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Institute for Environmental Studies

A STUDY OF THE APPLICATION OF SKYLAB EREP S-192 DATA TO LAND CLASSIFICATION IN THE MISSISSIPPI DELTA ALLUVIAL PLAINS REGION

EREP INVESTIGATION NO. 399

April 1973 - September 1975

C. W. Bouchillon, P. I.

Mississippi State University

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EREP Investigation No. 399

FINAL REPORT

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ERRATA SHEET

Report Title: A Study of the Application of Skylab EREP S-192 Data to Land Classification in the Mississippi Delta Alluvial Plains Region

EREP Investigation No. 399 Final Report of C. W. Bouchillon, Institute for Environmental Studies, Mississippi State University.

Correction:

Page 32, first paragraph, should read:

Data from Skylab EREP was processed by ERL at the NASA/NSTL facilities. The data used was the multispectral scanner (MSS) data from the magnetic tapes received by the NASA/NSTL-ERL Facilities.

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MISSIPPI STATE UNIV.

A STUDY OF THE APPLICATION OF SKYLAB EREP S-192 DATA TO LAND CLASSIFICATION IN THE MISSISSIPPI DELTA ALLUVIAL PLAINS REGION. FINAL REPORT.

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ACKNOWLEDGEMENTS

This report is the result of an interdisciplinary research team comprised of members from Mississippi State University and the Earth Resources Laboratory of Johnson Space Flight Center of the NASA.

Digital data processing for use classification, coded map printout, and relevant statistics were performed and furnished by ERL and in particular, Dr. Armin T. Joyce and Mr. Ken Cashion, who were also very helpful in liaison and expediting of these efforts.

Dr. Gordon Tupper of the Mississippi State University-Mississippi Agricultural and Forestry Experiment Station-Delta Branch Experiment Station provided the ground truth information relative to the test sites.

Dr. F. M. Ingels and Mr. Bob Boyd of the Mississippi State University Electrical Engineering Department provided project management, scheduling, and data recording and correlation as well as some user evaluation interviews.

Dr. Charles Baskin of the Mississippi State University-Cooperative Extension Service provided liaison with the agribusiness sector in the test site as well as some remote field ground truth information, and some user evaluation interviews.

The efforts of Mrs. Mary Jo Ingram and other supporting personnel also added to the successful accomplishments of this project.

PREFACE

The object of this investigation was to explore the possible uses of Skylab EREP data in making agriculturally oriented decisions from user point of view. The area of concern for this study was the Mississippi Delta region, near Stoneville, Mississippi. Skylab MSS data was to be analyzed through computerized pattern recognition programs by ERL at NASA/NSTL. This derived information would then be formatted in a style to be agreed upon as being the clearest presentation of the most useful data, probably a color coded map and corresponding statistics. Results of a similar study, utilizing ERTS satellite data, would be used to optimize the data format.

MSU researchers were then to identify possible low and intermediate level users and acquaint them with the Skylab data product. Through interviews it would be determined what are the possible uses of this data, what time table of data delivery, what particular information is most useful to them, what format would be optimum for presentation of this information, and what changes (i.e. additional information) could make the data of more value to them. Using this information an evaluation of Skylab EREP data's usefulness in making agricultural decisions would then be made.

Aircraft flights were made over the test area and ground truth data was collected over the test area during the planned period.

Through an unfortunate set of circumstances involving Skylab spacecraft problems as well as weather problems, the expected data did not materialize. As a result, the study was reoriented to emphasize a general land classification as opposed to a classification oriented to agronomic crops.

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A STUDY OF THE APPLICATION OF SKYLAB EREP S-192 DATA TO LAND CLASSIFICATION IN THE MISSISSIPPI DELTA ALLUVIAL PLAINS REGION

I. INTRODUCTION

With the launching of the Skylab space vehicle which contained nine additional visual bands than did ERTS (now termed LANDSAT) and with a broader coverage of the spectral range of the bands in the low reflective IR (including a thermal band detector), an opportunity to evaluate the potential use of space platform multispectral scanner data by users in the agricultural field of the Mississippi Delta was presented. A secondary objective was the evaluation of changes that might have been brought about post ERTS in the techniques of handling and classifying digital data received from multispectral scanners on space vehicles.

In particular the original objectives might be summarized as follows:

1. Obtain the necessary ground truth to identify major crops and ground cover within the defined test area, located in and around the Stoneville, MS, area.

2. National Aeronautics and Space Administration, Lyndon B. Johnson Space Center, Earth Resources Laboratory (NASA/JSC/ERL) would, through use of pattern recognition programs, perform a spectral analysis of S-192 and aircraft flight line data. The analysis would be based on training samples identified in the above mentioned ground truth exercise.

3. The Mississippi State University (MSU) research team, utlizing the output products of the spectral analysis performed by NASA/JSC/ERL, namely a crop identification and ground cover classification, would determine an effective means of utilizing these products in developing practical and cost effective applications to the agricultural programs of the area. This determination would be made through an interview program with potential users utilizing the NASA/JSC/ERL produced data products.

Data on agricultural plots was taken during each Skylab pass over the test area. Originally, we planned to use the same plots that had been instrumented for a study for ERTS, but the Skylab II orbit was some 60 nautical miles west of its intended orbit and these fields were not originally covered. A listing of Ground Truth Test Plots with the crop and field size as of September 1973 is presented in Section II of the report. For the Skylab IV Mission, however, the orbit passed over the instrumented fields and these fields were used as ground truth sites, but the summer crops had been harvested at the time of passage.

During a Skylab Earth Resources Experiment Package (EREP) Principal Investigator (PI) Data Meeting in July, 1974, held at NASA/JSC, Houston investigators for this project reviewed the S-192 data to determine all data potentially useful for this investigation. As a consequence of the data review, thirteen seconds from EREP 15 (5 August 1973, Pass 4, Track 62) and nineteen seconds from EREP 87 (21 January 1974, Pass 35, Track 62) were the only data requested by MSU for the investigation. Only S-192 data was to be used in this study and

computerized agricultural classifications would be implemented with the S-192 data when it was received by NASA/JSC/ERL from NASA/JSC. This data was originally scheduled to be delivered by September, 1974.

Due to circumstances beyond MSU's or NASA/JSC/ERL's control, the data requested was not delivered until late December 1974. The data originally picked to be received from the Skylab passes were:

SL 3-Pass 4, track 62, 5 August 1973, EREP 15
SL 4-Pass 35, track 62, 21 January 1974, EREP 87

The data obtained from SL-3 was almost entirely obscured by clouds over the particular area of interest so the decision was made to process the data from SL-4. Since the data from SL-4 was taken during January, it was not possible to attain the stated objective of this research which was to attempt crop identification and yield prediction. Every effort was made to maintain the integrity of the investigation by deciding to use winter wheat as a crop for identification.

The S-192 data underwent the necessary reformatting to allow training sample selection. From the first look at the data in January, 1975, it appeared that the best course open was to emphasize the classification of winter wheat; the only crop observable during the winter season. An attempt was made to classify winter wheat versus all else. If successful, this calssification would have been compared against county records from the area to ascertain accuracy of classification and

attempt a yield prediction based on the S-192 data. From the appearance of the data is was questionable whether even this limited crop identification would be of significant accuracy for evaluation by land use center personnel. A further complication is that the ground truth gathering operation had ended on schedule in the late fall of 1973, and no accurate ground truth data was available for January 1974.

The data was received well after the original scheduled delivery data and as a result the earliest NASA/JSC/ERL could anticipate delivery of the data products to the MSU research team was by early April, 1975.

Due to circumstances beyond MSU's control and due to severe problems with the availability and the quality of the data received, hardware and software difficulties, the data was not classified by NASA/JSC/ERL until May, 1975, resulting in a delivery to MSU of the data products on May 27, 1975. Unfortunately, the data products produced were not suitable for even winter wheat classification and in fact only cropland/pasture areas versus water or forest areas or urban areas or inert areas were depicted.

