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CN-194115

(E75-10227) THE RELEVANCE OF ERTS-1 DATA TO THE STATE OF OHIO Final Report, Jul. 1972 - Oct. 1974 (Ohio Dept. of Economic and Community) 150 p HC $5.75 CSCL 08F

N75-21752

Unclas

G3/43 00227

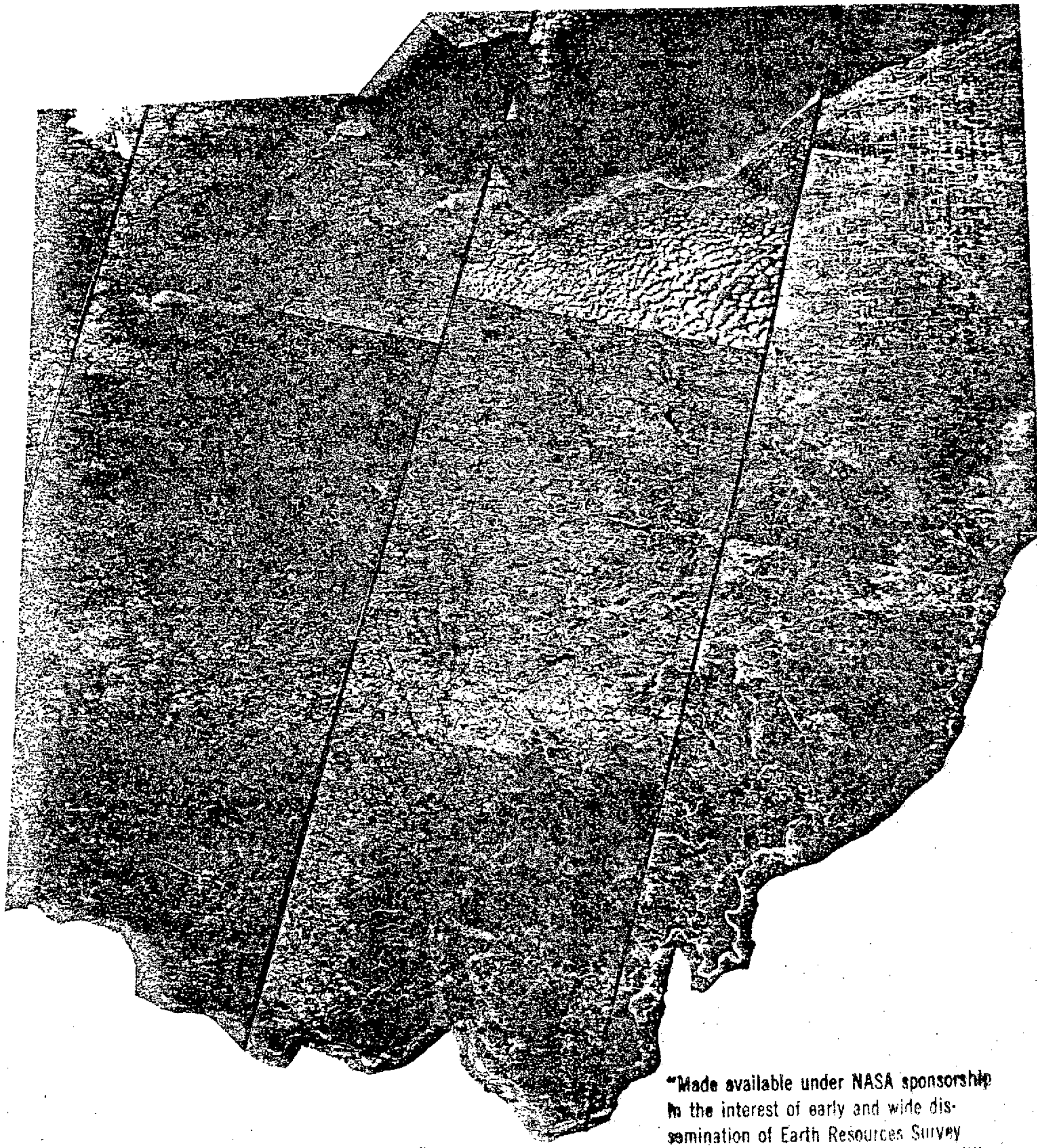
RELEVANCE OF ERTS-1 DATA TO THE STATE OF OHIO

1087A

DEPARTMENT OF ECONOMIC AND COMMUNITY DEVELOPMENT

COMMUNITY DEVELOPMENT DIVISION

ERTS-I VIEW OF OHIO
FROM 575 MILES ABOVE THE EARTH



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STATE OF OHIO
JOHN J. GILLIGAN, Governor

DEPARTMENT OF ECONOMIC AND COMMUNITY DEVELOPMENT

DAVID C. SWEET, Director

January 6, 1975

Receiving Officer
Scientific Investigation Support
Code 902.6, Building 16
Goddard Space Flight Center
Greenbelt, Maryland 20771

Gentlemen:

The enclosed final report represents a two-year effort in the evaluation of the utility of ERTS-1 data to resource management in Ohio. Working as a multidisciplinary team, the Ohio investigation has tested the application of ERTS-1 data in many different subject areas resulting in a number of significant findings.

As in any synergistic effort, a major factor necessary for success is cooperation and coordination. In addition to the numerous state, regional, and local participants in the program, we would like to extend our most sincere thanks to the National Aeronautics and Space Administration for making this investigation possible, and for their continued support throughout the program.

We feel that our investigation has been an important step in the effort to utilize ERTS data in a routine manner and we look forward to a continuing relationship with such NASA programs in an effort to improve the quality of life for our citizens.

Sincerely,

DAVID C. SWEET
Director

Enclosure

1087A

Project Title: THE RELEVANCE OF ERTS-1 DATA TO THE STATE OF OHIO

Contract Number: NAS5-21782

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October 10, 1974

Final Report for NASA Ohio ERTS Data User Program - July 1972-October 1974

Prepared for:
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle The Relevance of ERTS-1 Data to the State of Ohio		5. Report Date October 10, 1974
		6. Performing Organization Code
7. Author(s) David C. Sweet et.al.		8. Performing Organization Report No.
9. Performing Organization Name and Address Ohio Department of Economic and Community Development 30 East Broad Street Columbus, Ohio 43215		10. Work Unit No.
		11. Contract or Grant No. NAS5-21782
12. Sponsoring Agency Name and Address Goddard Space Flight Center Greenbelt, Maryland 20771		13. Type of Report and Period Covered Final Report for NASA Ohio ERTS Data User Program 7/72 - 10/74
		14. Sponsoring Agency Code

15. Supplementary Notes

Supporting organizations include the Ohio Departments of Natural Resources and Transportation, Ohio Environmental Protection Agency, The Ohio State University and Battelle Columbus Laboratories.

16. Abstract

This report summarizes the results of a multidisciplinary and multiagency experimental evaluation of the applicability of ERTS-1 data, in combination with correlative aircraft and on site radiometric and photographic data, to ongoing environmental quality, land use and resource management program activities of state, regional and local governments in Ohio. Included are discussions describing opto-electro-mechanical and to a lesser extent computer data analysis equipment and analytical procedures, user awareness activities, and illustrations documenting specific data applications. Specific discipline applications discussed in detail include surface mining and reclamation; suspended sediments and circulation patterns in water bodies; smoke plume and vegetation damage detection; land use feature classification, mapping, and trend analysis; forest and agricultural inventories; and Lake Erie ice monitoring. An assessment of the potential state utility of these experimental findings is noted and spatial, spectral, and temporal data recommendations for improving the operational usefulness of future earth resources satellite systems are also provided.

17. Key Words (Selected by Author(s)) ERTS-1 utility assessment ERTS-1: State of Ohio Data Collection System Resource Management Environmental Quality Land Use ERTS-1 analytical procedures & equip.		18. Distribution Statement	
19. Security Classif. (of this report) UNCLASSIFIED	20. Security Classif. (of this page) UNCLASSIFIED	21. No. of Pages 124	22. Price*

*For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

PREFACE

The objective of the Ohio ERTS user program was to determine if and how state government could benefit from orbital survey programs such as ERTS-1. The program was multidisciplinary in scope and involved the experimental evaluation of the potential applicability of ERTS-1 imagery and data relay capabilities to Ohio environmental quality, land use and resource management programs. The statewide program involved primarily the cooperation and participation of the Departments of Economic and Community Development (Lead Department), Natural Resources, Transportation, Environmental Protection Agency, and The Ohio State University. Technical program support was provided by the Battelle Columbus Laboratories.

The program concentrated on developing an effective multi-agency team for collecting and analyzing ERTS-1 data for Ohio; maintaining an active user awareness program; and, evaluating and demonstrating specific application possibilities. In general, state personnel were responsible for providing inputs relative to ongoing programs, problem areas, and data requirements which ERTS data could possibly fulfill. Battelle was responsible for the collection of the required correlative data and laboratory data analysis. Final assessment of the potential benefit of the experimental findings was the principal task of participating state personnel.

The Ohio ERTS-1 program succeeded in exposing earth resources data from space to a broad spectrum of potential users at the state, regional, and local level. An extensive data base (consisting of ERTS-1, aircraft, and ground truth data) has been assembled, and experience has been gained in analyzing ERTS data in imagery and digitized formats.

The final report summarizes the user awareness efforts conducted, data analysis procedures employed and, most importantly, results of the initial potential utility of ERTS data to comprehensive resource management in Ohio. Spatial, spectral and temporal recommendations for improving future satellite systems to maximize the operational utility of satellite data at the state level are also provided.

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THE RELEVANCE OF ERTS-1 DATA
TO THE STATE OF OHIO

by

David C. Sweet (Principal Investigator) et.al.

1.0 INTRODUCTION

This final report of the Ohio ERTS-1 program activities consists of nine sections and two appendices. Section 1 includes background materials, the objectives and scope of the program, principal participating organizations and personnel, study sites, and related programs which supplemented the ERTS-1 effort.

Section 2 summarizes data collection efforts including the status and quality of Ohio ERTS-1 data received and correlative aircraft and ground truth photographic and radiometric data collected. The results of the ERTS-1 Data Collection System (DCS) experiment using a single data collection platform (DCP) are also presented in this section.

Facilities, equipment, and data-analysis procedures employed in the program are described in Section 3 in conjunction with the data analysis plan followed. Results of the analytical efforts demonstrating data application possibilities and assessment of their potential utility to Ohio state government activities are contained in Section 4 and 5 respectively.

User awareness efforts conducted during the program are noted in Section 6 and miscellaneous activities such as educational and professional coordination activities are noted in Section 7. Sections 8 and 9 contain the summary, conclusions, recommendations, and references. Appendix A provides a summary of coverage and quality of all ERTS-1 data acquired over Ohio (August 1972 - June 1974) and Appendix B contains materials related to the Ohio ERTS/Skylab Data User Workshop.

1.1 Background

Following several meetings between State of Ohio and Battelle personnel in response to the NASA ERTS-A opportunity announcement in 1971, it was concluded that the various state agencies and thus, the citizens of Ohio could benefit from participating in the first experimental satellite earth resources user program. Hence, although some concern existed as to the compatibility of the ERTS data and state information/data needs, a consortium of State of Ohio agencies (under the leadership of Dr. David C. Sweet, Director of the Department of Economic and Community Development) and Battelle Columbus Laboratories jointly participated in developing a multidisciplinary proposal for evaluating the relevance of ERTS-1 data to the State of Ohio.(1) The Ohio proposal was accepted and the NASA funded program ran from July 1972, to October 1974. Numerous reports and publications have resulted from the effort to date(2-9), in addition to the required status reports (Type 1 and II). This report represents the final report of the Ohio ERTS-1 user program.

1.2 Program Objectives and Scope

The purpose of the proposed Ohio ERTS-1 program was to evaluate and demonstrate the relevance of ERTS imagery and data relay capabilities to comprehensive resource management in Ohio. More specifically, it was to test experimentally the applicability of ERTS-type data to decision-making processes involved in multidisciplinary state programs. Specific objectives included:

- Establishing an Ohio-ERTS Data Utilization Test Facility in Columbus for collecting and analyzing a combination of satellite, aircraft, and ground-truth data on selected natural and cultural resources of Ohio.
- Establishing an Ohio-ERTS core team comprised of resource managers, educators, and researchers knowledgeable in the capabilities, potentialities, and limitations of earth resources survey data.

- Developing and testing a methodology for converting satellite-acquired data into products and data formats useful for State physical, environmental, and economic development needs.

- Developing a comprehensive Ohio ERTS program that elicited participation of all state and local agencies concerned with managing, protecting, or researching the State's natural resources and environment.

- Obtaining experience in ERTS Data Collection Platform (DCP) operations and to determine the utility of the ERTS Data Collection System (DCS) to environmental monitoring in Ohio.

- Developing a rationale for evaluating the impact of experimental and operational earth resource satellite systems on the resource-management goals of Ohio.

