data is examined to determine if there were any system anomolies which might make further data reduction difficult, or impossible. Each of these frames are given a numerical quality rating of from 1-4 with 4 being excellent. This rating takes into account data dropouts and degradation from photographic reproducing. It does not concern itself with cloud cover.

The final step in the visual analysis is to give the frame a data rating. This rating again takes on values of from 1 to 4. This rating is an evaluation of how suitable this particular frame is for

further data reduction. A rating of 1 signifies that attempts to gain more information through data reduction techniques would be useless. A rating of 2 indicates that the data could give information over limited areas. A 3 means that the data is good and would lend itself well to further interpretation over most of the frames view. A rating of 4 signifies that the data is excellent.

All this information from the visual analysis plus site coverage numbers generated by the computer algorithm are recorded on the analysis sheets. (Table II-3)

Table II-4 shows coverage of all ERTS-1 frames received by MSU. The uncovered portion of the site is assumed to have had extensive cloud cover (>30%) or have experienced some sort of system failure

TABLE II-4

Site Coverage by Cycle

| Coverage | Cycle | No. of Cycles |
|---|---|---|
| 100% | 10,11,24,27 | 4 |
| 90-99 | 3 | 1 |
| 80-89 | 28 | 1 |
| 70-79 | 16,17,18,19 | 4 |
| 60-69 | | |
| 50-59 | 26 | 1 |
| 40-49 | 2,9 | 2 |
| 30-39 | | |
| 20-29 | | |
| 10-19 | | |
| 1-9 | | |
| 0% | 4-8,12-15,20-23,25 | 14 |
| | Total | 27 |

TABLE II-3

Analysis of Received Data, Gulf Coast

| Frame ID | Site Coverage by County Hancock | Harrison | Jackson | All | Site Cl Cov | Data Qual 4567 | Comments | Data Rating |
|---|---|---|---|---|---|---|---|---|
| 1032-15555 | 0% | 17% | 100% | 46% | 10% | 4444 | | 3 |
| 1050-15553 | 0% | 0% | 0% | 0% | NA | 4424 | Data Drop in 6 | 2 |
| 1051-16012 | 0% | 0% | 0% | 0% | NA | 4424 | Data Drop in 6 | 2 |
| 1051-16014 | 100% | 100% | 84% | 93% | 20% | 4424 | Data Drop in 6 | 2 |
| 1052-16070 | 0% | 0% | 0% | 0% | NA | 4424 | Data Drop in 6 | 2 |
| 1070-16070 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1070-16073 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1106-16074 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1158-15561 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1158-15564 | 0% | 24% | 100% | 48% | 0% | 4444 | | 4 |
| 1176-15562 | 0% | 12% | 100% | 44% | 0% | 4444 | | 4 |
| 1177-16021 | 100% | 100% | 96% | 98% | 0% | 4474 | | ? |
| 1177-16023 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1194-15562 | 0% | 0% | 0% | 0% | NA | 4444 | Cloudy | 2 |
| 1194-15564 | 0% | 41% | 100% | 54% | 0% | 4444 | | 4 |
| 1195-16020 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1195-16023 | 100% | 100% | 74% | 89% | 0% | 4444 | | 4 |
| 1196-16075 | 0% | 0% | 0% | 0% | NA | 4444 | Cloudy | 3 |

Ratings: 1 - Useless; 2 - Somewhat Useful; 3 - Acceptable; 4 - Excellent

TABLE II-3 (Continued)

| Frame ID | Site Coverage by County Hancock | Harrison | Jackson | All | Site Cl Cov | Data Qual 4567 | Comments | Data Rating |
|---|---|---|---|---|---|---|---|---|
| 1212-15563 | 0% | 0% | 0% | 0% | NA | 4444 | Light clouds | 2 |
| 1232-16081 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1248-15565 | 0% | 0% | 0% | 0% | NA | 4444 | clouds | 2 |
| 1285-16022 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1285-16024 | 100% | 100% | 27% | 70% | 0% | 4444 | excellent | 4 |
| 1286-16080 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1302-15563 | 0% | 0% | 0% | 0% | NA | 4444 | scattered clouds | 3 |
| 1302-15565 | 2% | 92% | 100% | 71% | 20% | 4444 | scattered clouds | |
| 1321-16022 | 100% | 100% | 34% | 73% | 10% | 4444 | scattered clouds | 3 |
| 1322-16074 | 0% | 0% | 0% | 0% | NA | 4434 | light clouds | 2 |
| 1339-16014 | 0% | 0% | 0% | 0% | NA | 4444 | light clouds | 2 |
| 1339-16021 | 100% | 100% | 31% | 72% | 20% | 4444 | scattered clouds | 2 |
| 1340-16073 | 0% | 0% | 0% | 0% | NA | 4444 | scattered clouds | 2 |
| 1358-16072 | 0% | 0% | 0% | 0% | NA | 4444 | scattered clouds | 2 |
| 1375-16012 | 0% | 0% | 0% | 0% | NA | 4444 | heavy clouds | 1 |
| 1376-16070 | 0% | 0% | 0% | 0% | NA | 4444 | scattered clouds | 2 |
| 1428-15543 | 0% | 0% | 0% | 0% | NA | 4444 | light clouds | 2 |
| 1428-15550 | 0% | 53% | 100% | 57% | 1% | 4444 | | 4 |
| 1429-16002 | 0% | 0% | 0% | 0% | NA | 4444 | scattered clouds | 3 |
| 1429-16004 | 100% | 100% | 60% | 84% | 5% | 4444 | light clouds | 3 |
| 1446-15540 | 0% | 0% | 0% | 0% | NA | 4444 | large cloudy area | 2 |

Ratings: 1 - Useless; 2 - Somewhat Useful; 3 - Acceptable; 4 - Excellent

TABLE II-3 (Continued)

| Frame ID | Site Coverage by County Hancock | Harrison | Jackson | All | Site Cl Cov | Data Qual 4567 | Comments | Data Rating |
|---|---|---|---|---|---|---|---|---|
| 1464-15534 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1464-15541 | 0% | 35% | 100% | 52% | 0% | 4 44 | | - |
| 1466-16051 | 0% | 0% | 0% | 0% | NA | 4 4 | | - |
| 1466-16054 | 0% | 0% | 0% | 0% | NA | 4 4 | | - |
| 1482-15534 | 0% | 0% | 0% | 0% | NA | 4444 | | 4 |
| 1482-15541 | 0% | 39% | 100% | 53% | 0% | 444 | | - |
| 1483-15592 | 0% | 0% | 12% | 5% | 0% | 4444 | scattered clouds | 2 |
| 1483-15595 | 100% | 100% | 70% | 88% | 15% | 4444 | scattered clouds | 2 |
| 1484-16051 | 0% | 0% | 0% | 0% | No Positive Transparencies | | | |
| 1501-15591 | 0% | 0% | 11% | 4% | 0% | 4444 | | 4 |
| 1501-15594 | 100% | 100% | 65% | 85% | 1% | 4444 | light cloudy | 3 |
| 1502-16050 | 0% | 0% | 0% | 0% | No Positive Transparencies | | | |

Ratings: 1 - Useless; 2 - Somewhat Useful; 3 - Acceptable; 4 - Excellent

A short list giving more items about cycles with non-zero coverage is given in Table II-5. An x in the extreme right column indicates that the data was used by NASA/MTF to produce land use maps.

TABLE II-5

Cycles with Non Zero Coverage

| Coverage | Cycle | Site Cloud Cover | Rating | Used |
|---|---|---|---|---|
| 100% | 10 | 0% | 4 | x |
| | 11 | 0% | 4 | |
| | 24 | 3% | 3 | |
| | 27 | 10% | 3 | |
| 90-99% | 3 | 20% | 2 | |
| 80-89% | 28 | 1% | 4 | |
| 70-79% | 16 | 0% | 4 | x |
| | 17 | 20% | 2 | |
| | 18 | 10% | 3 | |
| | 19 | 20% | 3 | |
| 50-59% | 26 | 0% | | |
| 40-49% | 2 | 10% | 3 | |
| | 9 | 0% | 4 | |

The important question is "how often do you get useful data?" From past experience we can define the term "useful" as any pass with less than 10% cloud cover having at least 3 good sensor outputs. These qualities seem to be required for this type data analysis technique. Applying this definition to the time span of one year [Cycle I beginning 1 Aug '72 through Cycle XX ending 26 July '73] resulted in Table II-6.