II. DATA MANAGEMENT

Computer classification of multispectral imagery requires ground truth information in addition to the MSS data. The MSS (S-192) data must have a sufficient number of operational bands producing data of satisfactory quality to allow classification of the ground cover by its spectral signature. Ground truth information must be supplied to train the pattern recognition routine. It must identify ample acreage in each of the desired classifications for this training procedure. Also, additional ground truth information is required to check the accuracy of the classified data. This ground truth is not used to train the computer routine.

Other data used in this investigation was S-190A & B imagery and aircraft overflight data (MSS). The S-190 data was used primarily to help locate the training plots in the S-192 data. Training plots are those fields for which ground truth information has been obtained which are used to train the classification routine. Training consists of determining the spectral signature of each of the desired classes from the training plots of the MSS data. The aircraft data was to be classified in the same manner as the S-192 data. The data products were not available from NASA/JSC/ERL in time to be included in this report. Certain bands have been chosen to simulate those bands available from Skylab sensors and these are deliniated later in this report.

Skylab Data.

The target area for this investigation was test site No. 320 in the Mississippi Delta region near Stoneville, MS. This area is at the intersection of track 29 and track 62 of Skylab's proposed orbit. Pre-mission (Sept. 1972) orbit information indicated that S-192 data would be taken and become available as shown in Table II - 1.

TABLE II - 1

DATA SCHEDULE FOR SITE NO. 320

SL-2

19 May 1973 275/6 Track 62
Splashdown 29 May 1973

SL-3

29 August 1973 1747/8 Track 29
15 September 1973 1993/4 Track 62
Splashdown 24 September 1973

SL-4

20 December 1973 3380/1 Track 29
Splashdown 26 December 1973

The timetable for this investigation was planned using the above information. Ground truth information was collected during the summer and fall of 1973 in order to be concurrent with the S-192 data when it became available.

Due to uncontrollable circumstances, Skylab was unable to meet its exact orbit or time schedule. After the completion of the SL-4 Mission, a search of all available S-192 data was undertaken to determine what MSS data was taken near the target area. The results of this search are presented in Table II-2.

Screening films from each of the five passes were viewed and it was decided that data from two of them should be ordered for possible classification by the ERL at NASA/NSTL. The data which was ordered and the reasons why the other data was not useful are indicated in Table II-2.

Considerable processing was required by the S-192 data to correct problems such as banding and low frequency noise. This processing takes place at NASA/JSC before the computer compatible tapes (CCT's) were made. Data from the CCT's is then used by the classification routine. Somewhere in this procedure it was decided that the data from SL-3, which had been ordered, was not of sufficient quality to warrant classification. The only S-192 data which was delivered to NASA/JSC/ERL and used in conjunction with this study was from EREP 87 which was taken on 21 January 1974.

Ground Truth

Ground truth information is necessary to train the computer classification routine. Several plots of each desired classification must be identified in the S-192 data in order for the routine to determine the usual spectral

TABLE II - 2

S-192 DATA TAKEN OVER SITE 320

SL-2

12 June 1973. Pass 10, Track 5, EREP 10
Data from this pass is north of the desired investigation site and quite cloudy.

SL-3

5 August 1973. Pass 4, Track 62, EREP 15
Good data over the southern part of target area (northern part not covered). Fifteen seconds of CCT's were ordered from this pass.

15 September 1973. Pass 31, Track 15, EREP 42
Data from this pass is the only data taken which covers the northern part of the target area, but it is completely clouded over the area of interest.

SL-4

3 December 1973. Pass 8, Track 62, EREP 58
Same coverage as that of EREP 15. Considerable clouding is present over the site.

21 January 1974. Pass 35, Track 62, EREP 87
Same coverage as that of EREP 15. The data is excellent. Nineteen seconds of CCT's were ordered from this pass.

signature of each particular classification. Other ground truth information is necessary to ascertain the accuracy of the final classified data. This information is not made available to the routine during the classification procedure.

Ground truth for this project was collected by three sections of MSU. The Extension Service Agronomy Section; The Delta Branch Experiment Station (DBES); and The Extension Service Forestry Section co-operated in collecting the ground truth information necessary for this project. Most of the ground truth for this project was also used in a similar study utilizing ERTS-1 data.

The Delta Branch Experiment Station (DBES) is located near Stoneville, MS, in the center of the target area. Experiment Station personnel identified 9 fields in the surrounding area and installed certain instruments in each field. These fields are listed in Table II-3 and their location is given in Figure II-1. Information about these fields including wind, solar radiation (pyroheliometer recordings), temperature, ground cover, plant height, weed, insect or disease infestation, and soil moisture was taken at the time of every ERTS-1 pass (once every 18 days) from June through early December of 1973. Additional data was taken on 24 July 1973 and 6 August 1973. The July data was taken to correspond to an aircraft overflight in conjunction with this project. The 6 August data was taken to correspond with the 5 August pass of Skylab. This is the pass (EREP 15) for which the

TABLE II - 3

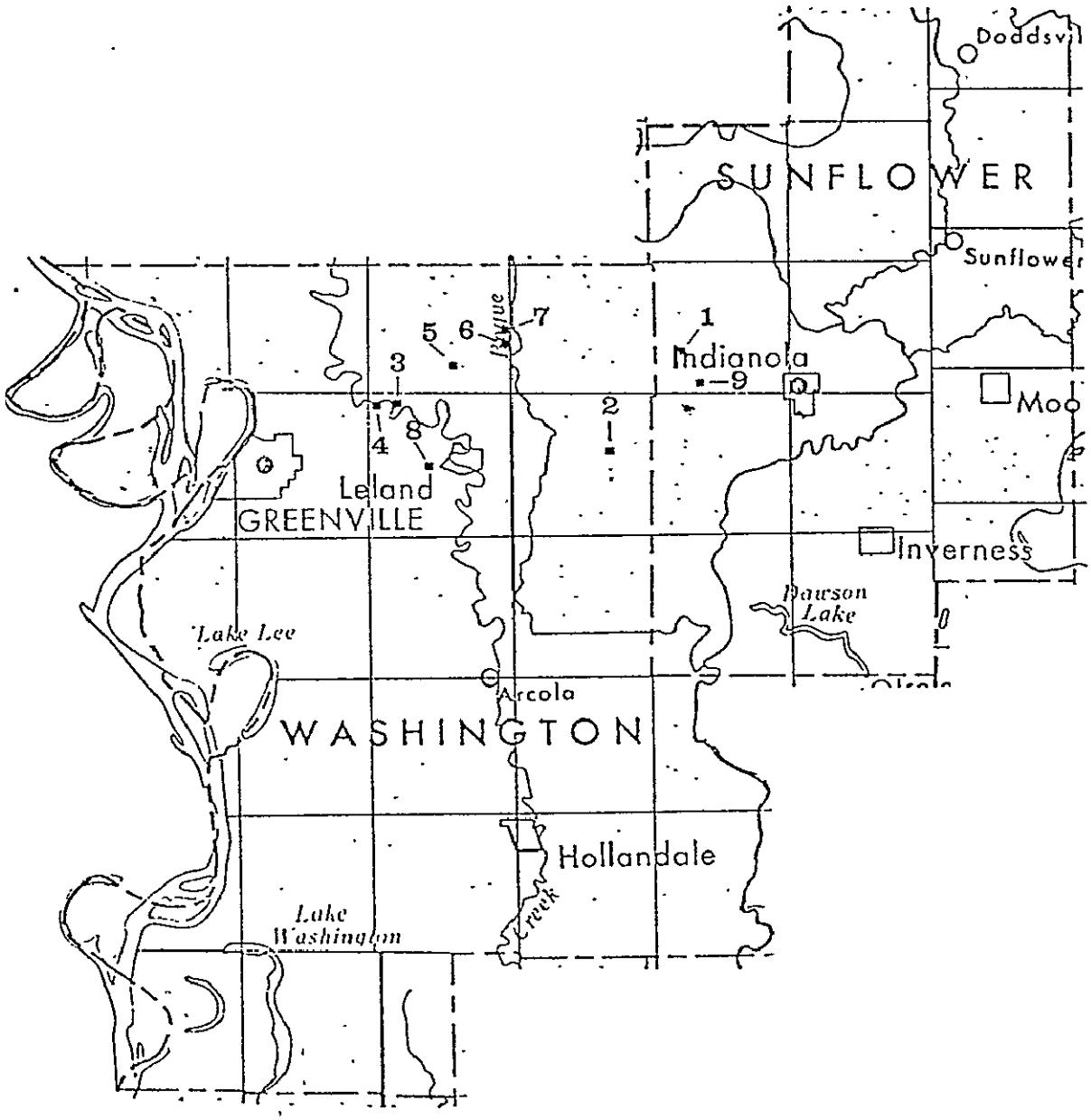
DELTA BRANCH EXPERIMENT STATION

Instrumented Fields

Field #	Crop	Size
1	Corn	73 acres
2	Pasture	150 acres
3	Cotton (2 x 2)	240 acres
4	Cotton (2 x 1)	247 acres
5	Forest	30 acres
6	Rice	145 acres
7	Soybeans (clean)	110 acres
8	Soybeans (and weeds)	100 acres
9	Cotton (solid)	300 acres