- Improving public awareness of efforts to apply science and technology to increasing environmental and natural resource problems.

- Providing NASA with the results of the ascertained relevance of ERTS-1 to the State of Ohio and to provide recommendations for appropriately modifying future earth-resource satellite systems.

In the pursuit of these objectives, emphasis in the Ohio ERTS-1 program was placed on user-oriented applications in three disciplines: Environmental Quality, Land Use, and Resource Management. Specific application areas evaluated in each of these three disciplines and their relationship to program study sites and participating state agencies are shown in Figure 1.

1.3 Participating Organizations

ERTS-1 data were analyzed jointly by Battelle researchers and State of Ohio resource planners and managers to determine what useful environmental, natural and cultural resource information could be obtained and its relevance to the State's on-going environmental planning,

Discipline Applications	State Agencies: Ohio Department of Economic and Community Development	Ohio Department of Natural Resources	Ohio Department of Transportation	Ohio Environmental Protection Agency	The Ohio State University	Other User Agencies	Study Sites: Cleveland - Lake Erie	Ohio Agricultural Research and Development Center (Wooster)	Ohio Transportation Research Center (East Liberty)	Zaleski State Forest	Ottawa Wetlands	Columbus/Franklin County	Other Study Areas
ENVIRONMENTAL QUALITY													
LAND QUALITY													
Surface Mining		●		●	●	●			●	●			●
Reclamation		●		●	●				●	●			●
Critical Environmental Areas	●	●		●	●	●	●	●	●	●	●	●	
WATER QUALITY													
Lake Erie		●		●	●		●				●		●
suspended sediments				●	●		●				●		●
circulation patterns													
algae blooms				●	●		●				●		●
Reservoir Monitoring		●		●								●	●
AIR QUALITY													
Smoke Plume				●			●					●	●
Vegetation Damage				●									●
LAND USE													
FEATURE CLASSIFICATION													
Levels I and II	●		●			●	●	●	●	●	●	●	●
MAPPING													
State (1:250,000 & Smaller)	●		●										●
Regional (~1:125,000)	●		●			●	●					●	●
Local (1:24,000 & Larger)	●		●			●	●		●			●	●
TREND ANALYSIS													
Developing Areas	●		●			●	●		●			●	●
Transportation	●		●			●	●		●	●		●	●
RESOURCE MANAGEMENT													
FORESTRY													
Inventories	●	●			●	●		●	●	●		●	●
Species Classification	●	●			●	●		●		●			●
AGRICULTURE													
Crop Identifications	●				●	●		●				●	
OTHER													
OTHER													
Ice Monitoring	●		●				●				●		●
Sanitary Landfill Detection				●								●	●

FIGURE 1. RELATIONSHIP OF DISCIPLINE APPLICATIONS, STATE USER AGENCIES AND STUDY SITES IN THE OHIO ERTS-1 PROGRAM

monitoring and enforcement activities. State of Ohio agencies which were the principal participants in this initial analysis of the potential uses of orbital survey data include the:

- Ohio Department of Economic and Community Development
- Ohio Department of Natural Resources
- Ohio Department of Transportation
- Ohio Environmental Protection Agency
- The Ohio State University.

The specific areas of interest of each of the State agencies above are noted in the following paragraphs. In addition, numerous other state, regional, and local agencies have participated in the Ohio ERTS-1 program to lesser degrees. An overview of principal organizations and personnel that participated in the ERTS-1 program is provided in companion Figures 2 and 3.

1.3.1 Ohio Department of Economic and Community Development (ODECD)

The Ohio Department of Economic and Community Development is serving as the lead agency in the Ohio orbital survey programs since it has been delegated broad planning authority on the state level in Ohio as stated in the following primary instructions from the Ohio General Assembly recorded in the Ohio Revised Code:

> The Department of Economic and Community Development shall develop and promote, plans and programs designed to assure that state resources are efficiently used, economic growth is properly balanced, community growth is developed in an orderly manner, and local governments are coordinated with each other and the state,... (Sec. 122.01).

The department is also directed to:

> Assemble, analyze and make available to governmental agencies and the public information relative to the human, natural and economic resources and economic needs of the state; (Sec. 122.06 (A).)

and to:

> Prepare and maintain, in cooperation with departments and agencies of the state, comprehensive plans and recommendations for promotion of more desirable patterns of growth and development of the resources of the state...(Sec. 122.06(B).)

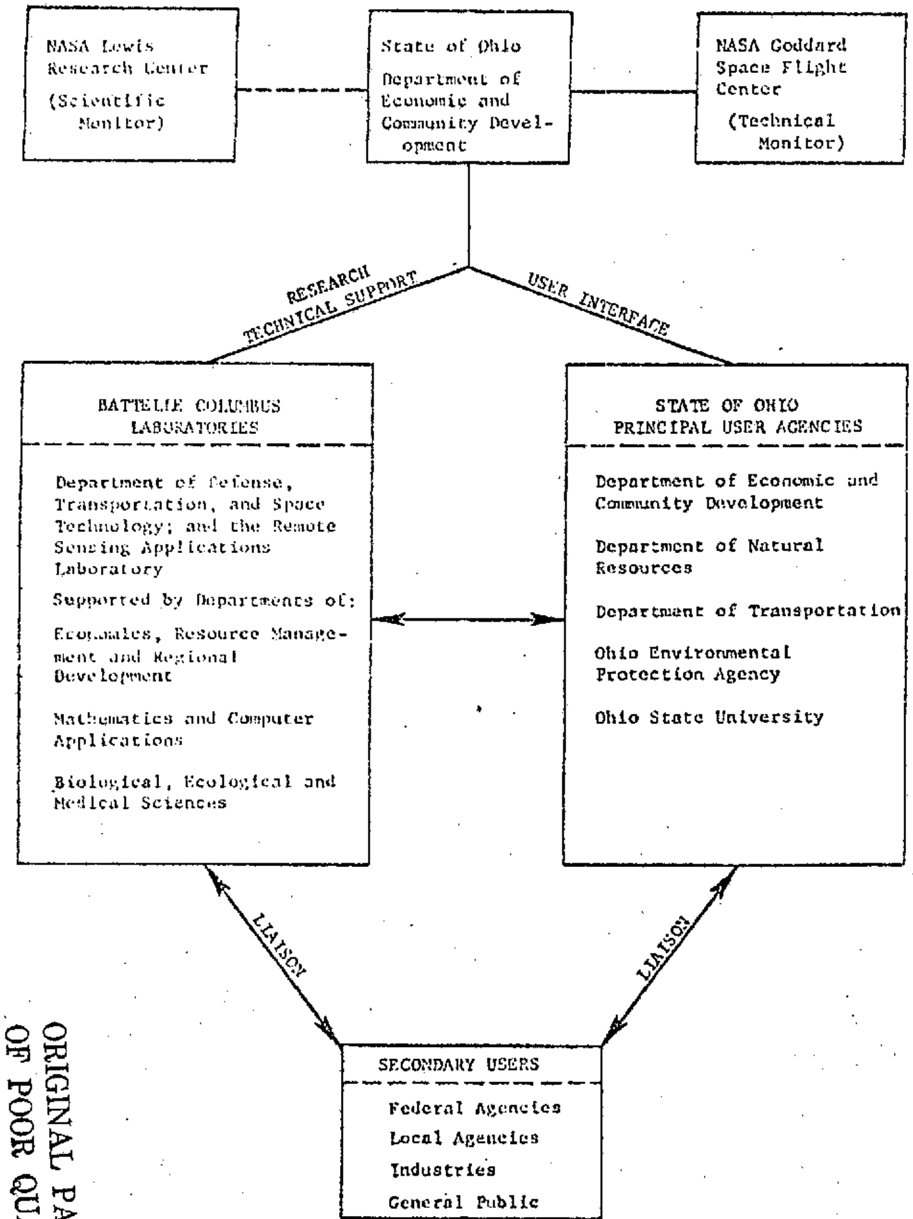
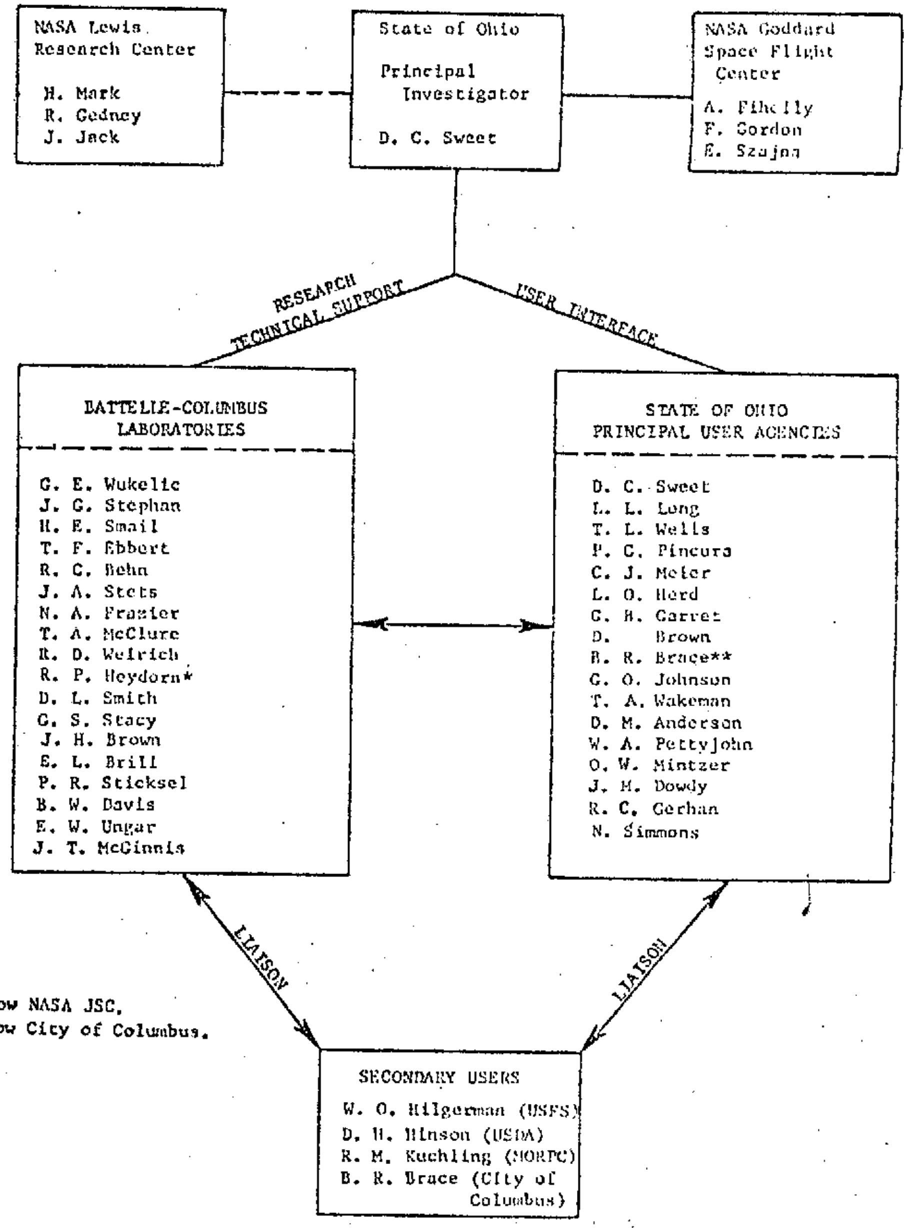


FIGURE 2. OVERALL OHIO ERTS-1 PROGRAM ORGANIZATIONAL CHART



* Now NASA JSC.
** Now City of Columbus.

FIGURE 3. PRINCIPAL OHIO ERTS-1 PROGRAM PARTICIPANTS

In addition to serving as the lead and coordinating agency in the Ohio ERTS-1 program, ODECD personnel have also assessed the relevance of ERTS-1 data as it applies to land-use planning, economic development, power siting, and the protection of agricultural lands.

1.3.2 Ohio Department of Natural Resources (ODNR)

The Ohio Department of Natural Resources has a number of responsibilities including water resource development, geological and soil surveys, State park and forest administration and strip mine reclamation. Department guidelines established by the General Assembly and the Governor focus on the "Improvement of the quality of life for the people of Ohio through the wise use of land and other natural resources". The wise use of land and other natural resources requires an adequate knowledge of present land uses and a determination of the optimum use of the land based on a number of factors (e.g., soil type, vegetative cover, cultural features, transportation networks, and geomorphology). Of prime interest to ODNR in the Ohio ERTS-1 program was the potential of using ERTS data to inventory the extent and degree of surface mining, the reclamation of new and old strip mined areas, and for providing data inputs to DNR's Ohio Land-Use Simulation Model (OLUSM), which yields estimates as to the optimal use of Ohio's land resources. The Department has added personnel and equipment for using remote sensing data and has funded an experimental program for testing the appropriateness of using ERTS data to support the Land Use Simulation Model.