TABLE II-6

Listing of Useful Data Taken from Aug '72 to Aug '73

| Hancock County | Harrison County | Jackson County | Entire Gulf Coast |
|---|---|---|---|
| Cycle 1 (Aug 6) | Cycle 1 (Aug 6) | Cycle 1 (Aug 6) | Cycle 1 (Aug 6) |
| | Cycle 9 [24%] | | |
| Cycle 10 (Jan 15) | Cycle 10 (Jan 15) | Cycle 9 (Dec 28) | Cycle 10 (Jan 15) |
| Cycle 11 (Feb 2) | Cycle 11 (Feb 2) | Cycle 10 (Jan 15) | Cycle 11 (Feb 2) |
| Cycle 16 (May 3) | Cycle 16 (May 3) | Cycle 11 (Feb 2) | |
| | | Cycle 16 [27%] | Cycle 16 [70%] |
| Cycle 18 (June 8) | Cycle 18 ( June 8) | Cycle 18 [34%] | Cycle 18 [73%] |

During the first year of operation, Hancock and Harrison Counties had 5 complete useful data takes and Jackson County had 4. The entire Gulf Coast experienced 3 complete takes and 2 others with over 70% coverage which were useful. This gives an indication that one could expect one out of every four or five cycles to yield data suitable for this type data analysis.

It is also of interest to know how the useful passes correlate with the seasons since seasonal changes cause large variations in some classifications [i.e., pine vs. hardwood forest is determined much more accurately in winter]. For this purpose a season must be defined with respect to the life cycles of native vegitation. Summer can be easily defined as the time between when crops come up and when they are harvested, approximately June 15 to October 1. Winter can be defined as the time after winter vegetation comes up (i.e., rye grass) and summer vegetation is dead until the summer vegetation starts back to life, or approximately December 15 to March 1. Spring and Fall are more difficult to define. For our study we have defined Spring as from April 1 to May 30 and Fall as being October 15 to December 1. These seasons are listed in Table II-7.

TABLE II-7

Vegetative Seasons

| Summer | Fall | Winter | Spring |
|---|---|---|---|
| June 15 | October 15 | December 15 | April 1 |
| to | to | to | to |
| October 1 | December 1 | March 1 | May 30 |

Working with these seasons and Table II-3, we see that the entire area had a useful pass each season of the first year except for Fall. This study has continued through the Fall of 1974 and the results are given in Table II-8.

TABLE II-8

Seasonal Correlation of Useful Data Takes

| Summer | Fall | Winter | Spring |
|---|---|---|---|
| 6 Aug '72 | None | 15 Jan & 2 Feb '73 | 3 May '73 [70%] |
| 19 Aug '73 | 24 Sept & 17 Nov '73 [both marginal] | -- | -- |

From the first year and a half's result it appears that one is likely to get a useful data pass each season, with the possible exception of Fall.

Finally it is desirable to know why only 1 out of every 4 or 5 passes can be expected to give useful data. From Tables II-1 and II-2 it is apparent that almost every pass that was not useful experienced a heavy cloud cover. Only once did the system performance prohibit data usage. It would appear that no improvement in the sensors would be able to overcome this problem.

## III. INTERVIEW PROGRAM

### A. Introduction

Data from ERL at NASA/MTF comes in four forms which are (1) Map Tapes (2) Color Land Use Transparencies (3) Color Coded Land Use Map Prints, and (4) Documentation. The map tapes are magnetic tapes giving the classified land usage for the Gulf Coast area for each resolution cell (56m x 79m). They are being used in an attempt to expand the present use of the MSU Computer facility in the remote sensing area. MSU has an Univac 1106 Mod. II Computer at Starkville. The color coded land use transparency is used during conferences between investigators and in explanations of our study to various concerned people and agencies. The bulk of our investigations are carried out using the color coded land use map prints and the corresponding documentation. These products are the final result of ERTS-1 data reduction on this project and it is the usefulness and value of this type product which we are attempting to evaluate.

At the time the interviews were conducted ERL at MTF had delivered two sets of land use maps. The first maps were made from August 6 and 7, 1972 ERTS data and were printed at a scale of 1:250,000 so that they would be directly comparable to the latest GRPC land use maps of the area. The maps showed the three-county area and much surrounding territory on 22" by 26" color reproductions of the original mosaic. There were six land use classifications for these maps, as well as "other" which denoted are as that that defied classification into any of the six classes. The groups selected for identification on these first maps were: Urban/Industry, Water, Forest, Marsh, Grass, and Cultivated. Figure III-1 is a reduced copy of this map.