Figure II - 1

LOCATION OF DELTA BRANCH EXPERIMENT STATION
INSTRUMENTED FIELDS



S-192 data was received but not processed by NASA/JSC/ERL. A shortened listing showing the information taken is given in Figure II-2.

Ground truth fields spread throughout the 6 county delta area were identified by the MSU Extension Service, Agronomy Section. The effort was aimed at locating cotton, soybean, and rice fields in each county in order to give any necessary geographical distribution for the training plots. Most of the 52 fields identified were not used as training plots for this project due to the fact that most crops had been harvested by the time that the Skylab data was taken in January. If the August Skylab data had been available, some of these fields would have been used to check the accuracy of the classification after it had been completed. A list of these fields by county is given in Table II-4. No attempt was made to monitor these fields during the growing season.

Since forestry is one of the largest industries in Mississippi, it is important to include the identification of forested lands in this study. Forests in the Delta are almost entirely restricted to the Mississippi River area as most other land has been cleared for crops. Through the Forestry section of the Cooperative Extension Service, twenty-one forest stands have been located in the Delta. Data on these stands is quite accurate and complete as most belong to commercial lumber companies who keep close records. The stands were selected to give variations in age, canopy,

FIGURE II-2. DELTA GROUND TRUTH COMPUTER CARD FILE

FIELD 1 73 ACRES CORN

* * * GENERAL INFORMATION * * *

SUNFLOWER COUNTY. RSH. T19N. SECTION 20. NORTH WEST CORNER
33 20 10 N LAT.. 90 44 35 W LONG.
JAMES ROBINSON. HOLLY RIDGE. MS.. (OWNER)
73 ACRES. CORN.12 TONS/ACRE
DUNDEE SILT LOAM.
EAST/WEST 40 IN ROWS. SOLID

* * * 18 DAY GROUND TRUTH DATA * * *

I.D.	DATE	WIND VEL	WIND DIR	SOL RAD	LOCAL TIME	TEMP	CLD CVR	GRD CVR	PLT HGT	INFESTATION WD	INFESTATION DIS	INFESTATION INS	SOIL MOISTURE 6C	SOIL MOISTURE 12C	SOIL MOISTURE 18C
D1 01	05/23	[illegible]	SW	373	10:45	80	80	5	10	NON	NON	NON	16.4	20.3	23.7
	DATA TAKEN BY: GORDON R TUPPER										PICTURES: RL 01.FRS 01-05				
	SOIL CONDITION: SMOOTH														
	CROP PHYSIOLOGICAL CONDITION: SOME REDDISH COLORING ON LEAF EDGES														
	CROP VISUAL CONDITION: FAIRLY UNIFORM														
	COMMENTS: LEAF COLORING - POSSIBLY PHOSPHORUS DEFICIENCY														
D1 02	06/11	3	SW	320	10:20	82	90	35	40	LGT	NON	NON	7.9	14.5	19.5
	DATA TAKEN BY: GORDON R TUPPER										PICTURES: RL 03.FRS 01-05				
	SOIL CONDITION: UNCULTIVATED														
	CROP PHYSIOLOGICAL CONDITION: GOOD GROWTH														
	CROP VISUAL CONDITION: GOOD														
D1 03	06/28	13	NNW	615	1:40	91	20	70	72	LGT	NON	NON	IRRIGATING		
	DATA TAKEN BY: GORDON R TUPPER														
	SOIL CONDITION: WET														
	CROP PHYSIOLOGICAL CONDITION: GOOD TASSELING. BEGINNING EAR FORMATION														
	CROP VISUAL CONDITION: GOOD														
	COMMENTS: IRRIGATING ON THAT DAY. NO SOIL MOISTURES TAKEN														
D1 04	07/24	3	SE	626	10:15	90	0	90	78	LGT	LGT	LGT	DRY		
	DATA TAKEN BY: GORDON R TUPPER										PICTURES: RL 09.FRS 03-06				
	SOIL CONDITION: SMOOTH														
	CROP PHYSIOLOGICAL CONDITION: DENT STAGE														
	CROP VISUAL CONDITION: JUST STARTING TO DRY UP IN MATURE CORN														
D1 05	08/03	5	NE	601	1:40	80	35	80	80	LGT	NON	LGT	11.1	14.6	14.7
	DATA TAKEN BY: GORDON R TUPPER										PICTURES: RL 11.FRS 01-05				
	SOIL CONDITION: DRYING OUT - AREAS TURNING WHITE														
	CROP PHYSIOLOGICAL CONDITION: MATURE - HARVESTING FROM SOUTH TO NORTH														
	CROP VISUAL CONDITION: YELLOWING														
D1 06	08/06	4	S	516	9:35	75	90	20	10	MED	NON	NON	10.7	13.0	16.7
	DATA TAKEN BY: GORDON R TUPPER										PICTURES: RL 13.FRS 01-05				
	SOIL CONDITION: DRY AND SMOOTH														
	CROP PHYSIOLOGICAL CONDITION: SOUTH HALF OF FIELD HAS BEEN HARVESTED														
	CROP VISUAL CONDITION: NORTH HALF MATURE														
	COMMENTS: CLEAR ON SUNDAY														

TABLE II - 4

COOPERATIVE EXTENSION SERVICE

Identified Fields

BOLIVAR COUNTY

1	Cotton (2 x 1: D & PL 16)	240 acres
2	Cotton (Solid: Stoneville 213)	190 acres
3	Cotton (2 x 1: Stoneville 213)	400 acres
4	Soybeans (Lee 68)	240 acres
5	Soybeans (Dare & Bragg)	720 acres
6	Rice (Starbonnet)	400 acres
7—	Cucumber	80 acres

SUNFLOWER COUNTY

8	Cotton (2 x 2)	80 acres
9	Cotton (Solid: D & PL 16)	245 acres
10	Cotton (Solid: D & PL 16)	200 acres
11	Cotton (2 x 2: D & PL 16)	350 acres
12	Cotton (2 x 2)	600 acres
13	Soybeans (Lee 68)	94 acres
14	Soybeans (Lee 68)	
15	Soybeans (Lee 68)	120 acres
16	Soybeans (Lee 68)	180 acres
17	Soybeans (Lee 68)	73 acres
18	Rice (Starbonnet)	150 acres

WASHINGTON COUNTY

19	Cotton (2 x 1:D & PL 16 & Stoneville 213)	320 acres
20	Cotton (2 x 1 x 2 x 2: Stoneville 213)	300 acres
21	Cotton (2 x 1 x 2 x 2: Stoneville 213)	300 acres
22	Cotton (2 x 1: Stoneville 213)	500 acres
23	Soybeans (Lee 68)	320 acres
24	Soybeans (Lee 68)	150 acres
25	Soybeans (Lee 68)	300 acres
26	Soybeans (Dare)	80 acres
27	Rice (Starbonnet)	400 acres