1.3.3 Ohio Department of Transportation (ODOT)

The Ohio Department of Transportation evolved from the reorganization of various departments in 1970. It has the responsibility of developing and maintaining a modern transportation system in Ohio. Within ODOT, a Division of Transportation Planning maintains and coordinates a statewide comprehensive planning activity for all modes of transportation and a Division of Aerial Engineering acquires aerial photography of the State and maintains a comprehensive aerial photographic data base of the entire state. ODOT involvement in the Ohio ERTS-1 program has principally included the acquisition of multispectral aircraft data for the ERTS-1 study sites, the preparation of photo base maps from ERTS-1 imagery, the reproduction of ERTS-1 imagery for statewide distribution and an initial assessment of ERTS-1 data to various aspects of transportation planning.

1.3.4 Ohio Environmental Protection Agency (OEPA)

The Ohio Environmental Protection Agency was created by the Ohio General Assembly in 1971, and has the prime responsibility for land, water and air quality control in Ohio. The agency has assessed the relevance of ERTS-1 data to water quality parameters of Lake Erie and other bodies of water, illegal landfills, and to new air quality models.

1.3.5 The Ohio State University (OSU)

The Remote Sensing Committee of The Ohio State University consists of representatives from over 15 schools and departments. These include the School of Natural Resources, the Departments of Geology, Geodesy, Civil Engineering and Botany, the Agricultural Research and Development Center at Wooster, and the Engineering Experiment Station at Coshocton. In co-operation with the Ohio ERTS-1 program this Committee promoted the educational aspects of ERTS-1 and other remotely sensed data through courses, seminars and student research.

1.3.6 Battelle's Columbus Laboratories (BCL)

As prime technical subcontractor of the Ohio ERTS program, the Columbus Laboratories of Battelle Memorial Institute has provided extensive technical research support to the state. In particular the Remote Sensing Applications Laboratory has provided extensive technical support to the Ohio ERTS-1 program primarily through three activities:

- Analyzing ERTS-1 imagery of Ohio.
- Collecting ground-based and aircraft data required for interpreting the imagery.
- Preparing topical reports based on ERTS-1 data for subsequent determination of their usefulness to environmental and resource managers in various Ohio governmental agencies.

In addition, other Departments at Battelle contributed expertise relating to the multidisciplinary applications of ERTS-1 data to the State of Ohio. Supporting activities included computer analysis, economic assessments, equipment design, installation and maintenance, resource management, land use implications and technical review.

1.3.7 Other Agencies

Other state, federal, local, and private user organizations and individuals contributed to the assessment of the utility of ERTS-1 data to Ohio resource management, environmental quality and land use practices, data requirements, and policies. Some of these individuals and organizations include: Dr. Herman Mark and Dr. Richard Gedney of NASA Lewis Research Center in Cleveland; Dr. Richard Gerhan of Baldwin Wallace College; Dr. Dennis Anderson of the Ohio Biological Survey; Dr. Charles Herdendorf of the Ohio State Center for Lake Erie Studies; David Hinson of Crossroads Resource Conservation and Development Agency; Ray Kuckling and William Habig of Mid-Ohio Regional Planning Commission; and Benjamin Brace, Carl Wilhelm, and Paul Baldridge of the City of Columbus. In addition representatives of the the U. S. Army Corps of Engineers, State of Ohio Office of Management and Budget, State of Ohio Department of Agriculture, and numerous individuals from various local governments contributed to the assessment of the utility of ERTS-1 data to Ohio interests.

1.4 Study Sites

Since the Ohio ERTS-1 program was multidisciplinary in nature, six principal study sites were selected on the basis of their compatibility with one or more of the following criteria:

- The site reflected a mixture of disciplinary interests.
- Site location in relation to State, Battelle, or NASA-Lewis facilities.
- Existing data available for use as ground truth information on the sites.

- Proposed and on-going projects at the site which provide ground data of value to data interpretation in the Ohio orbital survey programs.
- The need to collect baseline data of the site to plan or to evaluate effects of development and projected changes in land use, etc.

The location of each study site in relation to major Ohio cities and ERTS-1 overpasses of the State is shown in Figure 4. The relationship of the study sites to discipline and state user agency interests were shown in Figure 1. Descriptions of each study site are provided below.

1.4.1 Cleveland — Lake Erie Study Site

An 8 by 25 km long strip along the Cuyahoga River running through the middle of Ohio's largest city was chosen for urban land use and environmental studies. Within this sector of Cleveland are found heavy industries, old and new residential areas, intensive transportation networks, parks, shopping centers, a major airport, fields and open areas, quarries and a portion of Lake Erie at the mouth of the Cuyahoga River. In essence this study site contained all characteristic natural and cultural features which form typical land use patterns in Ohio. Also, heavy industry located along the Cuyahoga River and the Lake Erie shoreline provided the basis for both water and air quality studies.

1.4.2 The Ohio Agricultural Research and Development Center Study Site at Wooster

This agricultural study site in Wayne County was approximately 11 by 22 km in size and included the Ohio Agricultural Research & Development Center at Wooster. Field sizes and crop types found in the area were fairly representative of farming activities in Ohio including corn, wheat, soybean, oats, and hayfields. At the 2000 hectare agricultural experimental facility a large variety of crop types (tomatoes, potatoes, peas, etc.) is grown; however, most plot samples on the site were too small to be recognizable on ERTS imagery. However, the concentration of numerous crops and tree types found in Ohio made this an excellent site for radiometric signature collection.

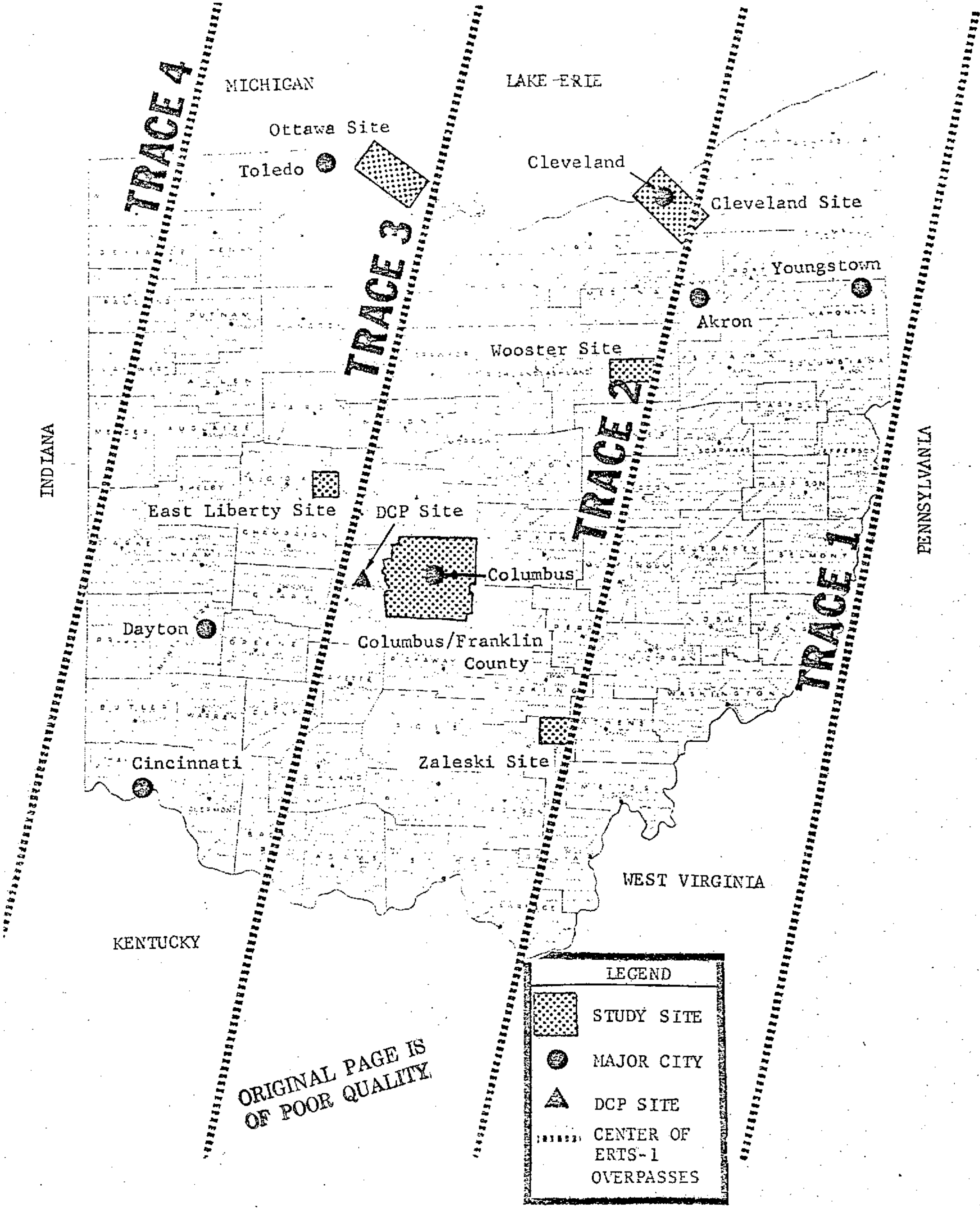


FIGURE 4. LOCATION OF OHIO ERTS STUDY SITES AND DCP SITE IN RELATION TO ERTS-1 OVERPASSES OF OHIO

1.4.3 Ohio Transportation Research Center Study Site at East Liberty

This Ohio ERTS-1 study site was located in portions of Logan and Union Counties and covers an area of 2834 hectares (7,000 acres). The largest transportation research center in the world was located within the study site. Its test track is 5.3 km long along its longest axis. The 70 million dollar facility is still undergoing construction affecting the rural agricultural and village community area. This area was monitored by Ohio researchers since its inception and provided an excellent means to study the effects of man-made activity and the resulting encroachment on a rural environment.

1.4.4 Zaleski State Forest Study Site

This Vinton County study site in southeastern Ohio was a moderately rugged area with maturely dissected relief features. Native hardwoods (90 percent oak and hickory) and some conifer plantations covered most of the 30,000 hectare area. A 160 hectare lake within the site, which provides regional recreational activities, contained a high pH/sulfur content causing the lake to appear vivid green. The study site area also included recently stripped mined areas which had been undergoing reclamation since 1972.

1.4.5 Ottawa Wetlands Study Site

This site, in Ottawa County, extended approximately 16 kilometers (10 miles) in a northwest-southeast direction paralleling and including the shoreline of Lake Erie. Lakeward, the site included the near-shore area of Lake Erie. Landward, a large part of the site was a fresh-water marshland of about 3,120 hectares (7,700 acres). Most of the area within the study site is in Federal and State ownership. At the mouth of the Toussaint River, the approximate southeast boundary of the site, the Davis-Besse nuclear power plant is presently being constructed. The site represented a mix of major land uses including recreational resources (e.g., hunting, trapping, fishing), wetland conservation areas, farms, and industrial and commercial developments near or bordering the lake front. This area was chosen as an ERTS study site because of its important wildlife, water and other unique natural and environmental features.

1.4.6 Columbus/Franklin County Study Site

This 1300 square km (500 sq. mile) study site was chosen during the program for land use studies because the Cleveland site was consistently cloud covered during the first six months of ERTS-1 over passes. This study site contained areas which had experienced rapid growth and areas which possessed a variety of natural, cultural and environmental features required for an extensive evaluation of ERTS data for land use purposes. The area contained heavy industries, large warehouse centers, intensive transportation networks, several rivers, reservoirs, old and new residential neighborhoods, parks, three airfields, etc. Local knowledge of this area facilitated ERTS data interpretation for land use, transportation, forestry, urban planning and agriculture. The area was also covered by other photographic coverage, including Skylab 2 and 3, and very high altitude aircraft flights.

1.5 Related Programs

Complementing the ERTS-1 effort, a joint State of Ohio - Battelle Skylab Earth Resources Experiment Package (EREP) proposal was prepared and accepted by NASA.[10] The results of analytical efforts to evaluate the use of these data for land use planning interests are contained in a final report recently prepared on the Ohio Skylab program.[11]

Several other programs were funded by participating agencies which contributed either directly or indirectly to the Ohio ERTS-1 program. Appropriate results of these programs are noted in this report. These programs included:

- An ERTS/Skylab Data User Workshop co-sponsored by the Ohio Department of Economic and Community Development and Battelle Columbus Laboratories.

- Color composite ERTS-1 mosaic of the State of Ohio supported by the Ohio Department of Economic and Community Development and the Ohio Power Siting Commission.
- A remote sensing short course co-sponsored by The Ohio State University and the Ohio Department of Economic and Community Development.
- Land use mapping from ERTS-1 computer compatible tapes supported by the Ohio Department of Natural Resources.
- Data Collection Platform instruments and interface development supported by Battelle Columbus Laboratories.
- Public educational program supported by Battelle Columbus Laboratories.
- Feature recognition and computer mapping from ERTS-1 computer compatible tapes supported by Battelle Columbus Laboratories.