Figure III - 1 Reduced Copy of Area Land Use Map
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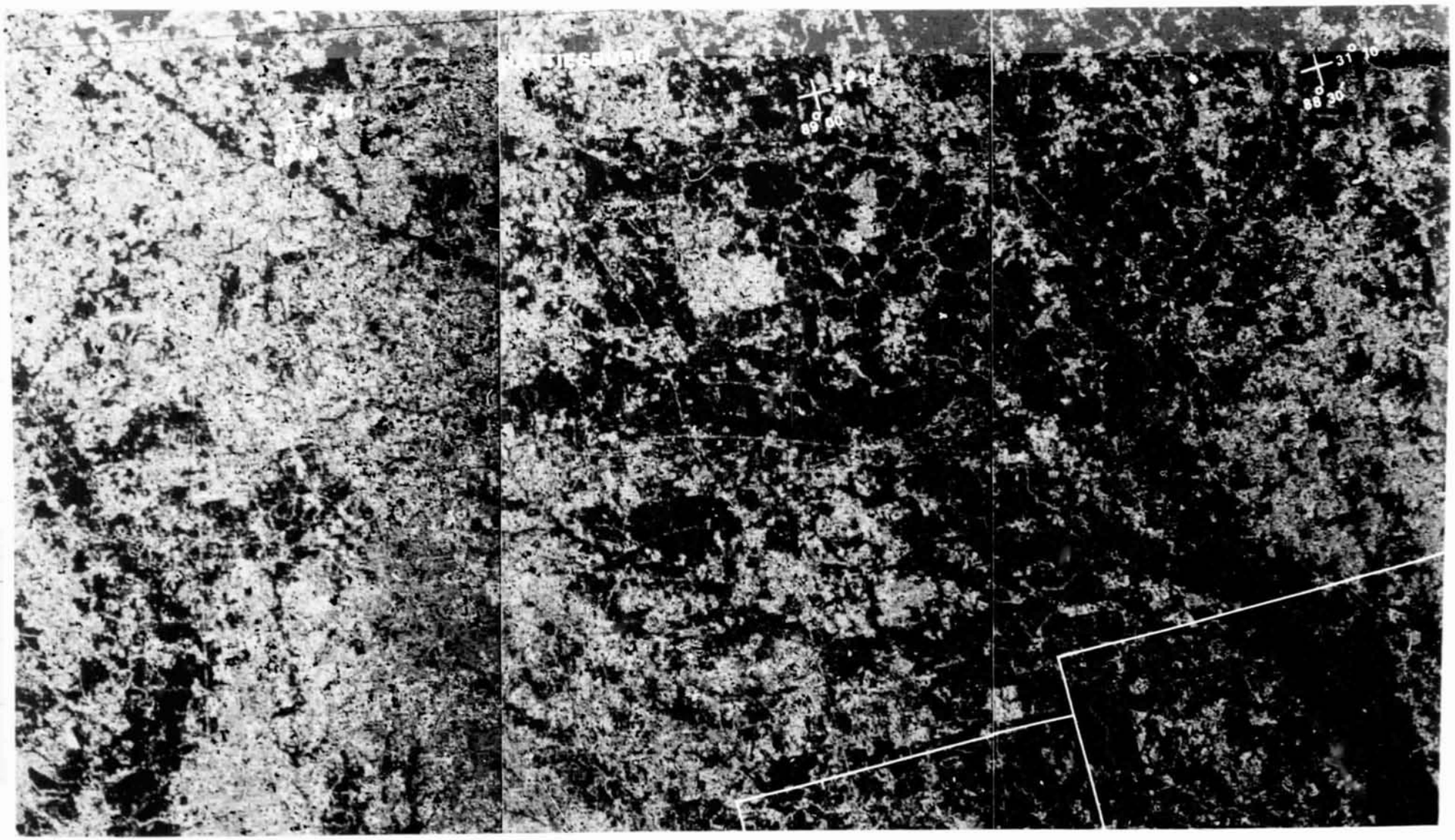
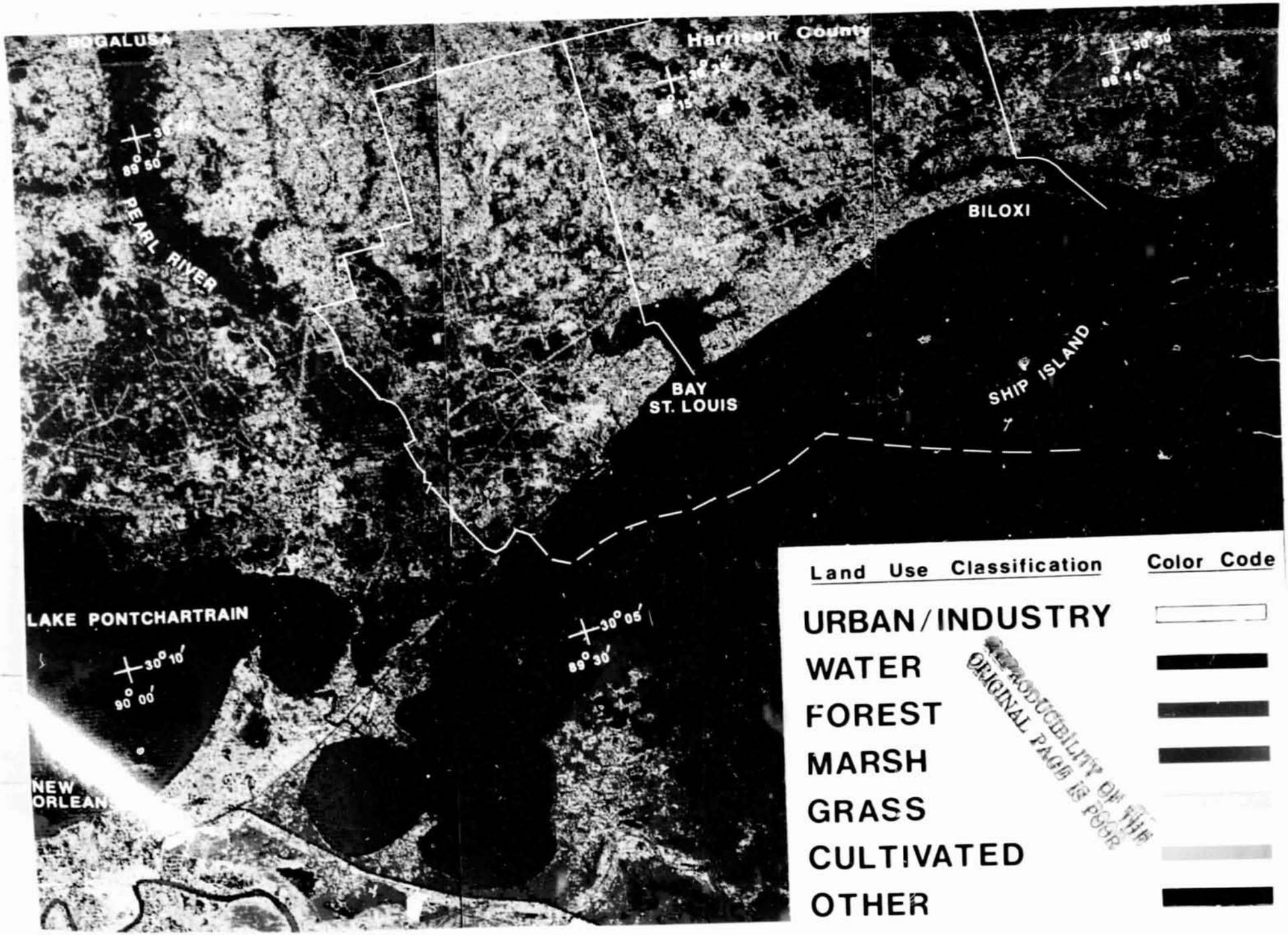
# COMPUTER DERIVED LAND USE CLASSIFICATION OF ERTS-1 DATA ACQUIRED AUGUST 7, 1972 - MISSISSIPPI GULF COAST



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A second set was also taken to the interview sessions. They were made from January 15 and 16, 1973 data. Only six selected townships were depicted on this set of two 22" by 24" color reprints (as well as the corresponding area from the previous map). The intention was to see if seasonal changes from fall to winter could be detected from ERTS type data. The new data was printed at a scale of 1:62,500, or 16 times the size of the first maps in order to give viewers an idea of how this data can be expanded and what detail is present when it is expanded. The areas shown were chosen to give a look at areas predominantly in different classifications, areas undergoing rapid change, and areas easily obtained from the MSS tapes. For these maps the Forest classification was divided into Pine and Hardwood groups and the Cultivated areas were separated into Stubble or Ryegrass. The other classifications were the same except for the addition of a Brush category. Figures III-2 and III-3 are reduced copies of these maps.

The interviews were conducted by two teams of personnel and are reported as such. The first set of interviews concern the area of Demography and Economic analysis. The second part of interviews concern the area of Land Use per se and were conducted by the Land Use Center of Mississippi State University.

The investigators visited and interviewed representatives of the agencies listed below. The agencies represent both publicly and privately supported groups as well as state-wide, regional, and local operations.

1. Central Mississippi Planning & Development Development District, Jackson
2. Community Development, Extension Service, Mississippi State University