TABLE II - 4 COOPERATIVE EXTENSION SERVICE (concluded)

HUMPHREYS COUNTY

28	Cotton (Stoneville 213)	100 acres
29	Cotton	90 acres
30	Cotton (2 x 1: Stoneville 213)	300 acres
31	Cotton	100 acres
32	Soybeans (Bragg)	400 acres
33	Soybeans (Simmes)	80 acres
34	Soybeans (Bragg)	230 acres
35	Soybeans (Simmes)	150 acres
36	Rice (Starbonnet)	212 acres
37	Rice (Bluebell)	300 acres
38	Rice (Starbonnet)	40 acres

SHARKEY COUNTY

39	Cotton (D & PL 16)	200 acres
40	Cotton (D & PL 16)	180 acres
41	Cotton (D & PL 16)	300 acres
42	Cotton (D & PL 16)	300 acres
43	Cotton (D & PL 16)	300 acres
44	Soybeans	2,000 acres

ISSAQUENA COUNTY

45	Cotton (D & PL 16)	188 acres
46	Cotton	120 acres
47	Cotton (2 x 2:D & PL 16)	
48	Cotton (D & PL 16)	58 acres
49	Soybeans (Lee 68)	200 acres
50	Soybeans (Bragg)	200 acres
51	Soybeans (Lee 68, Bragg & Simmes)	200 acres
52	Soybeans (Bragg)	300 acres

density, specie, and purity in order to determine how these factors effect classification accuracy. These stands were used both for training and for checking results. A list of these forest stands is given in Table II-5 and a map showing their locations in Figure II-3.

After the ground truth gathering had been completed it was learned that no good S-192 data was available for the 1973 growing season. Since 21 January 1974 gave the only good data, it was decided to shift emphasis of the project. In order to maintain the integrity of the investigation, it was decided to attempt to identify winter wheat, the only crop available in January. Toward this end the DBES personnel identified 10 winter wheat fields which were in Washington County during January 1974. A map locating these winter wheat fields is given in Figure II-4.

Unfortunately, after working with the EREP 87 data, it appeared that even this limited crop identification could not be accurately performed, because the wheat was not yet at a stage of growth adequate to allow accurate classification. Winter wheat is generally planted in the mid December time and a one month growth is just out of the ground. This sparcity of foliage cover makes detection by vertical means very difficult. As a result, the final classified results lumps all crop land and pastureland into a single category. This fact precludes accomplishing the goals originally stated for this study.

TABLE II - 5 DELTA FORESTRY PLOTS

			Map #
BOLIVAR COUNTY			
1	Red Oak, Sweetgum	90 acres	(13)
2	Sycamore	40 acres	(3)
3	Hackberry, Elm, Sweet Pecan	150 acres	(5)
4	Sweet Pecan, Sycamore, Gum	500 acres	(6)
5	Cottonwood, Sycamore	100 acres	(1)
6	Cottonwood (Mature)	75 acres	(12)
7	Cottonwood	800 acres	(2)
WASHINGTON COUNTY			
8	Oak, Elm, Hackberry, Cypress	50 acres	(18)
9	Cottonwood	175 acres	(15)
CHICOT COUNTY (Arkansas)			
10	Willow	500 acres	(4)
HUMPREYS COUNTY			
11	Red Oak, Elm, Gum, Ash, Overcup	210 acres	(11)
SHARKEY COUNTY			
12	Willow, Oak (& water)	40 acres	(21)
13	Green Ash, Hackberry	40 acres	(19)
14	Red Oak, Overcup Oak, Soft Elm, Pecan, Hackberry	550 acres	(14)
15	Nutall Oak, Hackberry	40 acres	(20)
16	Green Ash, Hackberry	40 acres	(9)
17	Overcup Oak	40 acres	(10)

TABLE II - 5 DELTA FORESTRY PLOTS (Continued)

ISSAQUENA COUNTY

18	Sweet Gum, Red Oak, Elm	82 acres	(17)
19	Pecan, Sweet Gum, Red Oak, Hackberry, Overcup, Green Ash	537 acres	(7)
20	Cottonwood	800 acres	(8)
21	Cottonwood	260 acres	(16)

FIGURE II-3 LOCATION OF DELTA FORESTRY PLOTS

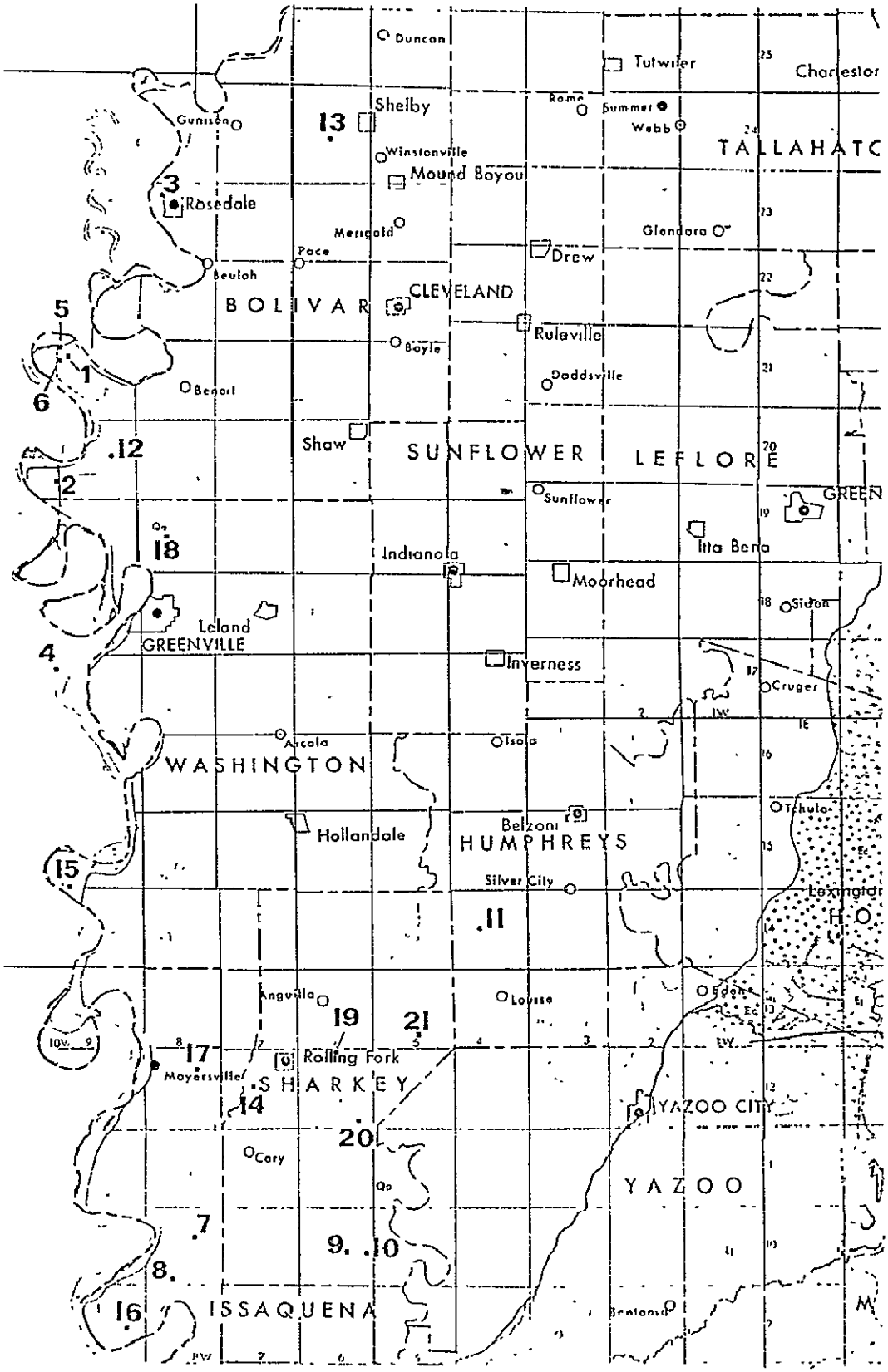
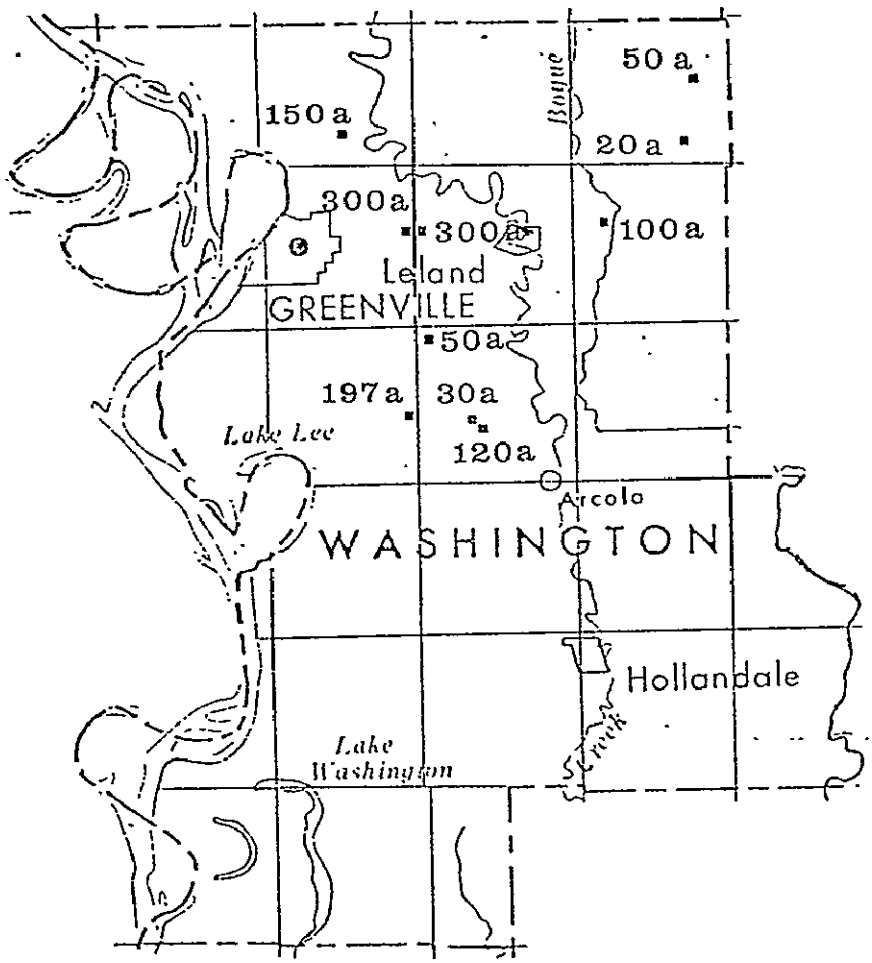