2.0 DATA COLLECTION

Section 2 provides a description of ERTS-1 data in general, ERTS-1 data acquired of Ohio areas, correlative aircraft and radiometric and photographic ground truth study-site data, and the results of the Ohio Data Collection System (DCS) experiment.

2.1 ERTS-1 Data

Since July 23, 1972, ERTS-1 has been providing repetitive (every 18 days) and continuous acquisition of multispectral data of the natural and cultural surface features on a global basis. The satellite is currently equipped with two separate systems of sensors for this purpose: a three-camera return beam vidicon system (RBV) and a four-band multispectral scanner system (MSS). The RBV system was used only sparingly during the very early phase of the mission, and no RBV data over Ohio were acquired. However, the MSS continues to provide global coverage far beyond its original life expectancy.

The multispectral scanner is a line-scanner device which uses an oscillating mirror to simultaneously scan the terrain passing beneath the spacecraft in four spectral bands of the electromagnetic spectrum:

Band 4	0.5 to 0.6 micrometers	blue-green
Band 5	0.6 to 0.7 micrometers	red
Band 6	0.7 to 0.8 micrometers	near infrared
Band 7	0.8 to 1.1 micrometers	infrared.

Each individual ERTS-1 MSS image covers more than 34,000 square kilometers (10,000 square miles) of the earth's surface with an overlap of approximately 10 percent along the spacecraft track.

The data are telemetered from the spacecraft to the ground receiving stations in the U. S. where they are recorded on magnetic tapes and converted into black-and-white photographic positives on 70-mm film (at a scale of approximately 1:3,369,000). The 70-mm film formats are subsequently enlarged to a 24 cm x 24 cm format resulting in an image scale of 1:1,000,000 and reproductions are transmitted to ERTS investigators. Master copies of the images are also immediately flown to the

Department of Interior Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, South Dakota, where they are placed in the public domain. Reproductions are available from the EROS Data Center at reasonable cost by the scientific community, industry, and the public at large.

2.2 Ohio ERTS-1 Data

ERTS-1 multispectral data in 70-mm transparencies, 24 cm x 24 cm prints and transparencies and digitized computer compatible tapes have been received periodically by the State of Ohio beginning with the August 21, 1972, ERTS-1 overpass. Ohio land areas are covered by one ERTS-1 pass on four consecutive days at about 10:30 a.m. local time (see Figure 4).

As recorded in Table 1, which correlates dates of ERTS-1 orbital passes with the data received, imagery has been received for 96 of the 152 passes that ERTS-1 flew over Ohio as of June 30, 1974. Thus, data for over 63 percent of the ERTS-1 Ohio overflights have been received. The data were usually received within one or two months after the ERTS-1 overpass.

The coverage and quality of ERTS-1 scenes received for each of the four Ohio orbital traces are noted in Appendix A. Of the 241 individual ERTS-1 scenes received, 69 percent were classified usable (fair, good, or excellent), depending on the amount of cloud content. Although consecutive usable data for all four ERTS-1 passes which cover Ohio once every 18 days were never received, all areas of Ohio were recorded cloud free by the satellite at least once during every season of the year. Multispectral color composites derived from combining two or more of the MSS bands were requested and received for most of the higher quality ERTS-1 scenes.

TABLE 1. SUMMARY OF ERTS-1 DATA
RECEIVED ON OHIO

Ohio ERTS-1 Overflight Dates	Trace* 1	2	3	4
1972				
Aug.	21**	22	23	24
Sept.	8	9	10	11
Sept.	26	27	28	29
Oct.	14	15	16	17
Nov.	1	2	3	4
Nov.	19	20	21	22
Dec.	7	8	9	10
Dec.	25	26	27	28
1973				
Jan.	12	13	14	15
Jan./Feb.	30	31	1	2
Feb.	17	18	19	20
Mar.	7	8	9	10
Mar.	25	26	27	28
Apr.	12	13	14	15
Apr./May	30	1	2	3
May	18	19	20	21
Jun.	5	6	7	8
Jun.	23	24	25	26
Jul.	11	12	13	14
Jul./Aug.	29	30	31	1
Aug.	16	17	18	19
Sept.	3	4	5	6
Sept.	21	22	23	24
Oct.	9	10	11	12
Oct.	27	28	29	30
Nov.	14	15	16	17
Dec.	2	3	4	5
Dec.	20	21	22	23
1974				
Jan.	7	8	9	10
Jan.	25	26	27	28
Feb.	12	13	14	15
Mar.	2	3	4	5
Mar	20	21	22	23
Apr.	7	8	9	10
Apr.	25	26	27	28
May	13	14	15	16
May/Jun.	31	1	2	3
Jun	18	19	20	21

* See Figure 4 for center line of ERTS-1 overpasses of Ohio.

** Dates underlined indicate ERTS-1 data were received from NASA.

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2.3 Aircraft Data

Multispectral aerial underflights of the Ohio ERTS study sites were flown to provide correlative data for resource identification and mensuration verification. The aircraft underflights followed an ERTS-1 overpass within one or at most two days, cloud conditions permitting. Other factors such as areas in which timely opportunities existed, data requirements for utility assessment/user awareness programs, and seasonal vegetation coverage were also considered in the planning of aerial under flights.

A twin-engine Beechcraft aircraft equiped with a 15-cm Zeiss RMK-A cartographic camera and a four Hasselblad EL 500 70-mm multiband camera configuration with 100-mm planar lens was used to acquire the appropriate multispectral aerial photography (see Figure 5). The flight altitude was 3.66 km which provided 24 cm x 24 cm photographic format at a 1:24,000 scale and a 70-mm photographic format at a 1:48,000 scale. Handheld Ektachrome 35 mm aerial shots were also taken from the aircraft on a selective basis. Aerial photographic data acquisition dates are listed by study site in Table 2.

Panchromatic film was used in the Zeiss cartographic camera. The Hasselblad multiband camera films and filter combinations were:

Camera		Filter Type
1	Plus X Pan	25
2	2424	89B
3	Ektachrome Infrared	12
4	Ektachrome ER 5257	Haze

In addition to the multispectral aerial photographic data acquired over Ohio ERTS study sites as part of the Ohio ERTS-1 program, other aerial data collected prior to or during the Ohio ERTS-1 program for other State and Federal programs (such as the Skylab program) were also utilized during various data utility assessments throughout the program. Aerial photographic coverage of the entire state acquired from 1958 to 1964 at a scale of 1:24,000 for use in the preparation of the 1960 land use study and mapping program was also used in the ERTS-1 program, especially for feature identification and trend analysis purposes.

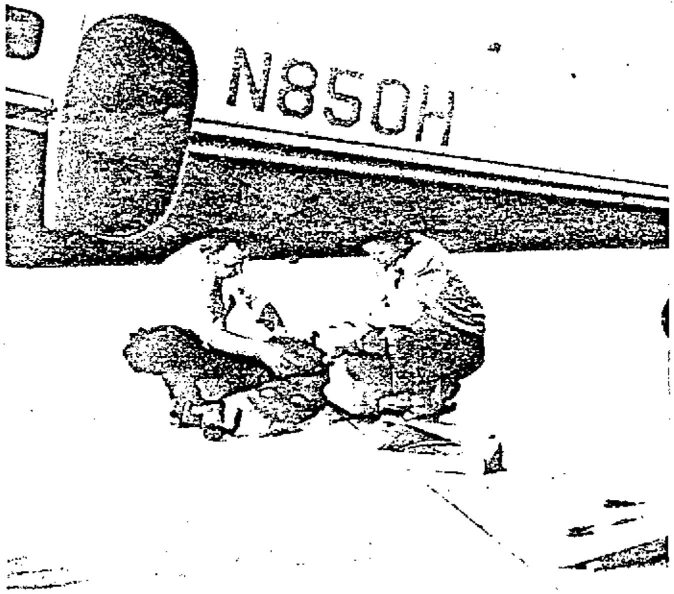

Fig. 5a. State and Battelle Personnel Preparing for an Ohio ERTS-1 Study Site Aerial Survey.

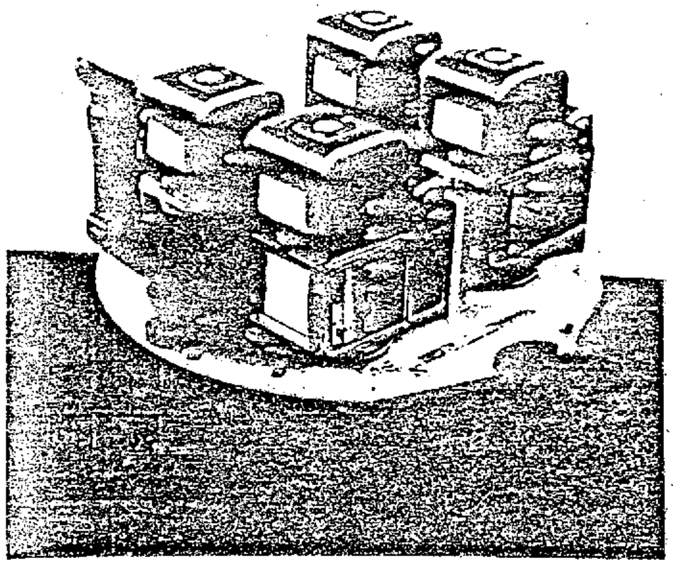

Fig. 5b. Hasselblad EL 500 70-mm Aerial Camera Configuration Used to Acquire Multispectral Photography of Ohio ERTS-1 Study Sites.

FIGURE 5. AERIAL PHOTOGRAPHIC DATA ACQUISITION EQUIPMENT

2.4 Study Site Ground Truth Data

Photographic and radiometric ground truth surveys of the Ohio ERTS study sites were conducted to obtain spectral data used in analyzing ERTS-1 imagery. These ground truth surveys, like the aerial photographic underflights, were conducted on days coinciding or within one or two days of an ERTS-1 overpass of Ohio. Literature surveys, various maps and other relevant data pertaining to the study sites, and other areas of special interest were assembled.

TABLE 2. AIRCRAFT, RADIOMETRIC, AND PHOTOGRAPHIC GROUND TRUTH DATA BASE OF OHIO ERTS-1 STUDY SITES

Study Site	Aerial Photography Date Flown	Photographic and/or Radiometric Ground Truth Surveys Date of Survey	Features of Interest
Cleveland	8/29/72 6/14/73	8/15/74 6/14-15/73 6/21-22/73	Urban, Lake Erie sedimentation, shore & beach erosion, surface mining
Columbus/Franklin County	4/17/72 3/15/73	8/12/73	Land use, urban
East Liberty Research Transportation Research Center	8/29/72 6/14/73 10/25/73	8/18/72 9/14/72 6/26/73	Land use/development, agricultural crops, surface mining
Ottawa Wetlands	8/29/72 6/14/73	8/11/72 6/26/73	Wetlands, flooding, agricultural crops, Lake Erie shore erosion and sedimentation
Wooster Agricultural Research and Development Center	8/29/72 6/14/73 10/25/73	9/11/72 9/27/72 6/1/73	Agricultural crops
Zaleski State Forest	8/29/72	8/15/72 10/14/72 10/24/72 7/30/73	Forestry, surface mining and reclamation

2.4.1 Radiometric Ground Truth Surveys

A Model SR ISCO spectroradiometer and strip chart recorder (see Figure 6) was the primary sensor used to acquire ground truth spectral data. Table 2 shows the radiometric survey dates by study site and the selected features surveyed. These radiometric surveys were conducted simultaneously with photographic surveys of the selected features. Figures 7a and 8a illustrate some of the areas in which radiometric surveys were conducted. Because of the sensitivity of the radiometer to temperatures below 50-60 F, the spectroradiometric field work at the various study sites were conducted only during the warmer months of the year. The radiometer had a spectral range of 0.35 to 1.55 micrometers. Spectral data collected were annotated and corrected relative to instrument calibration, cloud and weather conditions and the time of day. Resulting graphs (such as those shown in Figures 7b and 8b) were utilized as interpretation aids during the analysis of ERTS-1 imagery.