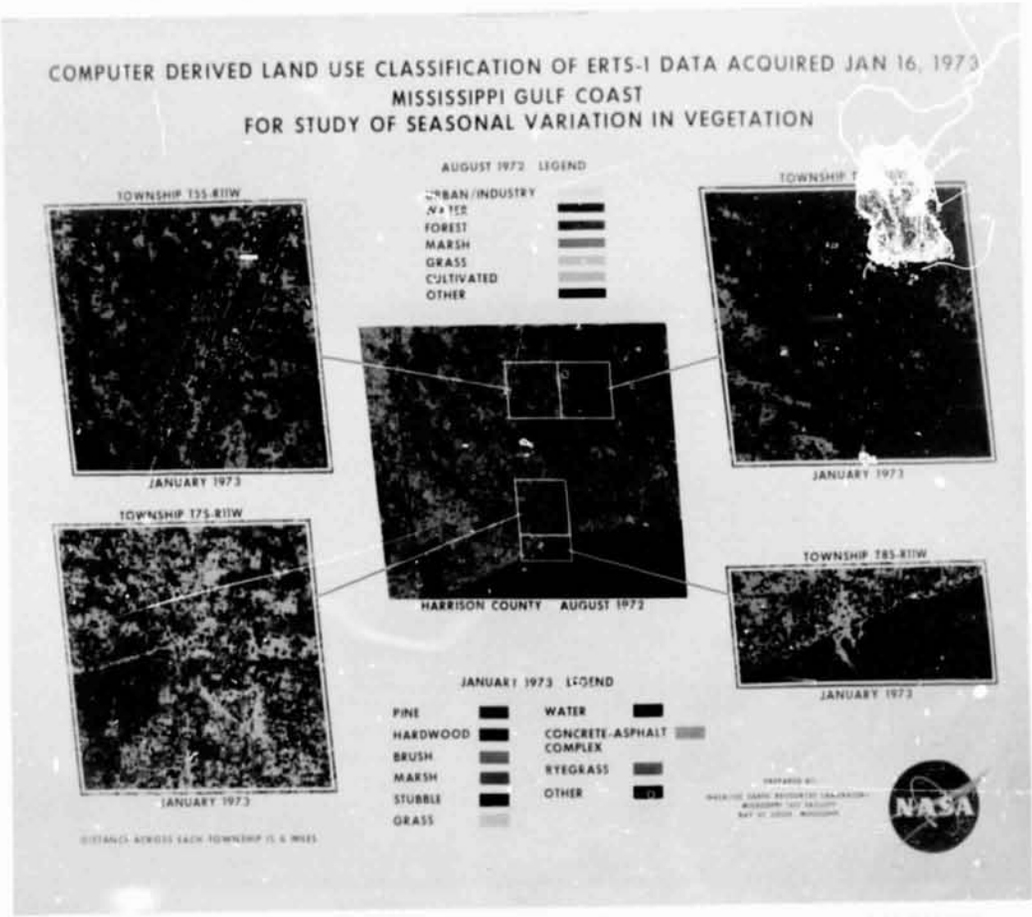


Figure III-2. Reduced Copies of Selected Township Land Use Maps

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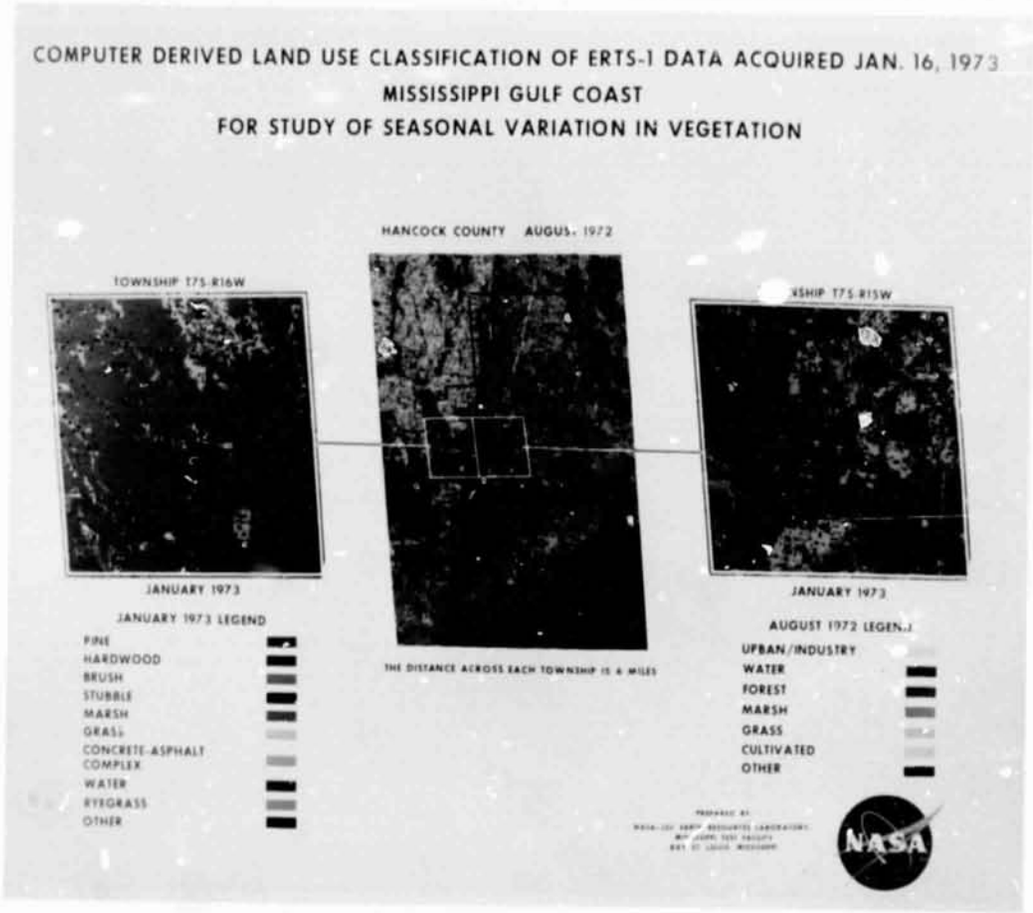


Figure III-3. Reduced Copies of Selected Township Land Use Maps

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3. Comprehensive Planners, West Point
4. Geology and Geography Department, Mississippi State
5. Gulf Regional Planning Commission, Gulfport
6. Institute of Urban Research, Oxford
7. Jackson City Planning Board, Jackson
8. Lee County Council of Governments, Tupelo
9. Mississippi Economic Council, Jackson
10. Mississippi Highway Department, Jackson
11. Mississippi Research & Development Center, Jackson
12. North Mississippi Industrial Development Association, West Point
13. Pat Harrison Waterway District, Hattiesburg

A. summary of each visit and a composite of all interview results was developed and these summaries are presented below.

B. Demographic and Economic Analysis Interviews

Institute of Urban Research
Oxford

The Institute of Urban Research presently uses maps provided by the U. S. Bureau of the Census. The maps show boundaries of census enumeration areas and are used to compute population density and locate population statistics. They are updated to conform to census years.

The ERTS data could give only a rough estimate of the information needed by the Institute of Urban Research. Interest was expressed in blow-ups of entire counties as has been done for certain of the townships. Data giving the acreage of counties is needed. Particular interest was expressed in obtaining data showing inhabitable and uninhabitable land

area. The maps with sufficient resolution to be overlaid with census tracts or boundaries would also be useful to them. They need to be able to identify streets. The Institute's urban change studies will be concerned with comparing land use patterns to urban changes and changes in the occupational structure of an area. They propose to monitor where people are moving and to tie this in with the occupational structure of the area. It was felt that if ERTS-1 maps could be obtained on a better resolution they could be used on an annual basis and the agency would probably be willing to pay $200.00 for a map. The time lab of six months would nc be a problem.

Lee County Council of Governments
Tupelo

The Lee County Council of Governments uses existing and future land use maps as well as special classifications maps. The special classifications maps show land capabilities, watershed usage, soil associations, traffic volume, water and sewer service areas, gas and power service areas, industrial areas, residential building conditions, and population distribution. Aerial photography maps are purchased from the Soil Conservation Service. The special classifications maps are hand-drafted on base maps of the county and city areas and are prepared by the Council. Actual county, field survey is the method used to obtain the data. Some of the maps are updated annually, some monthly. They experienced a lag of approximately three years in obtaining the SCS maps. An exact figure for the cost of present mapping could not be provided.

The officials at the Lee County Council of Governments felt the information they need could not be easily derived from ERTS data. However,

their cartographer felf that the ERTS map (as is) could supplement their present sources of mapping data. Early delivery on a yearly basis would be attractive to them. A six month lag in delivery would be satisfactory. They would probably prefer data taken in winter. More detail, however, is needed before an ERTS-type map would be highly useful to them. They asked the question of whether ERTS data can be blown up to a larger scale than already provided for the townships. One official felt the Countil would not be willing to invest any great amount in 1:250,000 maps used in the interview.

The chief use the Council might have for ERTS-type maps would be detailed agricultural land use.

Pat Harrison Waterway District
Hattiesburg

Pat Harrison Waterway District uses standard USGS quadrangle maps and develop their own land use maps. These maps are used to show existing land use in drainage areas and to determine waste deposits in streams by studying land use. Their primary interest is in determining what effect changes and developments have on environmental conditions. Some of the maps Pat Harrison Waterway uses are updated every 10 years, some more frequently. Approximately $3,000 was spent to make a set of maps from data already assembled.

It was felt that ERTS data provided better detail than the USGS maps. However, ERTS data does not provide the detail needed. It was concluded that the remote-sensing data taken from aircraft would be the answer to their needs. They felt ERTS data would not be adaptable for urban and water resource planning but is good for broad regional planning. They felt their organization would need the data every three to five years. The time

lag of six months would not be a problem. Pat Harrison Waterway District would not invest in ERTS-1 data but would be interested in purchasing aircraft data.

As to land use data needed, this organization is primarily interested in water quality data. They need data showing the effects of industrial and urban changes on water quality. Recreational use data would also be of benefit. For the purpose of showing river systems, the Pat Harrison Waterway District could make use of photos sensitive to heat patterns.

Community Development
Mississippi State University

Community Development of the Cooperative Extension Service at Mississippi State University seldom uses maps. Their primary function is to assist county rural development committees in their planning. It was felt, however, that the data would be best used in regional and national planning.

Planning at the present time is too fragmented, they felt, and ERTS data could provide the broad perspective needed. Various agricultural crops, differentiated and with acreage given, would provide valuable information. They saw ERTS data as possibly being used in planning the nation's food supply. It was felt regional planning commissions could probably use ERTS data on a seasonal basis. They felt larger blow-ups of townships from the present 6" x 6" to 18" x 24" would give better comprehension of the data as presently classified. As to detail, it was felt that greater detail would be needed for city planners. If devised to pick up each house, planning for community services and facilities (e.g.,

sewer and water systems) could be augmented, even in county areas. (Again, it was felt that the different classifications should be separated out for certain purposes, providing some maps concentrating on agricultural uses only.) The time lag of six months was not seen to be a particular problem to anyone. In fact, ERTS data would be some of the most current, up-to-date data obtainable. They felt the cost of ERTS data should be kept as low as possible since many planning agencies operate on a tight budget. It was also suggested that perhaps an extensive set of ERTS maps could be purchased by one agency, university, organization, etc., and that other state agencies could make use of the data as needed. Cooperation between agencies would reduce cost and duplication.