Figure II - 4

LOCATION OF WINTER WHEAT FIELDS
IN MISSISSIPPI DELTA



Use of S-192 Data

The S-192 multispectral scanner was designed to operate with 13 discrete spectral bands with wavelengths ranging from .4 μm to 12.5 μm. The scanner has a conical line scan with an instantaneous square field of view of .182 milliradions (79.25 meters square area on the ground). The radius of the forward 110° ground scan sector is 22.6 nautical miles (41.85 km) giving a swath width of 40 nautical miles (74.08 km) for data collection.

During the 21 January 1974 overflight (EREP 87), the S-192 scanner had five bands operational and another three bands working but too noisy to give any useful data. The condition of each band is given in Table II-6.

All work with the S-192 data was performed at the ERL/NSTL facility by NASA or NASA contractor personnel.

Thirty ground truth areas were located in the S-192 data for the purpose of training the classification routine. These were located using the DAS (Data Analysis Station) to display the unrectified Skylab data and using film from the Earth Terrain Camera as a visual aid. It appeared that Scientific Data Output (SDO) Channels 3, 11, and 15 which correspond to bands 4, 11, and 13 permitted the best geographic location of the training fields. (For the spectral wavelengths corresponding to each band, see Table II-6, page 22). Color selection to give the best definition of classified areas was done manually using the PIDS (Portable Image Display System).

Using previously developed pattern recognition programs, the S-192 data were examined to determine the optimum band

TABLE II - 6

S-192 STATUS FOR EREP 87

Operational Bands

Band.	Wavelength (μm)	Color
4	.56 - .61	Yellow-Green
6	.68 - .76	Red
11	1.55 -1.75	IR
12	2.10 -2.35	IR
13	10.2 -12.5	Thermal IR

Operational But Noisy

Band	Wavelength (μm)
7	.78 - .88
8	.98 - 1.08
9	1.09 - 1.19

Not Operational

Band	Wavelength (μm)
1	.41 - .46
2	.46 - .51
3	.52 - .56
5	.62 - .67
10	1.20 - 1.30

selection to yield accurate classification. It was determined that data from band 4, while necessary to locate geographic areas in training, did not converge well and thus should not be used in the classification program. A list of how the bands were used is given in Table II-7.

The availability of thermal IR data was the most significant difference between this work and the preceeding studies involving ERTS data. However, thermal data must be handled differently since it is emissive radiation and cannot be considered to be consistent with the reflected radiation measured by the other bands. The mathematical relationship between a particular ground cover and its emitted thermal IR may well not hold for a similar type ground cover in a different location. This means that the thermal channel should be used as a primary data input with other channels relating to it in a secondary role, or the thermal channel should be used to assist a reflective band in detecting a particular selected ground area; but not by equal combination with all bands to locate all ground details. Also, diurnal and seasonal changes cause large variations in thermal data. A complete contrast reversal can occur between winter and summer data even from variations throughout the day.

Thermal IR data was found to be very useful in this work. First it afforded accurate geographic location of water which was quite helpful in locating the training plots in the S-192 data. Also, it allowed for separation of water

TABLE II - 7

USE OF S-192 BANDS

BEST VISUAL DEFINITION
(Locating Training Sites)

Band	Channel	Wavelength (um)	Color
4	3	.56 - .61	Yellow - Green
11	11	1.55 - 1.75	IR
13	15	10.2 -12.5	Thermal IR

BEST CLASSIFICATION RESULTS

Band	Channel	Wavelength (um)	Color
6	7	.68 - .76	Red
11	11	1.55 - 1.75	IR
12	13	2.10 - 2.35	IR
13	15	10.2 - 12.5	Thermal IR

into several different classes. The exact nature of this separation is not completely determined but should be related to depth, sediment content and turbidity. It allows for separation of catfish ponds from river water and permits detection of flooded areas from under a heavy forest canopy.

Classified Data

The final data product for this investigation was color coded classification maps as shown in Section III. Classification was performed over parts of Bolivar, Washington, Sunflower, Humphreys, Sharkey, and Issaquena counties in Mississippi as well as some of Arkansas. There were 10 classification groups in addition to unclassified areas. A reduced version of the classified map is given in Figures III-1 and 2 with the classification explained in Table III-1.

One training area was inadvertently neglected in training sample selection and has consequently been "classified" as Unclassified. This is a particularly muddy area of the southern portion of Lake Chicot in Arkansas. This same reflectance/emissive product appears bordered by Rolling Fork, Mississippi; Deer Creek, and Little Sunflower River, all in Sharkey County. The same condition exists around some of the larger river banks.

In addition to classification maps the ERL at NASA/NSTL has been able to determine the acreage in each

classification for Washington County. Unfortunately, none of the 6 counties is completely shown by the Skylab data so Washington County was chosen for this study since; (1) about 84% of the county is given by the Skylab data and (2) since the DBES is in Washington County, there is more information available about that county than any of the others. Software considerations made the calculations somewhat more difficult to obtain than was originally expected and does leave the accuracy of the results subject to some doubt. However, once the process becomes routine the acreage calculations made from classified S-192 data will be accurate and easy to obtain. The acreage figures are given in Table II-8, and data from prior surveys is also given for the purpose of comparison.