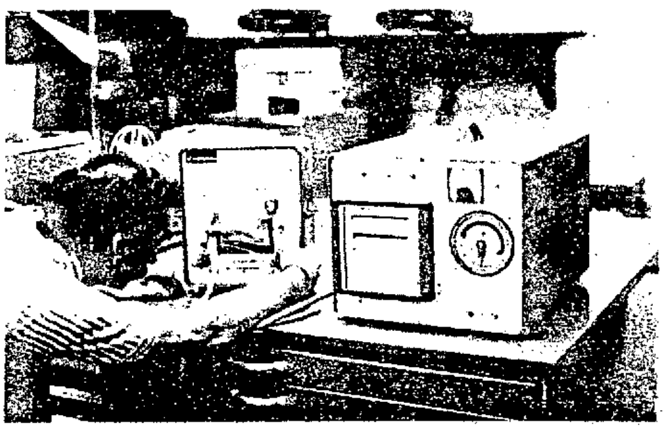

FIGURE 6. ISCO RADIOMETER AND RECORDER USED FOR ACQUIRING ON-SITE SPECTRAL SIGNATURES OF OHIO'S NATURAL AND CULTURAL FEATURES

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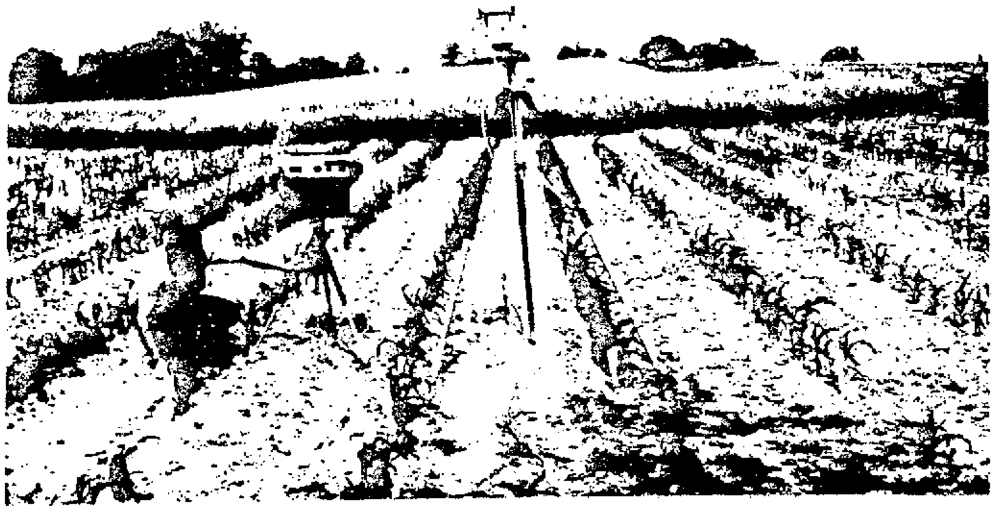

Fig. 7a. Radiometric Survey Being Conducted In A Corn Field At The Wooster Agricultural Study Site on June 12, 1973.

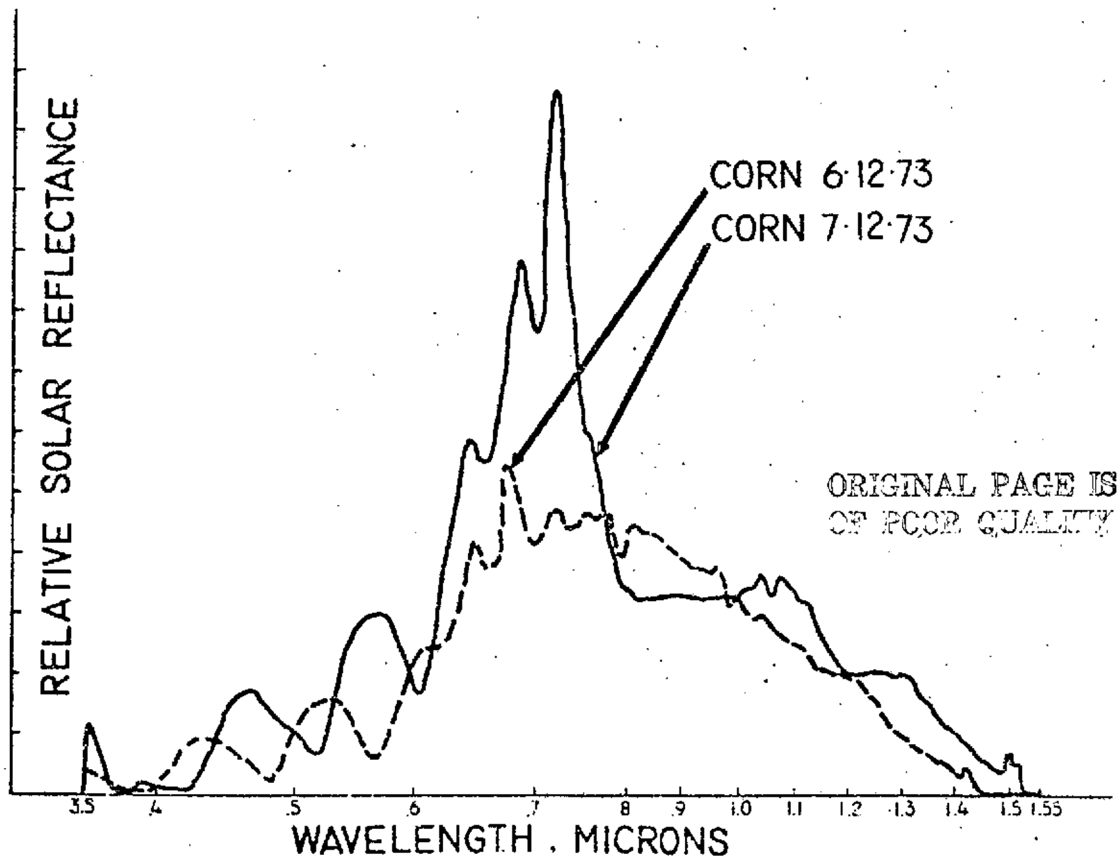

Fig. 7b. One Month Radiometric Comparison Of Spectral Signatures Acquired In The Corn Field Shown in Figure 7a.

FIGURE 7. ACQUISITION OF RADIOMETRIC SIGNATURES OF OHIO AGRICULTURAL RESOURCES

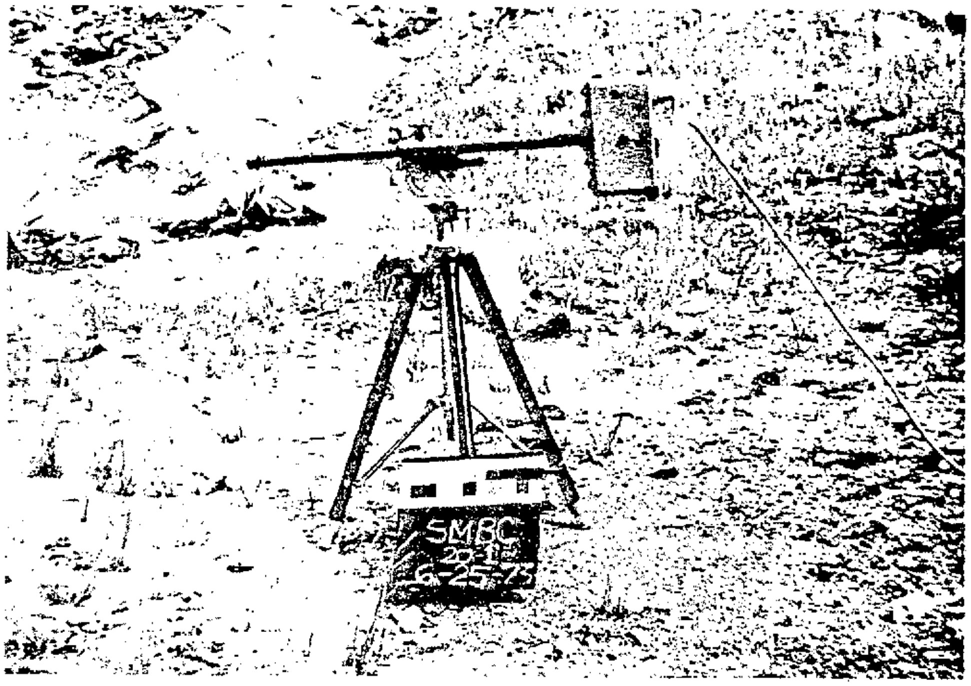

Fig. 8a. Radiometric Survey Being Conducted In a Strip Mined Area On June 25, 1973.

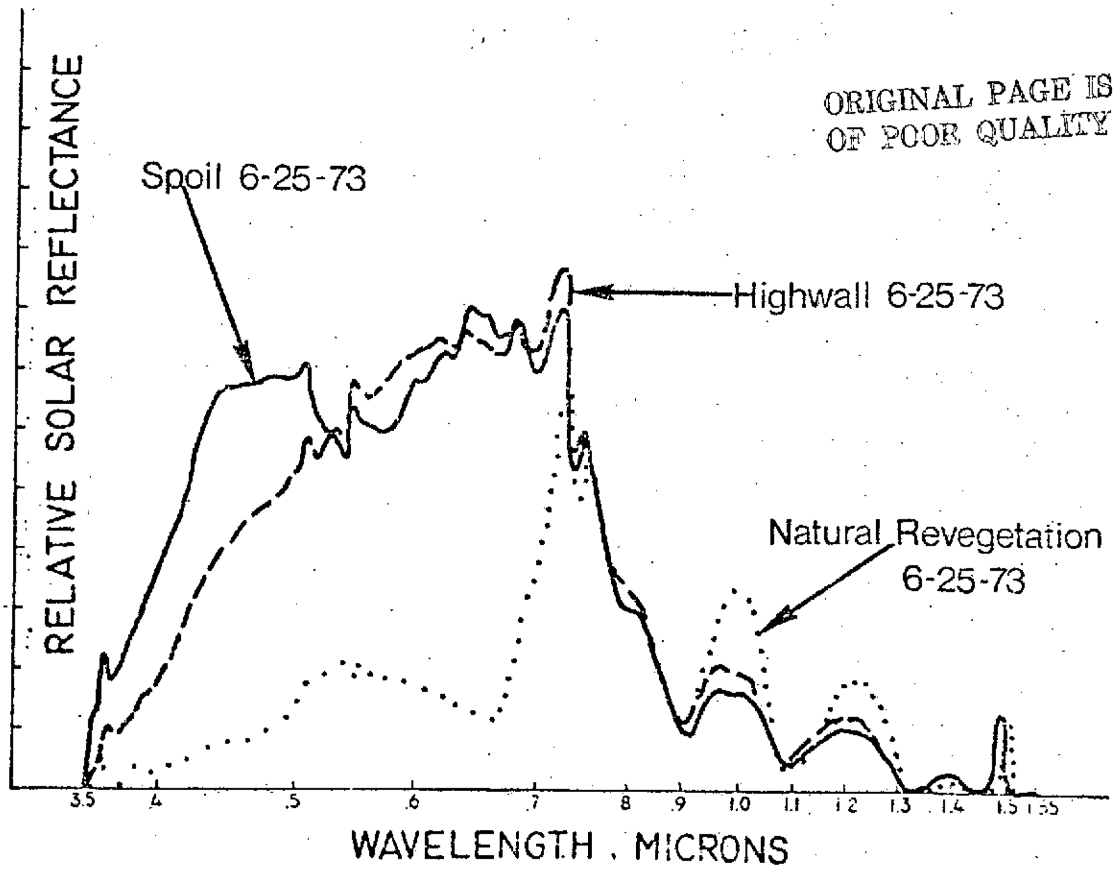

Fig. 8b. Radiometric Comparisons of Strip Mined Features.

FIGURE 8. ACQUISITION OF RADIOMETRIC SIGNATURES OF OHIO STRIP MINE FEATURES

2.4.2 Photographic Ground Truth Surveys

The primary sensors used to obtain photographic ground truth data of the Ohio ERTS-1 study sites were 35-mm cameras with Ektachrome and infrared color film. The photographic data collection activities were conducted during radiometric ground truth surveys. For selected portions of the study sites, 16-mm photography was also acquired at various times throughout the program. The photographic data base proved to be an invaluable aid during the laboratory analysis of ERTS data as well as establishing a permanent historical record of conditions which existed at that time of the ERTS-1 photography.

2.4.3 Literature Surveys

Publications relative to the Ohio ERTS-1 program interests were collected and filed at Battelle's Remote Sensing Laboratory. An up-to-date catalog and record of ERTS-1 data in tabular and microfilm form and Skylab orbital survey data in map and tabular formats for the entire world are also maintained. Relevant information on the study sites and literature relating to Ohio environmental and natural resource interests in general were assembled from various sources. This data base included statistical data, maps, books, publications, etc. Maps most frequently used included USGS topographic map at scales of 1:250,000 and 1:24,000, land-use maps, geological maps, hydrological maps and county highway maps. Maps were used during ground truth surveys for recording feature updating as required.

2.5 Data Collection System/Data Collection Platform Effort

In addition to providing multispectral imagery, ERTS-1 also acts as a relay for transmitting to the NASA tracking complex a variety of environmental data collected by ground-based sensors from various remote locations. This data collection capability of ERTS-1, called the Data Collection System (DCS), consists of three subsystems: the Data Collection Platform (DCP), the satellite equipment, and the Ground Data Handling System. The purpose of the DCS is to provide users with near real-time data collected from various remote locations in readily usable formats such as magnetic tapes, computer printouts and punched cards (See Figure 9). The DCS system has the potential of providing a continual flow of information required for better management of the earth's resources and the identification of adverse environmental developments for early remedial action.