North Mississippi Industrial Development Association
West Point

North Mississippi Industrial Development Association presently uses USGS aerial photography maps. They use maps to show industrial sites, existing and proposed. The maps are updated every five years and are inexpensively obtained. The exact cost was not known.

At present, ERTS data does not provide the information needed. They felt ERTS data would be good when considering the regional concept, e.g. the Golden Triangle area and that ERTS data might be used to study the amount and direction of commercial and industrial growth, if more detail were provided. North Mississippi Industrial Development Association would need such data every five years. ERTS data does not provide the detail needed, since identification of buildings, etc., is necessary for their planning. The time lag of six months would not be a problem. They were uncertain as to the worth of ERTS data.

North Mississippi Industrial Development Association needs site location data identifying roads, streets, creeks, railroads, etc. They could also make use of topographic data.

Jackson City Planning Board
Jackson

The Jackson City Planning Board uses aerial photography taken with infra-red film at an altitude of 60,000 feet. The maps are presented by the City Planning Board. Special information maps showing sewer and water service areas, gas and power service areas, residential, commercial, etc., are prepared from windshield survey techniques taking actual counts. The aerial photography maps represent a one-time investment. Subsequent updating will be done each summer using windshield surveys. Certain of the special information maps are updated weekly. Frequency of updating depends on the particular map. No exact figure could be provided for the cost of the Planning Board's maps. One set had cost $600 to prepare.

They felt the information from the 1:250,000 map would be of no great use to them. They are interested in more specific classification of data. It was felt obtaining the magnetic tapes would provide a good source of information since they own their own computer and could use digitized information. If ERTS data could be made suitable for their purposes they would use it on an annual basis. They felt greater detail and more classifications would be necessary for their planning purposes. At one point, an interest was expressed in data with the same resolution but enlarged to a scale of 1" to 200'. The time lag of six months would not present a problem. The officials were uncertain as to the amount they would pay for ERTS data.

The type of land use data the City Planning Board needs is that showing urban changes. Input into modeling in the determination of the best places for residential areas, access roads, etc., would also be useful.

Mississippi Highway Department
Jackson

The Mississippi Highway Department uses county and city maps which show residential and industrial sites. Their soil stabilization maps show railroads, streets and streams. The Highway Department develops 82 county and 260 city maps through field survey inventory, i.e., riding the roads and recording data. USDA and SCS are sources for photographs from which some maps are prepared. The maps are updated on a 5-year cycle basis, with some maps being updated more often than others. Five or six county maps are purchased each year. Spending includes $100,000 for mapping and $100,000 for inventory per year.

It was felt ERTS data would be a good source of data but was uncertain as to its use. They felt ERTS data could possibly be used to measure changes from previous inventories. Such information could change their priority of inventories. The Highway Department could use ERTS data annually, possibly more often. The concrete, asphalt classification would need greater accuracy. For the purpose of illustrating general changes and growth they felt ERTS data, at the 1:250,000 scale provides the detail needed. The land use classifications are more than needed for their purposes. The comment was made that the Highway Department usually looks to the Economic Development Districts for land use information. The time lag of six months would not be a problem.

Highway Department officials felt they needed land use data as an aid in updating their surveys. They also need land use data which shows drainage detail.

Central Mississippi Planning and Development District
Jackson

The Central Mississippi Planning and Development District uses base maps of the district which are interpretive for land use patterns and regional planning, showing existing and proposed uses. Special information maps show availability of sewers, water, recreational areas, industrial sites, transportation, agriculture, etc. The base maps are developed by the CMPDD with the R & D center as a source for some funding. A set of aerial photography maps are also being prepared by CMPDD. The aerial photography maps represent a one-time investment. CMPDD hopes to eliminate mapping updating by obtaining computer data and using the computer owned by the City of Jackson for information on changes that have occurred. They felt elimination of "eyeball" interpretation would be an improvement. The land use base maps cost approximately $2,500 to prepare. Complete information on cost was not provided.

The CMPDD will be receiving original film from NASA which will be blown-up to a scale of 1 to 24,000. A stereoscope will be used in an attempt to pull off first and second level data showing land use. They are scheduled to do townships within the next fiscal year. CMPDD visualized ERTS data being used to show changes and growth from one year to the next. ERTS data would give a firmer grip on what is happening--a broader perspective. With the up-to-date information from ERTS showing land usage, more time could be focused on land capabilities, allowing

determination of the best uses for the land. The ERTS data would be needed annually. The biggest problem in making use of ERTS data they felt, was that one would almost have to have computer capabilities. The detail of ERTS data is excellent for broad regional planning. For urban areas, more detail is needed. The time lag of six months would not present a great problem. In terms of cost, the feeling was more as to what they would be able to pay rather than what they would be willing to pay. They have little flexible money and would be dependent upon the R & D center for funding to purchase the data.

CMPDD needs second level classification data of townships. NASA aerial photography maps blown-up to a scale of 1 to 24,000 will be used for this purpose.

It was suggested that getting all groups together who can make use of ERTS data would prove beneficial. If agencies would cooperate with each other, this would perhaps reduce the cost in obtaining such data. Different expertises together might be helpful in determining various uses of the data, also.

Mississippi Research and Development Center
Jackson

The Mississippi Research and Development Center is currently preparing a set of maps using aerial photography taken at 60,000 feet. The maps will provide third level data using the 50 classifications established by the Department of the Interior as a national land-use classification system. The maps will be used to show land-use patterns and are being developed from NASA aerial photography. The maps will take approximately four years to make and there will, perhaps be a 10-year lag

in updating. The R & D Center is authorized to spend $100,000 per year for mapping. The maps currently being developed cost $32 per township.

The R & D Center is very interested in making use of ERTS data in another year or two to compare with the maps presently being made. They are interested in ERTS data as a means of evaluating growth and for the purpose of establishing ground truths. The representatives at the R & D Center felt ERTS data would be useful to them as a supplement in updating basic maps. They possibly would use only the digitized information for updating purposes. ERTS data would be used on an annual basis. The officials felt better resolution would be needed before the detail is great enough for their purposes. They are interested in more classifications, as well, and are ultimately interested in fifth level classification of data. The time lag of six months would not present a serious problem, but, it the lag could be reduced to 2 1/2 months, it would be good. The R & D Center people were uncertain as to what they would be willing to pay for ERTS data.

Land-use data which would establish ground truths is needed, and they felt ERTS data could be used for this purpose. Urban land-use data is also needed.

Comprehensive Planners
West Point

The Comprehensive Planners of West Point use regular base maps showing streets, highways, section lines, townships, etc. From these, land use maps are developed using windshield survey techniques. They first obtain existing land use maps and then develop future land use planning maps. The Comprehensive Planners develop their own maps but use

SCS and others as sources for information occasionally needed. They do not update maps unless someone contracts them to do so. Most of their projects are funded by the Federal Government, e.g. HUD, or by private concerns. They felt the maps should be updated at least every five years, though many are not. Source maps run from $100 to $500. Critical aerial photography costs from $60 to $100 per acre. One set of maps was sold to a client for $4,000; another set was sold for $11,000. The cost varies.

It was felt they could get some of the information they use from ERTS data, and, that if they had someone who could interpret the data, some ground survey could be eliminated, perhaps resulting in a saving of time and cost. ERTS data, they thought, might be a more accurate interpretation of land use, if given greater detail. They visualized ERTS data being used for quality control of resources and perhaps in matters of pollution control. They perceived an interest in rural data on a 5-year basis and data for monitoring urban changes on an annual basis. Especially for urban areas, the more detail provided, the better the information. More classification would be needed for certain of their purposes. The time lag of six months might present a problem. If they had a contract to fill, in which they needed up-to-date data and the timing was not at the proper sequence, the delay of six months could present a problem. Comprehensive Planners were uncertain as to what they would be willing to pay for ERTS data. They felt it would depend on what the contracting agency wanted to pay and whether it could be done less expensively using another method.

The land use data they need is that showing residential users (location and general type), industry (heavy and light), recreational

parks and playgrounds, major concentrations of forests, prime cultivatable lands, major bodies of water, drainage features of land, topography, and soil conditions and capabilities.

Gulf Regional Planning Commission
Gulfport

The Gulf Regional Planning Commission uses existing and future land use maps. They develop many of their own maps and use Highway Department maps, as well. Their maps are updated and published on a 3-year interval basis.