There are several details involved in arriving at the acreages which certainly affect the accuracy and interpretation of these figures. One problem is that the S-192 data does not entirely cover Washington County. The northeast corner of the county (about 16%) is not covered by the data. Since statistics for comparison are available only for the entire county it was decided to assume that the area not shown was similar (in land classification) to the other 84% of the county. This assumption appears to be well justified from classification work done previously from ERTS-1 data.

One source for error arizes from the manner in which the county boundaries must be defined for the acreage

TABLE II-8

WASHINGTON COUNTY ACREAGE BY CLASS

CLASS	FROM S-192 CLASSIFICATION ACRES	% OF COUNTY	SURVEY DATA % OF COUNTY
Urban	42,429	9%	5.9%
Inert	11,461	2%	2.1%
Water	28,233	6%	6.4%
Crop/Pasture	257,505	53%	64 %
Forest (Total)	92,901	19%	14.5%
Mixed Hardwood	41,355	8%	3.6%
Oak-Hickory	32,527	7%	Not Available
Oak-Gum-Cypress	19,019	4%	10.9%
Unclassified	55,597	11%	6.8%

SOURCES OF SURVEY STATISTICS

"1967 Soil and Water Conservation Needs Inventory for Mississippi" issued by State Conservation Needs Committee, June, 1970.

"Forest Area Statistics for Midsouth Countries", USDA Forest Service Resource Bulletin 50-40, 1973.

"Mississippi Agricultural Statistics 1954-1973", Supplement #9 by Mississippi Crop and Livestock Reporting Service, 1975.

computation routine. The program counts the number of cells in each classification category assuming straight lines as boundaries. The boundaries of Washington county are not all straight and a certain amount of error is introduced when the boundaries are approximated by straight lines. The boundary approximation used is shown in Figure II-5 and was chosen to give what appeared to be the best equilization between extra land included in the count and Washington county land excluded.

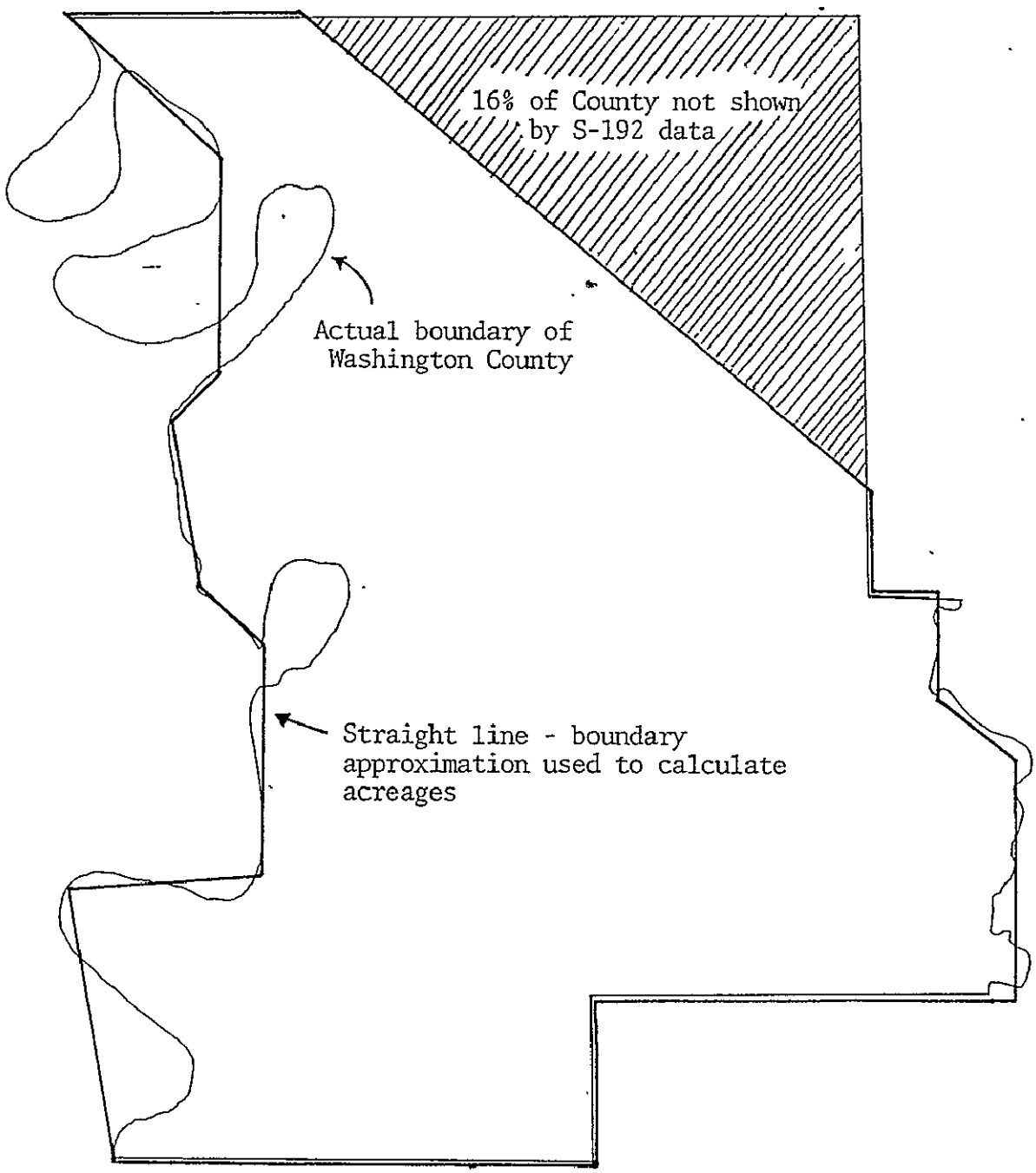
The difference in classification categories between the S-192 data and the survey data add a source for confusion in making a direct acreage comparison. One example is that "unclassified" land in the survey data has very little relation to land left unclassified by the pattern recognition routine using S-192 data.

Another source for differences between comparative figures comes from the classification technique. As an example a school and shaded playground would probably be classified as urban by the survey while it would appear as part urban, part grassland, and part forest in the Skylab data. Also, small stands of trees were probably overlooked by the surveys while they would be identified as forest by Skylab data. Differences such as these could account for considerable disagreement between acreage figures in similar categories while not showing either figure to be in error.

FIGURE II-5

BOUNDARY APPROXIMATION FOR WASHINGTON COUNTY

USED FOR ACREAGE CALCULATIONS



In view of all the justifiable sources for small differences the general agreement between acreages given by Skylab data and those given by surveys seems to indicate that the classification of S-192 data performed in this study is of reasonable accuracy.

Aircraft Data

On 22 August 1973, an aircraft overflight was made in support of this and several other studies. Data over the Stoneville, MS, area was taken at an altitude of 20,000 ft. with one-additional flight line directly over the experiment station from 4200 ft. It was decided to classify the data from this overflight as if it had been the Skylab data expected at the start of this project. To this end, channels used for classification were limited to those obtainable from Skylab (had all S-192 sensors been working). A computer program was used to identify the 4 best aircraft MSS bands for use in a classification routine. The term best refers to channels having the maximum average pairwise divergence between classes. While other choices may be better for identifying one particular class the bands given in Table II-9 are optimal for doing the entire classification. The closest S-192 bands are also given in Table II-9. The classification of the aircraft MSS data has not yet been completed by the ERL at NSTL.

TABLE II-9

OPTIMUM CHANNELS FOR CLASSIFICATION

OPTIMUM AIRCRAFT MSS			CORRESPONDING S-192	
Channel —	Nominal Wavelength μm	Color	Band	Wavelength μm
2	.40 - .44	Blue	1	.41 - .46
6	.64 - .68	Red	5	.62 - .67
8	.76 - .80	IR	7	.78 - .88
11	1.18 -1.30	IR	10	1.20 - 1.30
No Thermal Available				

III. INTERVIEW PROGRAM

Data from Skylab EREP was processed by ERL at the NASA/NSTL facility. The data used was the multispectral scanner (MSS) data which was sent to earth in digitized data streams and recorded on magnetic tapes. These tapes were the data items which were received by the NASA/NSTL-ERL facility.