ERTS DATA COLLECTION SYSTEM USER PRODUCTS 07/05/73 USER ID : [illegible]

PLAT ID	SAT ID	TIME CODE	STA ID	PLAT.ID QUALITY	ERROR FLAG	MSG QUAL	(ENCODED) DATA (AND QUALITY) BITS (IF ENCODED, EN... 0 = DATA BIT=0,QUALITY BIT=1(GOOD) 2 = DATA BIT=0,QU... 1 = DATA BIT=1,QUALITY BIT=1(GOOD) 3 = DATA BIT=1,QU...
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	G	7777	0	7	[illegible]
6155	1	3 [illegible]	G	7777	0	7	[illegible]
6155	1	3 [illegible]	G	7777	0	7	[illegible]
6155	1	3 [illegible]	G	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 [illegible]	G	7777	0	7	[illegible]
6155	1	3 [illegible]	N	7777	0	7	[illegible]
6155	1	3 185164022	G	7777	0	7	[illegible]
6155	1	3 185164022	N	7777	0	7	[illegible]

FIGURE 9. TYPICAL ERTS-1 DATA COLLECTION SYSTEM (DCS) DATA FORMAT

In this program, a single Data Collection Platform (DCP), located at Battelle's West Jefferson, Ohio, facility, was used to demonstrate the utility of the Data Collection System (DCS) for potential State use in an operational mode (See Figure 10). The site proved to be advantageous because of its rural location, the existence of a small lake on the property, protection from vandalism and its proximity to Columbus. Data were obtained from the DCP at least once every 12 hours during periods when it was functioning.

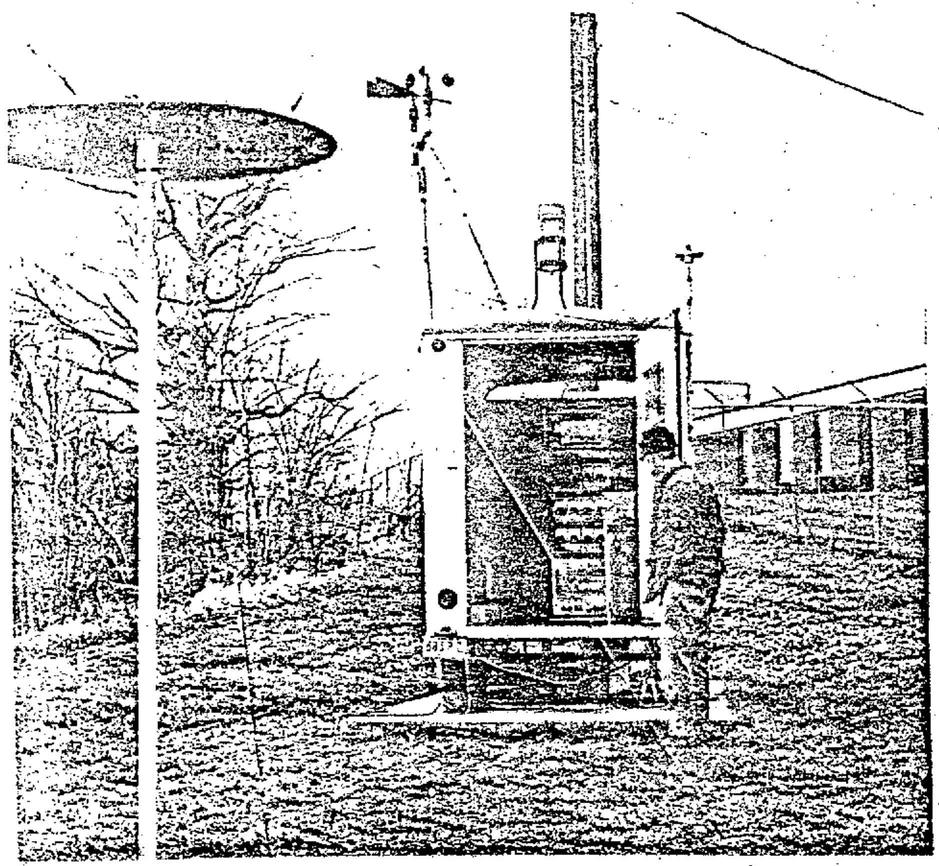

FIGURE 10. VIEW OF DCP ANTENNA INSTALLATION IN RELATION TO WATER QUALITY MONITOR TRAILER

The DCP installation used was comprised basically of a trailer-housed Schneider Instrument Company Model RM25A Robot Monitor (See Figure 11). Although data from all of the sensors could not be transmitted simultaneously, the monitor was instrumented to sense the following seven water quality and five atmospheric parameters:

Water Quality	Atmospheric
Temperature	Air temperature
Conductivity	Wind speed
Dissolved oxygen	Wind direction
Turbidity	Rainfall
pH	Solar radiation
Oxidation-reduction potential	
Dissolved chlorides	

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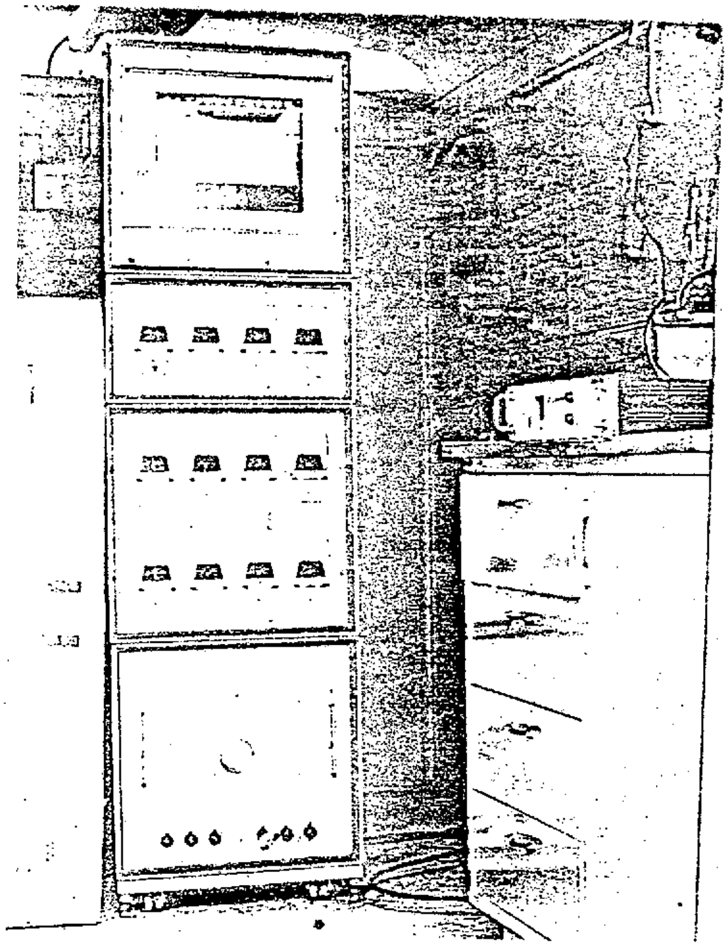

FIGURE 11. TRAILER-HOUSED SCHNEIDER ROBOT MONITOR UNIT CAPABLE OF SENSING SEVEN WATER QUALITY AND FIVE ATMOSPHERIC PARAMETERS

After the DCP was received, the power supply and a set of amplifiers to interface the Schneider equipment with the DCP were fabricated. (See Figure 12 for interface schematic.) The antenna was erected adjacent to the trailer, and the DCP became operational on December 22, 1972. The DCP requires a power source of about 24 volts direct current for operation and is designed so that it can be operated from either available power sources or batteries.

Three major operational functioning problems arose during the DCP experiment: electromagnetic interference, weather related station outages, and sensor deterioration. During the initial installation, the 60-cycle noise at the site was such that the locally-fabricated amplifiers could not be used. The electromagnetic interference problem was later overcome when new amplifiers were fabricated and installed. A severe wind storm tore the antenna cable from the antenna ground plane, thus disabling the platform and causing station outage. Two other similar station outages, probably caused by lighting damage, required the DCP to be shipped to the NASA-Wallops Station for repair. Platform inactivity also caused sensor components to deteriorate from lack of use. Consequently, considerable effort and expense were required to refurbish the sensors so the experiment was terminated on July 23, 1973.

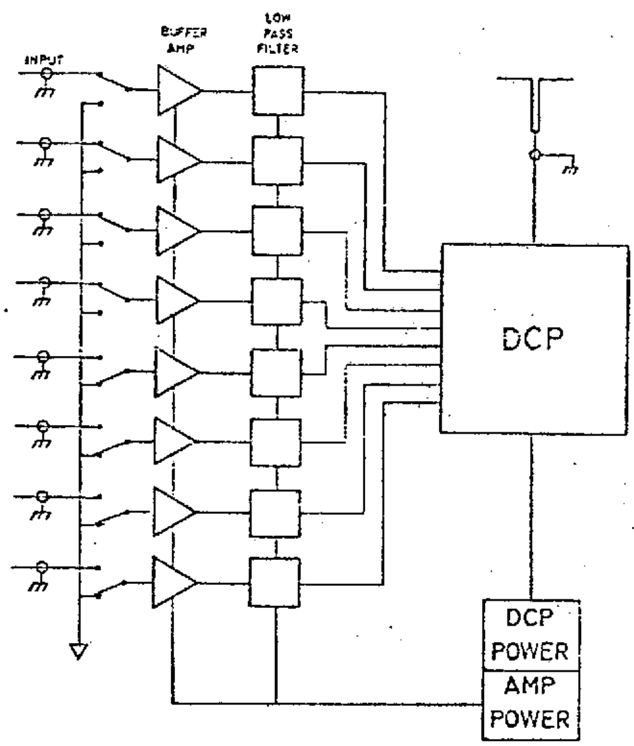

FIGURE 12. SCHEMATIC OF INTERFACE FABRICATED TO LINK WATER QUALITY MONITORING SENSORS WITH DCP.

The DCP functioning problems did not permit an opportunity to interface Battelle air quality monitoring instrumentation with the DCP. Also planned activities to connect the DCP to a completely mobile system to make it as accessible as possible to State activities having an interest in its potentialities were not realized because of the cost and the possibility of vandalism as well as the operational functioning difficulties experienced.

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In essence, experience was gained in the installation and use of the DCP; a prototype interface device suitable for future use was designed, fabricated and utilized; and, several months of data collection and relay were accomplished demonstrating the "traffic handling" capability of the DCS.

3.0 DATA ANALYSIS

Various data analysis activities were undertaken, both in the state agencies' facilities and at the Battelle Columbus Laboratories. In subsequent paragraphs a description of the facilities and equipment utilized, the data analysis plan followed and the specific analytical procedures employed are discussed in detail.

3.1 Facilities and Equipment

During the first phase of the program, a special laboratory was established at Battelle's Columbus Laboratories in direct response to requirements for the effective and timely acquisition and analysis of ERTS and other remotely sensed data. The analysis of ERTS-1 imagery was performed primarily on opto-electro-mechanical equipment located in this laboratory. The facility was designed to provide the most effective in-depth research possible with state-of-the-art equipment while providing visiting user personnel with an opportunity to view the data in enlarged and color enhanced formats and in combination with other remotely sensed correlative data.

The laboratory arrangement permitted ERTS-1, aircraft, and/or ground truth data to be accessed and viewed from centrally located consoles. Hence researchers and photointerpreters could perform analysis tasks with a minimum effort for the retrieval and display of numerical, graphic, and image data. The facility includes a built-in 35 mm and 70 mm rear projection system for comparitive viewing. Cartographic data sketches, photos, etc., were mounted on wall panels and movable easels. A sketch of the laboratory is shown in Figure 13. Adjacent facilities include offices, map files, dark room, computer facilities and other support facilities. The laboratory has undergone almost continuous modification to accommodate a wide range of research tasks and users.