The officials at Gulf Regional felt ERTS data could provide a source of data against which to measure their own projections. They felt ERTS data could be used to study the impact of Interstate 10. GRPC sees ERTS data as the "broad brush approach" and presently is interested in the data. The officials at Gulf Regional felt ERTS data could be used for soil conservation, forestry, and topographic detail purposes. They felt ERTS data would provide a good supplement to present data and that they would be interested in obtaining the data seasonally, taken at mid-winter and mid-summer intervals. It was felt that better resolution and further classification of marsh lands would improve their use of ERTS data. They were uncertain as to the worth of ERTS data.

The officials at Gulf Regional feel ERTS data will have to be adapted to the needs of planners and that some ground verification will still be necessary.

Geology Department
Mississippi State University

The Geology and Geography Department uses topographic quadrangle maps taken at scales of 1 to 62,500 (approximately), 1 to 24,000, and

1 to 250,000. The maps are used chiefly for teaching and to a minor extent for research. County maps are also used.

ERTS-1 data, it was felt, presents a good overall view of regions. The primary use these individuals saw for ERTS data was in monitoring changes. They felt ERTS data combined with geological and geographic knowledge would present excellent information as to the specific conditions, broad configurations of land forms, and land use. For broad configurations, they thought the ERTS map might be more useful than lower level photos. As to frequency of use, they felt ERTS data could be consulted after each set of information is produced for data on pollution control. They, however, did not express this as an intention of purchasing ERTS data with such frequency In terms of detail, the geologists feel ERTS-1 data gives limited information since the resolution is poor, though for the broad view it is still good. They felt airplane photography could not be replaced by the ERTS map. They were uncertain as to how much they could or would be willing to pay for ERTS data. One suggestion was that extensive purchase of this type of information should be made by one agency or university in the state with the understanding that other groups and agencies would be able to study and use the data. They felt that two or three weeks' study of the maps might be needed to exhaustively determine their potential. It was suggested that a traveling display of NASA maps, kept one to two weeks in each location would be helpful. With this type of sharing, agencies could determine the value of the data for their purposes. They would then know how often they would want to purchase the data.

The Geology Department would be interested in data showing chalk formation, lineations in the earth's surface, etc. For Geography, land

use data, giving a further breakdown of agricultural uses, e.g., data distinguishing exact crops, would be valuable.

C. Summary Evaluation of D & E Analysis

The types of maps currently used by the various agencies included existing and proposed land-use maps, special information maps, site-location maps, topographic detail maps, maps showing drainage features, water quality data, soil conditions, and capabilities maps, etc. For special information maps and other maps requiring great detail, ground observation, actual count is the method most often used for obtaining mapping information. Aerial photography seemed to be the most frequently used method of obtaining a fairly detailed but broader view of an area. Frequently mentioned sources for mapping data were the U.S. Geological Survey, Soil Conservation Service, Mississippi Highway Department and U.S. Department of Agriculture. Less frequently mentioned as a source was the U. S. Bureau of the Census. Many of the agencies developed a portion of their own mapping information and used that in combination with information from another source or sources. Updating of maps depends on use. City and regional planners update special information maps as much as weekly or monthly. Most updating is done on an annual or two-to-five year cycle basis. A number of agencies had or were purchasing NASA aerial photography maps on a one-time investment basis.

In general, most agency representatives are interested in making use of ERTS-1 data. The majority who were interviewed saw use of ERTS-1 data as a supplement to current mapping data; none saw it as a replacement. Many felt ERTS-1 data provides the broad perspective of information

needed or, at least, would be a valuable and complementary source of information. The agencies whose primary interest is in urban planning cannot get the information needed from ERTS-1 data. Only in terms of very general growth and change information, such as, perhaps the direction of change, would ERTS-1 data be of any use.

Other than for a broad general view of an area, most felt 1:250,000 scale maps do not provide the detail needed. For specific planning purposes, even at the regional level, more detail is necessary. For example, data on the water quality of a district or region would require much more detail that the 1:250,000 maps provide. In terms of classification, agency representatives often mentioned a much more detailed classification of a particular type of land use as being desirable. For example, a greater break-down of agricultural land uses, urban land uses, marsh lands, etc., would better serve the specific needs of various agencies. Along the same line, other representatives mentioned separating out classifications and concentrating on only one or a few in a map.

Frequency of perceived use varied. Only the geologists at Mississippi State University felt the data would be useful on more than a seasonal basis. Their interest in more frequent use was in matters of pollution control. Some few agency representatives felt ERTS-1 data would be of value in showing seasonal differences. The majority of representatives expressed interest in obtaining ERTS data on an annual basis. Primary interest was in comparing year-to-year changes. For agencies whose mapping updating is less frequent, representatives felt ERTS-1 data would be valuable on a three-to-five year interval basis. The time lag of six months in obtaining data was satisfactory to most agency representatives. In fact, ERTS-1 data would be obtainable in less time than from most other sources.

Desired land use data varied according to specific functions of agencies. Suggested needs of land use information included detailed agricultural use data, water quality data, drainage feature data, topographic detail maps, quality control of resources data, soil conservation, pollution control data, site-location, and industrial, commercial, residential, recreational, and urban growth and change data, in general.

D. Land Use Center Interviews

This section of the report prepared by the Mississippi Cooperative Extension Service Land Use Center is a feasibility study of ERTS-1 Data as applied to various land uses by different agencies.

During the course of the study, 73 people were interviewed in all parts of Mississippi, representing 11 major agencies. Four agencies have not returned questionnaires. Several held the questionnaire to think about the answers before returning the forms.

Six questions were asked pertaining to ERTS-1 feasibility as a planning tool. These questions were presented after the interviewee had looked at the computer derived land use classification of ERTS-1 data acquired in August 1972 and January 16, 1973.

The questions were:

1. Can you use data at the 1:250,000 scale?
2. Is the ERTS data accurate enough for your use?
3. How often would you use ERTS-1 data?
4. Do you need comparison ERTS data?
   a. Monthly?
   b. Seasonally?
   c. Annually?
   d. Decade?

5. What type of la. use data do you need?

6. What type of uses do you see for ERTS data?

Detailed Interviews

1. Soil Conservation

Two people were interviewed at the Soil Conservation Office in Jackson, Mississippi. It was their opinion that ERTS-1:

(a) Can be used at the 1:250,000 scale for limited purposes and as a check and guide for field soil surveys.

(b) 1:250,000 scale can be used for general use but is too small for field application.

(c) Can be used one time each year and two to five year intervals.

(d) Comparison data would be needed annually.

(e) Land use data needed consists of vegetative cover as related to soil surveys and broad planning statewide.

(f) Type of uses seen in SCS was for broad planning and program development for county and multi-county use.

2. U. S. Forest Service

Four people were interviewed at the U. S. Forest Service in Jackson, Mississippi. It was their opinion that ERTS-1 data:

(a) Can be used at the 1:250,000 scale.

(b) ERTS data is accurate enough for would like 4" = 1 mile scale.

(c) Can be used daily and yearly for management

(d) Comparison data would be needed seasonally and annually.

(e) Land use data needed consists of vegetation types, transportation systems, water elements, land use changes, population centers, forest types (pine and hardwood), grass areas (Savannahs) and wet grassland.

(f) Types of use seen in USFS were visual resource management, forest type mapping, decision-making in relation to timber management activities, mapping of timber stand density (number of trees per acre), mapping of timber stands by age, class grouping, geological

surveys, hydrological surveys, water pollution studies, storm area damage, erosion inventories, wildlife habitat and distribution of various habitat, percent of forest clear cut annually, difference between pine species, and difference between hardwood species.

3. Mississippi Marine Resource Council

One person from the Council located at Long Beach, Mississippi reported that ERTS-1 data:

(a) May not be suitable for use at 1:250,000 scale.

(b) Can be used in broad aspects only.

(c) Can be used seasonally.

(d) Comparison data would be needed seasonally.

(e) Land use data needed consists of more detail on wetlands, such as done on marsh mosquitoes Evaluate wetland (Coastal) 1" = 500'.

(f) Type of use seen in MMRC is soil accumulation inventory underwater from thermal scanner.

4. Land Use Center

One person from the Mississippi Cooperative Extension Land Use Center stated that ERTS data:

(a) Can be used at 1:250,000 scale.

(b) Can be used for general use but statewide composites and 35 mm slides are needed.

(c) Can be used quarterly.

(d) Comparison data would be needed seasonally, annually and decade

(e) Type of land use data needed is statewide composites showing land use: water, crops, pasture, forest, special crops, and urban.