Using statistical classification schemes that have been developed and refined at NASA/NSTL-ERL, the MSS data was classified according to the crop and a color coded map was printed which identifies a section of land with its type of crop.

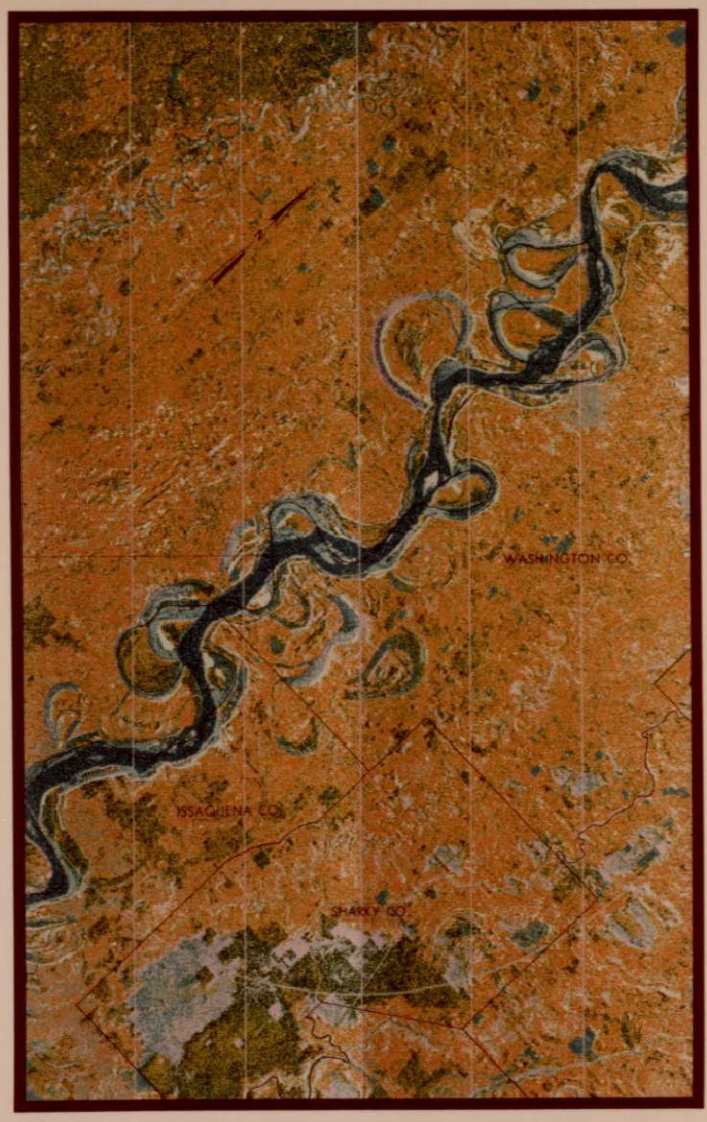
The data that Mississippi State University (MSU) received from NASA/NSTL-ERL was a color coded map, which as explained in Section I and II, was not what was originally scheduled to be produced. Copies of the color coded maps used for interviews are shown in Figure III-1 and Figure III-2.

A definition of the class titles is in order for the viewer to properly appraise the map product, see Table III-1.

For the interviews of this project it was suggested by NASA/JSC/ERL that due to the very limited time available after receipt of the map products and due to the very limited classification categories available, the interviews be conducted with only a few personnel who could assess the map products not for what they were in current form but for their potential usage under a more favorable time scale and with a full classification range available.

COMPUTER IMPLEMENTED LAND SURFACE CLASSIFICATION USING SKYLAB IV/S-192 MULTISPECTRAL SCANNER DATA

DELTA ALLUVIAL PLAINS



- UNCLASSIFIED
- URBAN
- WATER 1
- WATER 2
- WATER 3
- WATER 4
- INERT
- CROPLAND/PASTURE
- MIXED HARDWOOD
- OAK/HICKORY
- OAK/GUM/CYPRESS

APPROXIMATE SCALE (MILES)

0 5 10 15 20

COMPUTER COMPATIBLE TAPES USED FOR THIS CLASSIFICATION DERIVED FROM SKYLAB S-192 MULTISPECTRAL SCANNER DATA ACQUIRED JAN. 20, 1974

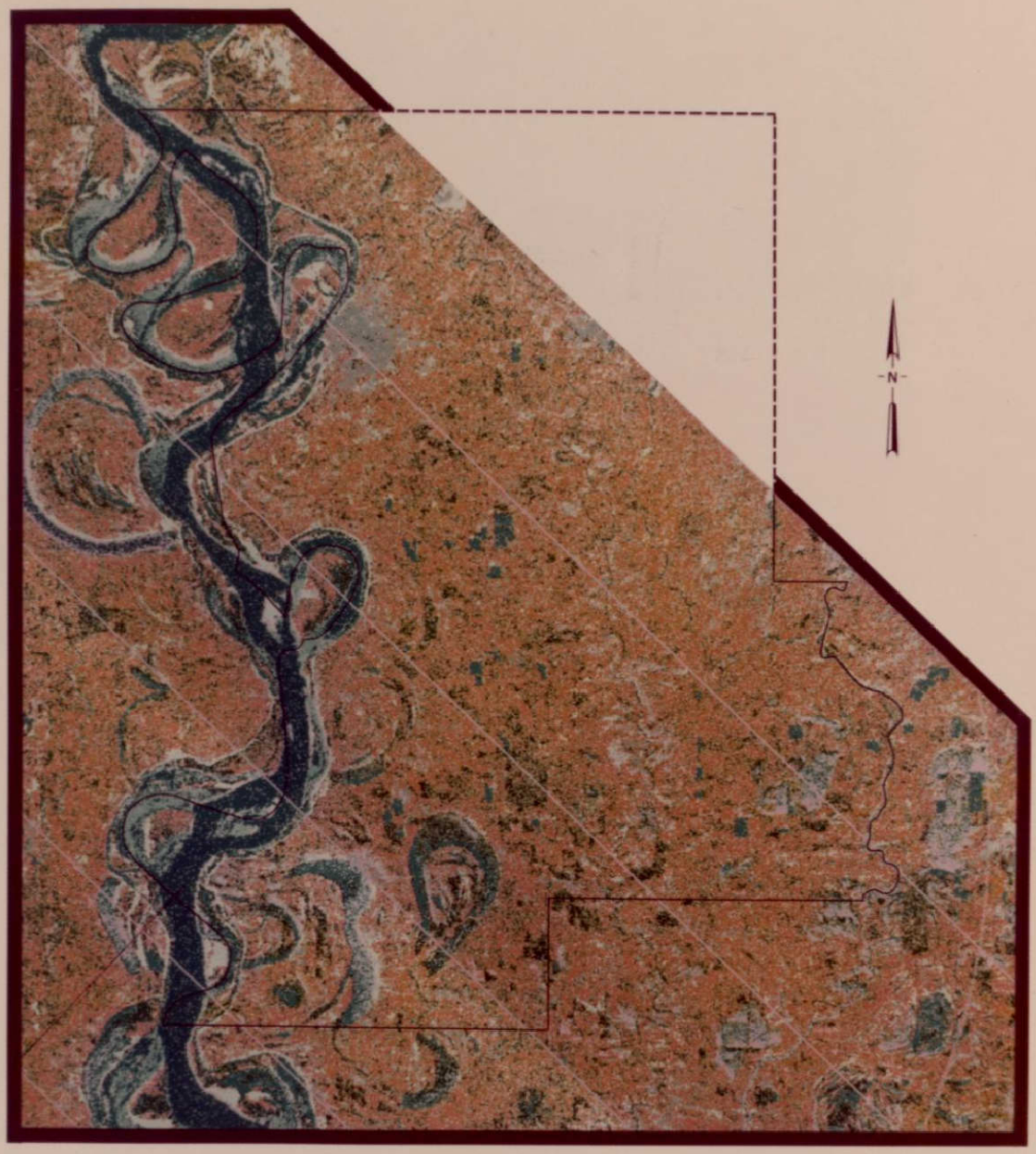
prepared by
NASA/JSC EARTH RESOURCES LABORATORY
NATIONAL SPACE TECHNOLOGY LABORATORIES
BAY ST. LOUIS, MISSISSIPPI