Table 3 provides a list of the major data analysis equipment located at various State agencies and Battelle which were used in the Ohio ERTS-1 program. The light tables, rearview projectors, and the Richards

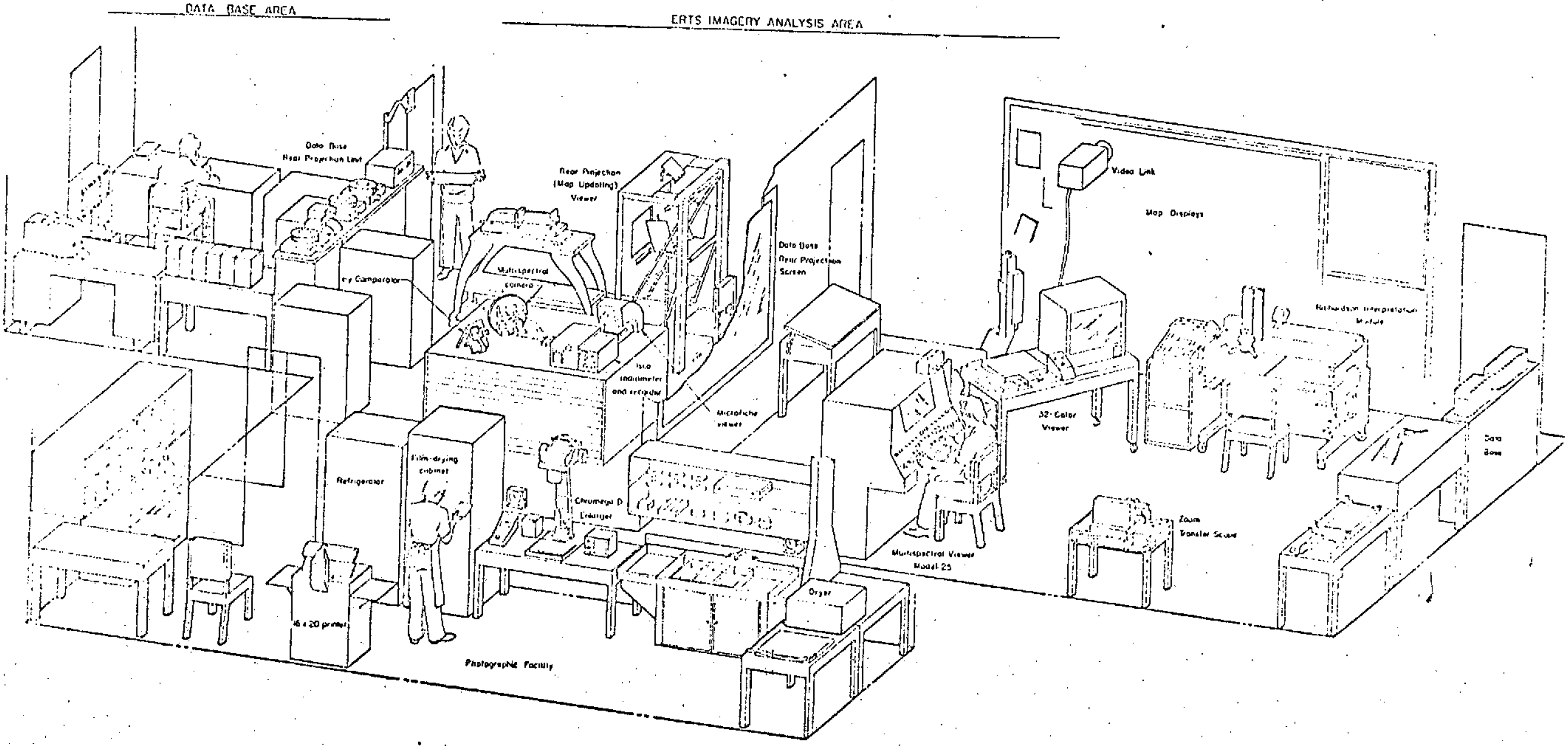

FIGURE 13. BATTELLE'S REMOTE SENSING APPLICATIONS LABORATORY

TABLE 3. DATA ANAYLSIS EQUIPMENT USED DURING THE OHIO ERTS-1 PROGRAM

Type of Equipment	Manufacturer	Purpose for Which Equipment Was Used
	-- OHIO DEPARTMENT OF NATURAL RESOURCES --	
Plotters	Kelsh	Stereoplotting
Zoom Transfer Scope	Bausch & Lomb	Overlaying of map and photographic data
Cordinatorgraph	Dell Foster	Plotting
Digitizers	Dell Foster	Transforming of data from image to digital format
Light Tables	Richards Corp.	Viewing and editing of film
Mirror Stereoscopes	Kail and Skkisha	Stereoviewing and plotting of imagery
Stereometer Parallax Bar	General Electric	Imagery mensuration
	-- OHIO DEPARTMENT OF TRANSPORTATION --	
Analytical Stereoplotter	Nistri-Bendix	Stereoplotting
Computer System	IBM 800	Computer Mapping and Data Storage
Data Grid Digitizers	K & E	Computer mapping
Plotters	Kelsh	Stereoplotting
Photo Printers	Mark-III Log E and CP-18 Log E	Duplicating ERTS and aircraft imagery
Photo Enlarger	Saltzman	Producing photographic materials
Rectifier Printer	Kargl	Producing rectified prints
Copy Camera	Robertson	Copying materials photographically
	-- BATTELLE COLUMBUS LABORATORIES --	
32-Color Viewer	Spatial Data Systems, Inc.	Qualitatively & quantitatively evaluating ERTS imagery by converting densities to desired color
Multispectral Image enhancement Viewer	Spectral Data Corp.	Overlaying up to 4 ERTS images to produce color composites and to enhance specific image features
Multiple Interpretation Module (MIM)	Richards Corp.	Monocular and stereoviewing, comparison, magnification, and mensuration of ERTS and aircraft imagery
Folding Mirror Stereoscope	Wild Heerbrugg	Stereoviewing & plotting of aircraft imagery
Microdensitometer	MACBETH	Evaluating precise density of imagery
35-mm & 70-mm rear projection systems	Kodak and Bromberger	Projecting 35-mm & 70-mm data base for comparison viewing
Light tables	Colight & others	Viewing & editing of film

Multiple Interpretation Module were used for standard data analysis. The Spectral Data Corporation Multispectral Viewer and the Spatial Data Density Slicing Color Viewer were used for color enhancement, magnification and multiband analyses. Details of the analytical procedures are presented in Section 3.3.

3.2 Data Analysis Plan

The data analysis plan formulated and followed during the course of the 18 months of analytical research focused on learning to what extent satellite earth resources survey data can be used in routine functions for managing the State's environment and resources.

A synopsis of the Ohio ERTS-1 data handling, analytical evaluation plan followed is presented in Figure 14. As schematically shown in Figure 14, ERTS-1 imagery was processed and analyzed in the following manner:

(1) Of the three sets of photographic images received by the Ohio DECD, one was given to the Ohio Department of Natural Resources for their evaluation and subsequent loan to the Aerial Engineering Section of the Ohio Department of Transportation for requested reproductions.

(2) The remaining two sets of photographic imagery and the computer compatible tapes were cataloged at Battelle and correlated with earlier ERTS-1, aircraft underflight, and ground-truth imagery as well as radiometric data. The 70-mm and 24 cm x 24 cm transparencies were then viewed on the laboratory equipment in this order:

   (a) Examination through high magnification and stereo-viewing (where possible) to evaluate the quality of the imagery and to determine if areas of highest priority (such as the Ohio ERTS-1 study sites) were successfully recorded.

   (b) Analysis on the multispectral viewer of areas or features of prime interest to determine to what degree these may be enhanced. This mode of viewing was also employed to view the same two bands taken at different dates for purposes of comparison to detect changes over time.

   (c) Analysis on the 32-color viewer to determine the characteristic density range of a feature of interest in all four ERTS bands through magnification and

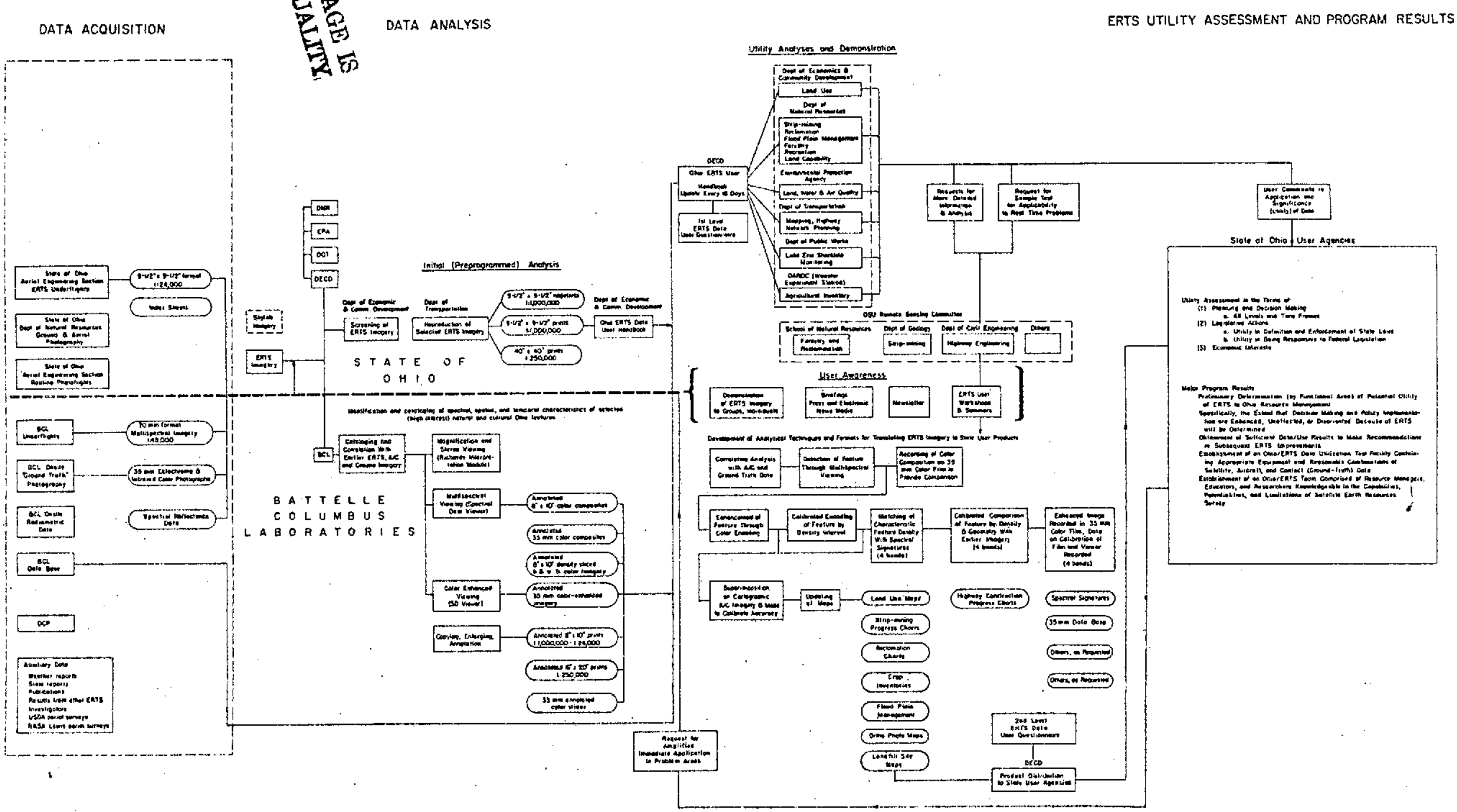

FIGURE 14. OHIO ERTS-1 DATA ACQUISITION, ANALYSIS, AND UTILITY ASSESSMENT PLAN

encoding of the density range into discrete colors. The feature thus enhanced was then recorded by its characteristic density. The characteristic controls on the instrument panels which enhanced the given feature were also recorded.

(d) Areas of interest were then enlarged to scales of 1:250,000, and 1:125,000 and annotated to provide geo-coordinates, scale, and identification of the most important features on the imagery. These demonstration and public information products were subsequently forwarded by DECD to various State user agencies and the press.

(e) Investigators in the various user agencies reported back to the Battelle Remote Sensing Applications Laboratory to further explore their specific areas of interest. A more intensive study was then initiated at the laboratory where user agency and Battelle personnel jointly analyzed the imagery. Usually one or more investigators of a specific user agency became directly involved by providing pertinent background information and working with Battelle personnel to find the solution to a particular problem.

(f) Results were then accurately recorded by density and color instrument control settings. Black and white and/or color prints and transparencies were made from the viewer screens. These products were used to update maps, for feature comparisons, and the fabrication of sketches and map overlays for demonstration purposes.

3.3 Analytical Procedures

Emphasis in the Ohio ERTS-1 program was placed on the analysis of multispectral imagery using opto-electro-mechanical devices. This procedure sacrificed some resolution but permitted very effective initial interaction between potential users and satellite data interpreters. Limited computer analysis conducted focused on producing demonstration products only.

3.3.1 Image Analysis

ERTS-1 imagery was primarily analyzed using a multispectral viewer, a density slicing/color enhancement viewer and a multiple interpretation module.

The Spectral Data Corporation multispectral viewer with 70 mm and 24 cm x 24 cm film drives, shown in Figure 15a, was especially designed and built for the Ohio ERTS program. It provided for the simultaneous analysis of up to four ERTS-1 bands with each channel having three color filters and 20 neutral density filters in steps from 0-100% transmissivity. False color composites to enhance desired features were readily derived from various MSS bands and the film drives facilitated multidate analysis since one set of MSS 70 mm positive transparencies of each ERTS-1 scene was placed on the film drive spools.