(f) Type of use seen in LUC is land use changes.

5. County Agents

Of 64 county agents interviewed with the Mississippi Cooperative Extension Service in 64 counties:

(a) 76% can use ERTS data, 19% cannot use it, and 5% were undecided.

(b) ERTS data was accurate enough for 71% of the county agents while 20% were undecided.

(c) The largest area of use was regular use on a daily to monthly basis but almost 75% of the use of the data would occur on a yearly basis.

(d) Comparison data would be needed seasonally and monthly on selected crops during the growing season.

(e) The type of land use data most needed was either crop related of soil related. 34% -- soil related; 44% -- crop related; 14% -- land planning; and 8% -- don't know.

(f) The types of use seen for ERTS data were agricultural data (70% of the answers) and land use analysis (22% of the answers).

6. Golden Triangle PDD

One planner from the Golden Triangle Planning and Development District in Oktibbeha County reported that ERTS:

(a) Data can be used at 1:250,000 scale.

(b) Data is accurate in some cases, especially when used for monitoring changes in land use on a regional level.

(c) Can be used annually.

(d) Comparison data would be needed annually.

(e) Type of land use data needed is land use classification breakdown to 2 digit level.

(f) Data appears to be a valuable planning tool on the county, regional, and state level. May be used for inventory and analysis of existing land use and for recording and evaluating land use changes.

Evaluation of Land Use Classification

The results of the 7 color classification printout from the computer derived land use are very promising when compared to the laborious manual method in use from conventional aerial photographs and windshield surveys. The new technique will undoubtedly advance knowledge and reduce human labor.

The purpose of this part of the evaluation is to point out ways this technique can be improved.

A. August 6, 1972 Data

1. Forest: Appears to be one of the most valuable uses of the data collected. Over 50% of Mississippi is in forest and large area mapping of timbered areas is practically nonexistent. The principal problem will be in recording new plantations of timber. The age and size that timber must attain to be recorded as forest on ERTS should be determined.

2. Grass: To our knowledge, grasslands have never been mapped in the state of Mississippi. ERTS offers an opportunity to record a use which accounted for one-third of 550 million dollars of the agricultural income in Mississippi in 1972. Livestock are dependent on grasslands and permanent pasture is the most important grassland.

   A statewide map showing only grassland would be extremely important to Mississippi livestock producers.

3. Minimum Size Map Units: Some statistical sampling of error due to an inability to correctly classify small amounts of acreage (less than 260' by 184') might prove useful for greater estimating accuracy.

B. January 16, 1973 Data

1. Much interest was expressed by the interviewees as they looked at the data enlarged to 1" = 1.06 miles for T17S - T16W and T7S - R15W shown in the second data package received June 14, 1973.

2. Concrete-Asphalt Complex: A net increase of 1.6% occurred in this classification within the five month test period. Probably, deciduous trees allowed sand bars to show through which accounted for this increase.

E. Summary of Land Use Center Interviews

We are able to state at this point that agencies responsible for Land Use Planning in Mississippi are interested in and desire to purchase data products such as those we are demonstrating. However, it is not possible at this time to estimate what cost level those agencies can afford nor what time schedule they would require for such data. Questions to be answered are: how often do they need this data, what time period is allowable after acquisition by system before the data becomes obsolete, what is the cost factor worth on a single usage and repeated usage basis? These questions should be answered first by NASA in approximate figures. Our experience leads us to believe that the user will find a way to purchase it if he knows how much and when to go for the data.

The following points do seem evident at this time:

1. The difference in the data base of the ERTS-1 system versus the data base for the conventional system is such that it is difficult to compare the computer generated maps of ERTS-1 to the Land Use Classification maps done by conventional methods. The biggest factor is the difference in the classification categories.

2. ERTS-1 computer generated maps do have the advantage of not tiring or overlooking an area when making the maps. A good example of this is the Broadwater Pier Complex on the Biloxi, MS coast. The Land Use Classification maps made by conventional methods by a professional consulting company overlooked this area and it was left off the map. This area, however, is strikingly shown on the ERTS-1 computer generated map. Thus it seems ERTS-1 data products will be thorough.

3. Another point in favor of the ERTS-1 data is the classification of undeveloped land, usually shown as a single classification by conventional methods, into it natural features such as forestead, marsh, dry, cultivated, etc.

4. However, a point of contention is the nature of the supervised classifications scheme which treats each cell without an "interpretive memory" of the area surrounding it. that is, the human classification will tend to group like areas together while the ERTS-1 classification will name each cell if possible.

Anticipated results of this investigation are the ERTS-1 data will provide a valuable supplement to currently available data and will supply data that is vital to an automatic analysis system designed to monitor uses of land resources in a rapidly changing rural to urban/ industrial environment. Through the use of ERTS data, an up-to-date source of land use information will be abailable.

An automatic land use classification should enable standarization of data and provide a timely and accurate inventory of regional and national resources. Agencies, who in the past have worked independently and without coordination, will have a source of data giving a much broader perspective.

Since the data is initially contained on magnetic tapes, the systematic storing of large quantities of data, which can be recalled in a variety of forms, potentially will have great value. The digitized information process, eliminating photoanalysis and automatically classifying any area, is an advantage over the more time-consuming and possibly less accurate process of human interpretation.

## IV. Comparison of Selected Land Use Information Extraction Procedures

At the present time, much land use information is presented in the form of statistical tabulations derived from ground surveys. However, ground survey procedures are not easily judged or compared with procedures based on remote sensing because the statistics generated by ground surveys are usually not referenced to geographic units smaller than a county. In addition, most ground surveys are based on sampling procedures and some are not implemented to produce information each year. Consequently, the comparisons in this section will be limited to procedures based on remote sensing.

Table IV-1 shows a comparison of three different procedures that have been utilized to produce land use maps and statistics for the Mississippi Gulf Coast counties. The three procedures were:

1. The use of large-scale black and white aircraft acquired aerial photography and conventional image interpretation techniques.
2. The use of small-scale color infrared aircraft acquired aerial photography and conventional image interpretation techniques.
3. The use of digital data acquired by ERTS-1 and computer implemented techniques.

The first procedure in which black and white aerial photography was the source of the basic data was applied by the Gulf Regional Planning Commission to produce maps of four coastal counties which together encompass a land area of approximately 2650 square miles. These maps were finished

TABLE IV-1

Comparison of Three Selected Information

Extraction Procedures

| | Photo Interp. Black and White 1:24,000 | Photo Interp. Color Infrared 1:120,000 | Computer Implemented ERTS Digital |
|---|---|---|---|
| Cost of Basic Data Per Square Mile | $11.97[1] | $0.36[2] | $0.06[3]<br>$0.012[4] |
| Cost of Information Extraction Per Square Mile | $28.34 | $8.35 | $2.04[5]<br>$0.41[6]<br>$0.14[7]<br>$0.10[8] |
| Manhour Effort | 6200 | 3300 | 500 |
| Timeframe | 12 months | 6 months | 1 month |
| Accuracy | 92 - 96% | 92 - 96% | 89 - 95% |

[1] --Commercial contract.
[2] --$8 per frame purchased at EROS Data Center.
[3] --$160 per set of 4 tapes purchased at EROS Data Center and prorated over 2650 square miles (see text).
[4] --Same as above, but prorated over 13260 square miles.
[5] --Prorated over 2650 square miles (see text).
[6] --Prorated over 13260 square miles (see text).
[7] --Prorated over 66,300 square miles (see text).
[8] --Same as (7) but with reduction in computer time for classification incorporated.

just prior to the time that Hurricane Camille hit the Mississippi Gulf Coast, the result of which was that there was a need to update the maps even before they had been utilized to any significant degree.

The second procedure utilized small-scale (1:20,000) color infrared aerial photography to produce 1:24,000 scaled land use maps for the same four counties covered prior to Hurricane Camille.

The principle difference between the two procedures based on the use of aerial photography was that the use of small-scale color infrared photography permitted a considerable cost savings in land use mapping mainly because of the reduced number of frames necessary to cover the area. These cost savings are illustrated by comparing cost figures in columns one and two of Table IV-1 which were derived from cost figures contained in an existing report (see reference No. 4).

The third procedure was implemented by the NASA Earth Resources Laboratory utilizing ERTS digital data and computer implemented techniques to generate a land use map (see Figure III-1) and statistical data to be used as material for this investigation. As illustrated by cost figures in column three of Table IV-1, the use of ERTS digital data and a computer implemented technique offers the greatest potential for cost shaving in land use classification.