NASA

FIGURE III-1

COMPUTER IMPLEMENTED LAND SURFACE CLASSIFICATION USING SKYLAB IV/S-192 MULTISPECTRAL SCANNER DATA

WASHINGTON COUNTY, MISSISSIPPI



APPROXIMATE SCALE (MILES)

0 5 10 15

- UNCLASSIFIED
- URBAN
- WATER 1
- WATER 2
- WATER 3
- WATER 4
- INERT
- CROPLAND/PASTURE
- MIXED HARDWOOD
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COMPUTER COMPATIBLE TAPES USED FOR THIS CLASSIFICATION DERIVED FROM SKYLAB S-192 MULTISPECTRAL SCANNER DATA ACQUIRED JAN. 20, 1974

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NATIONAL SPACE TECHNOLOGY LABORATORIES

BAY ST. LOUIS, MISSISSIPPI

FIGURE III-2

TABLE III-1

CLASSIFICATION CATEGORIES

Unclassified	- That which did not fit in any of the 10 classes defined
Urban	- Developed areas consisting of stores and houses, but not necessarily void of tree and grass areas
Water 1	- River - main stream of flowing water
Water 2	- Oxbows and river banks with slow moving water
Water 3	- Catfish ponds and similar standing water such as that isolated around levees
Water 4	- Oxbow slews and eddy portion of rivers
Inert	- Gravel pits, sand banks and bars, and concrete parking lots
Cropland-Pasture	- Self explanatory
Mixed Hardwoods	- Self explanatory
Oak-Hickory	- Self explanatory
Oak-Gum Cypress	- Self explanatory

In accordance with this suggestion MSU investigators conducted interviews with the Coordinator of the Land Use Center of the Mississippi Cooperative Extension Service and with a representative of the Delta Branch Experiment Station. Results of those interviews are given below:

(A) The Skylab S-192 multispectral scanner data does appear to offer good definition of urban areas, for example, note the resolution element of 260 feet square or about 1.57 acres which is suitable for some land classification usages.

(B) The data map inspected does appear to give good definition of hardwood forests and for the lumber industry it should be very useful. Currently the lumber industry is using three mile grid samples. It would be a point of interest to determine whether Skylab data could locate sparse valuable trees like Mahogany.

(C) The data maps could be very useful for flood identification, especially with backwater and slow moving water areas distinguishable from the wet fields as the water 1, water 2, and water 3 classifications are defined. Damage estimates could be made by superimposing an overlay with building locations. Identifications of disaster areas could also be made rather easily.

(D) Inert land adjacent to water has high significance with respect to recreational value. Sand banks and bars are good for water sports. There is a need to examine the inert classification to see if plowed ground is not also included. Also, there is a need to investigate whether sand can be separated from concrete by thermal considerations, certainly asphalt could be separated from sand and concrete.

(E) Crop and pasture is the most valuable land in terms of food and fiber production, but there is a need to be able to separate crops from pasture, perhaps by live vegetation (pasture, winter wheat) versus dead vegetation (cropland) in the winter.

(F) Winter data (January) is not entirely without value. It gives good location of winter crop/pasture (e.g. winter wheat, winter ryegrass). It would have been more useful if the data had been taken over the hill country. It is already known that 95% of the Delta is in crop/pasture but there exists little data on the location or size of individual crops and pasture in the hill country.

(G) This nation is a regimented society with limited concerns. The soybean farmer does not care about where the forests are. As a result, thematic

(one class) maps would be much more useful than the conglomerate map. A grey level, two classifications computer printed map is a product which can be produced by NASA/NSTL/ERL at this time. These maps would be a possible solution to this need.

In all, it certainly is evident that Skylab EREP data could be useful. Some possible applications of it are mentioned above and these applications could make use of it in its present format if necessary; ways to improve data format are apparent and the great flexibility of the data processing methods allows changes in formats without a great deal of effort.

It is certainly unfortunate that the program was beset with technical problems both on the spacecraft and on the ground; problems which in effect prevented this project from making its main thrusts.

IV. CONCLUSIONS AND RECOMMENDATIONS

The original objectives of this project were by necessity reoriented due to a lack of availability of computer generated land use classification maps and statistical tables for the areas under consideration (see the introduction for a more complete description of the problems).

Ground truth was collected in good detail consistently through the active period of the contract which coincided with the crop seasons; a data bank exists in a MSU computer card file with this ground truth data (see the section on Data Management for more explicit details concerning the ground truth data).

The use of the Skylab EREP data in the form of computer generated statistical tables for crop yield estimates was not accomplished due to the lack of availability of those tables for the test areas for the 1973 crop year.

The main thrust of the program then, was an interview series using the 20 January 1974 classification map which was produced by NASA/NSTL/ERL. The results of the interviews show a good deal of genuine promise and need for the use of Skylab EREP data by the Mississippi Agricultural and Land Use Planning Industry. A general summary of the conclusions is presented below. While many different requests for variations in scale and availability are to be expected, we feel these conclusions are fairly general in application.

The conclusions and recommendations presented here are based upon data provided that was much less than optimum and

consistent with the difficulties experienced with the hardware and software. The investigator provides these conclusions and recommendations:

1. Skylab EREP data can be used for general evaluation in its present form, with respect to resolution and classification accuracy, for cursory evaluation by land use evaluators.

2. Seasonal mappings were deemed necessary for most users for delineation of wet lands and drainage patterns. Assessing flood characteristics of areas would be an important application.

3. Winter mappings appear to be expecially valuable for cataloging winter small grains and winter pastures as well as flooding areas.

4. The use of Skylab EREP data for mapping and monitoring the levee grass lands appears to be a practical application which again has no suitable data source available today.

5. Forest inventory, a Mississippi crop which is widely changing in its boundaries, is one in which the use of Skylab EREP data would appear to be particularly applicable.

It is recommended that:

1. The classification maps be printed with only two or three items depicted per map. The present system with eight to ten classification are too confusing and hard to read (see reference 6 for example and discussion of capability). In fact thematic maps (maps depicting one item or classification) would be highly desirable; and the grey level computer printed maps mentioned before (Page 38) could be a satisfactory product.

2. The scale of 1:62, 500 appears to be the scale desired by most potential users and hence future maps of this scale should be available.

3. Inclusion of some land marks on the map products so that specific areas may be located is highly desirable.

4. A map showing drainage patterns and changes in drainage patterns be generated for flood land evaluation and location.

5. A map showing the change in Forest boundaries and the change in forest types be generated for use by foresters.

6. Determine whether asphalt can be separated (as a classification item) from concrete and sand.

7. A catalog of map products which could be provided from the computer classification scheme be made by NASA and distributed to potential users and to state agencies. This catalog should have illustrations of the product and should explain to the user how to order what he wants. Pricing, time scale of availability of data and delivery schedule should be included.

At this time we can state that Skylab EREP data appears to be very useful in some aspects; it shows promise of providing several types of data not now available in any form and it could make feasible some monitoring functions that are not practical today. However, the system must be refined and organized so that a smooth flow of data on a known time scale would be available.

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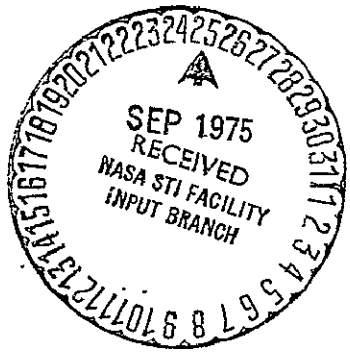
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