It should be emphasized that the cost figures in column three for the land use classification produced with ERTS digital data for this investigation are preliminary in nature. Inasmuch as computer implemented techniques were developmental at the time that the land use classification was produced for this investigation, many cost elements were difficult to calculate accurately.

The computer compatible tapes containing the ERTS digital data can only be purchased (EROS Data Center, Sioux Falls, S. Dak.) as a set of four tapes which encompass an area of 13260 square miles (100 by 100 nautical miles). However, the four county area referred to earlier encompasses only 2650 square miles of the 13260 square miles covered by the set of four tapes which cost $160. Consequently, the unit area cost of the basic data contained on the set of four tapes would be $0.06 per square mile if prorated over 2650 square miles, but only $0.012 per square mile if prorated over the 13260 square miles encompassed by the tapes.

A similar situation arises when data processing costs are calculated. The total cost of $5400., including 3.3 CPU of computer time, would calculate to be $2.04 per square mile if prorated over the 2650 square miles that were the focus of this comparison, wherease the calculation would result to $0.41 per square mile if prorated over the 13260 square miles for which a classification was performed for this investigation. It should also be noted that with the computer implemented technique used for this investigation it is more practical to perform the classification for all 13260 square miles covered by the set of four tapes than it is to perform a classification for a portion of each tape.

A far greater reduction in cost would be shown if a larger area was to be classified. Although more research is needed to determine the degree that geographic extension of signatures is possible, it is not unrealistic to think that two additional scenes (each with a set of four tapes) up a given ERTS track and two additional scenes down at ERTS track, which together with the center scene would encompass twenty tapes or

66,300 square miles, could be processed in one classification run on the computer. In this case, all ground truthing could be carried-out within the center scene, all signature development would be performed with the four tapes corresponding to the center scene (as was done for this investigation), but the costs would be prorated over the 66,300 square miles covered by the twenty tapes. The main cost that is directly related to the area covered is the run on the computer during which the actual classification is performed. In the case of twenty tapes, the computer time (using the same program as used for the classification performed by this investigation) would increase from 3.3 CPU used for four tapes in this study to 13.7 CPU for twenty tapes. Costs would, then, be prorated over 66,300 square miles, the result of which would be $0.14 per square mile. Furthermore, new software developments that have occurred since the land use classification for this investigation was performed, have reduced the CPU time for classification from 2.6 CPU per scene (4 tapes) to 1.3 CPU (see reference 5). Consequently, by use of the more recent software, 7.2 CPU would be required to process twenty tapes. With the incorporation of this possibility, the unit cost of the land use classification could possibly be reduced to $0.10 per square mile when extensive areas are to be classified.

The above mentioned costs and those shown in Table IV-1 include only the costs of producing a land use classification and presenting it in a map format. However, it should be noted that the compilation of acreage statistics from a map present a significant cost item. In the case of the computer implemented technique as used to produce the land use classification for this investigation, acreage statistics can be abstracted by the computer from the computer compatible tapes that are utilized to produce the

land use map. Furthermore, these same tapes can be utilized in a computerized system designed to combine land use information with other information; whereas, to accomplish this for land use information contained on the maps produced by the two procedures based on the interpretation of photography, the map information must first be digitized.

Other important elements to consider in the production of land use maps is the timeframe within which work can be carried out, and flexibility in utilizing the information. Table IV-1 shows the man-hour effort and the timeframe utilized for each of the three procedures used for comparison in this study. As can be seen, the use of ERTS digital data and the computer implemented technique resulted in significant reduction in both effort and time over the other two procedures. Of course, shortening the timeframe would be possible in the case of the procedures based on photo interpretation by placing more personnel on the job; however, this is usually not feasible from a practical viewpoint. Most organizations cannot carry a large staff of photo interpreters if they are not fully utilized throughout the year, and a large temporary work force creates many administrative problems. In addition, the computer implemented technique is highly flexible. As noted previously, the computer implemented technique utilizing ERTS digital data is more compatible with computerized information systems. Also, the computer implemented technique is more flexible than photo interpretation techniques in which extracted information is recorded on a map format because information digitized from a map is always restricted by the size and shape of the geographic unit for which digitization is performed.

Furthermore, the computer implemented technique offers more flexibility for presenting the extracted information in map formats. The

computer compatible tapes that contain the classification can be used to produce a generalized map presentation (see Fig. 1 in this report), or they can be used to produce thematic map presentations. In addition, such map products can be produced for variety of scales.

Finally, Table IV-1 indicates the general classification accuracy attained by the three procedures compared in this section expressed as a percentage of the study area classified correctly. As shown, the accuracy of the computer implemented technique based on ERTS digital data is somewhat lower than the two techniques based on aerial photo interpretation, but all are well within the realm of use by resource planners and managers. It should also be noted that there is considerable potential for improving the accuracy of computer implemented classification by utilizing data acquired during two or more seasons (see reference 6). This technique could also be utilized with aerial photography from two or more seasons, but with more difficulty than when using digital data on computer compatible tapes.

In summary, the results of the interviews conducted during this investigation indicate that many users want information more frequently than possible with photo interpretation techniques, and that they would welcome any procedures resulting in cost reduction. The comparison made in this study indicates the use of ERTS digital data offers both a reduction in cost and a shortening of the information extraction timeframe. In addition, it offers more flexibility in information handling and presentations on map formats.

## V. Conclusions and Recommendations

The conclusions drawn from the interviews and from study of the received data may be summarized as below. While many different requests for variations in scale and availability are to be expected, we feel these conclusions are fairly general in application.

1. ERTS data can be used at the scale presented for many applications.
2. ERTS data was accurate enough for general use in many situations.
3. In-Office use of data would range from daily to five year intervals with bulk at seasonal monthly use.
4. Usage of data for comparison purposes was greatest seasonally, followed closely by annually, then decade. Only selected county agents had a use for monthly data during the growing season. Here, however, would be a problem with the ability to obtain and distribute ERTS data that rapidly.
5. ERTS data most needed was land use and vegetative cover consisting of forest, crops, pasture and wetlands. Water and population centers were also needed.
6. Types of uses for ERTS data invisioned, consisted of environmental related and natural resource such as land use, geology, timber, water,spoil deposits, erosion, flooding, and habitat studies. A broad market for specific individual items exists for such things as: soybeans, water, hardwood, cultivated land, and soil types. Acreage, percent of state, and a map of distribution for each specific item would be desirable.
7. Even with no other improvements, it is felt that the ERTS land use data gathering technique will advance knowledge and reduce human labor.

Other recommendations are:

1. That efforts be concentrated on the purification of classifications so that total land and water may be reported with ERTS as a single figure equalling 100%. Then added by classification to equal 100%.

2. That the marsh classification be changed to wetlands and recorded in such a way as to clarify an innundated forest, pasture or other dual use as well as identify marsh and swamps.

3. That the urban/industrial classification be studied to find a way to eliminate barren areas such as sand and gravel from the classification so that new urban/industrial growth can be reported directly. For example, reporting and comparing the January data on an annual basis might identify the amount of new growth.

4. Efforts to improve the "other" classification (up to 29%) over water should be studied.

5. Separation of cultivated lands recorded in May should be divided in August into grass, crops and urban development, etc. and the whole totaled to 100% of the previous cultivated land. It is assumed that new subdivisions, roadway, or pipelines under construction with raw earth would read as cultivated.

6. A single map printout of water and "other" is needed to compare with known water bodies and the statistical table to identify percent of error for water.

7. Some statistical sampling of error due to acreage less than 260' x 184' might prove useful for greater estimating accuracy if this is possible.

8. The increase in January, 1973, pine by 8.8% over August, 1972, forest T7S-R15W must be studied and resolved, as well as the apparent right-of-way which disappeared in the January data.

9. Research is needed to develop a method of reporting total crop inventory. From ERTS for example such data as hardwood, pine, or soybeans.

10. A winter pasture and summer pasture study is needed to identify grass lands and permanent pasture.

11. Further seasonal comparison studies are needed of the same test area enlarged to one inch equals one mile as shown in the January 1972 flights.

12. Produce maps giving only one, two or three types of classifications.

We feel very optimistic about the future of the ERTS data gathering system and its potential for various users. There is a great deal of improvement to be made before a convenient system will be available which attracts a large number of users but we feel the advantages of the system are many and the potential is there.

## VI. References


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