The Spatial Data density slicing color viewer, shown in Figure 15b, permitted the discrimination of densities as small as .01 D, and electronic encoding/color enhancement displays in up to 32 colors. A built-in electronic planimeter measured areas of equal densities with 99.5% accuracy and a one-minute dot reference grid facilitated analysis and mapping of the data. The television system was modified to provide for magnification up to 80X with camera settings correlated in steps corresponding to map scales ranging from 1:500,000 to 1:24,000 and larger. A 24 cm x 24 cm XY comparator movement provided for locating points especially at high-image magnifications. A half-silver mirror system and a dual TV monitor setup provided the capability to superimpose cartographic and multidate photographic data at a common scale. A Richards Multiple Interpretation Module, shown in Figure 15c, provided for stereoviewing, mensuration, and magnification of imagery up to 100X. Figures 16 and 17 show other evaluation options and analytical techniques for linking the multispectral and density slicing viewers by using a dual television system with the result that density slicing could be performed on one to four data channels. This camera system provided an inexpensive yet effective method of transferring enlarged, enhanced, filtered, overlayed, color encoded, etc., imagery or portion thereof to a map, overlay, report, or viewgraph. These photographic modifications permitted accurate and rapid overlay of ERTS data onto existing maps and other data sources, readily permitted multidate and multiband analysis, and avoided the requirement for manual time consuming drafting and the corresponding errors associated with such drafting methods. Thirty-five mm, 70 mm, and 10 cm x 12 cm photographs were taken of 80% of the TV

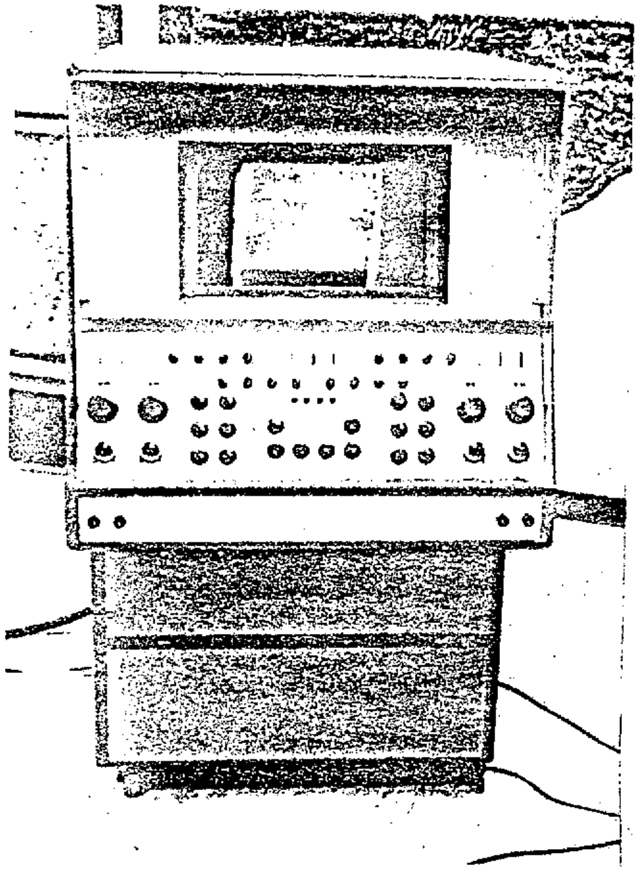

Fig. 15a. Spectral Data Multispectral Viewer For Image Enhancement And Comparison

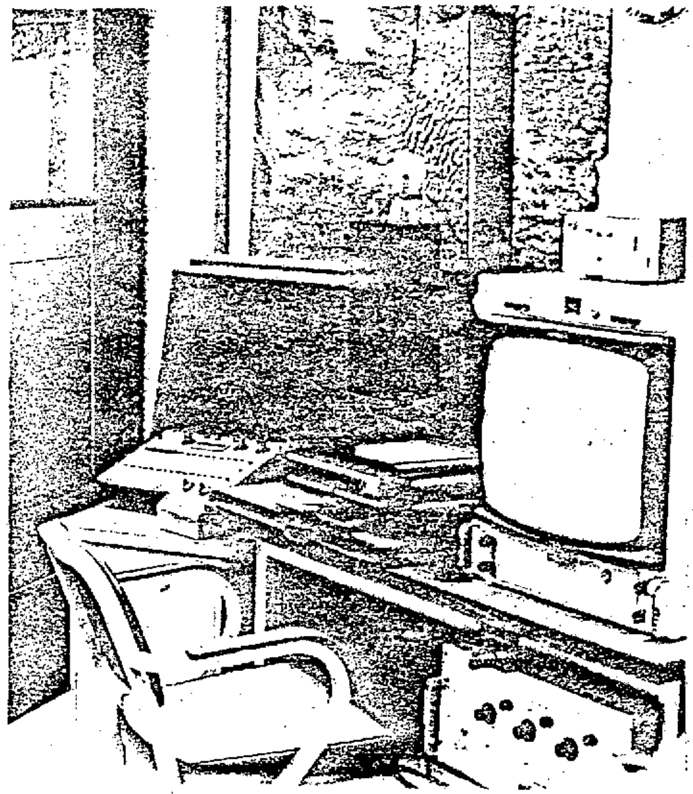

Fig. 15b. Spatial Data Density Slicing 32 Color Viewer

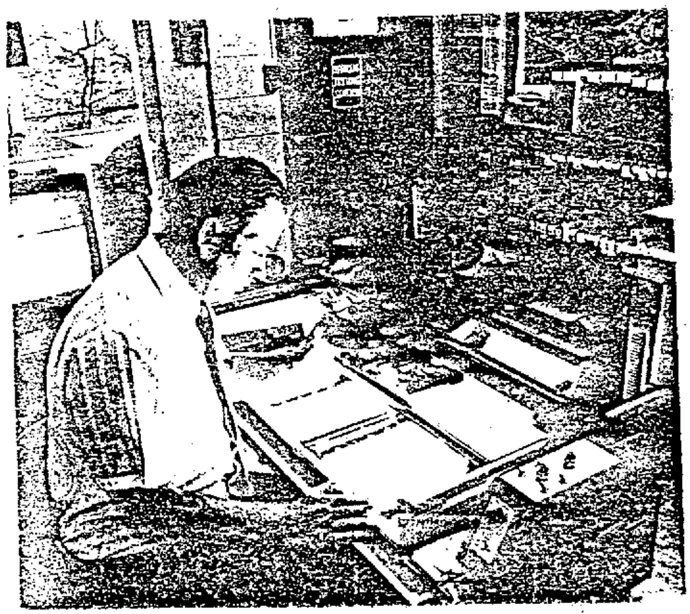

Fig. 15c. Richards Multiple Interpretation Module

FIGURE 15. DATA ANALYSIS EQUIPMENT USED BY STATE AGENCIES AND BATTELLE IN THE OHIO ERTS PROGRAM

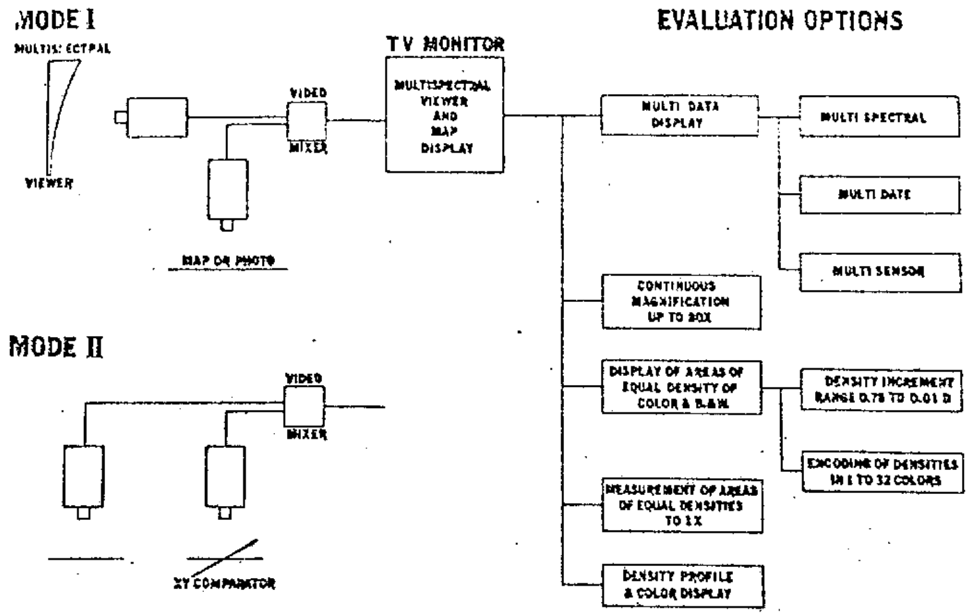

FIGURE 16. ERTS-1 IMAGERY ANALYSIS AND EVALUATION OPTIONS

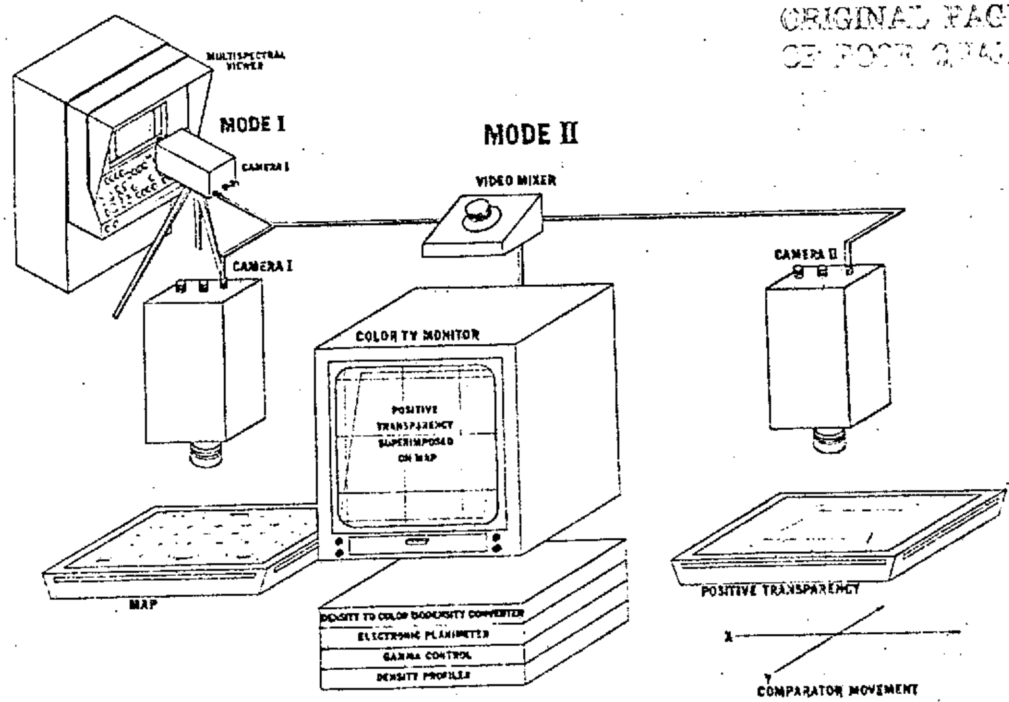

FIGURE 17. ANALYTICAL TECHNIQUE FOR COMBINING MULTISPECTRAL AND DENSITY SLICING VIEWERS

screen of the Spatial Data density slicing viewer. The resulting black and white and color imagery was then used in transparent overlays, viewgraphs, 35 mm and 70 mm transparencies, and paper prints for reports and publications. Annotations were added either on the TV screen, during production, or on the finished product.

3.3.2 Computer Tape Analysis

A Control Data 6400 computer was used for the processing of the digital ERTS-1 tapes. The demonstration products were limited to land use analysis in the Columbus/Franklin County area and included 8 character grey-level printouts, multiband analysis, and feature recognition, identification and mapping. These preliminary computerized demonstration products were used to illustrate how features 0.57 hectares (1.4 acres) in size can be readily distinguished at a scale of 1:30,000.

4.0 DATA APPLICATION ANALYSIS AND RESULTS

The program concentrated on determining, through experimental analyses, the extent that repetitive, small scale satellite imagery could be useful at the state level. Figure 1, in Section 1.0, identified the major application areas studied in the broad discipline categories of environmental quality, land use, and resource management. This section elaborates on the approach taken and the results obtained for each of the application areas analyzed.

4.1 Environmental Quality

The preservation of Ohio's air, water and land quality is the prime responsibility of the Ohio Environmental Protection Agency. However, the Ohio Departments of Natural Resources, Economic and Community Development, and Transportation also have extensive interests and programs which relate to maintaining the state's environmental quality. Of common concern to all interested state agencies is the availability of adequate, economical and timely information required to plan, manage and control activities affecting the environment. Determination of the potential value of ERTS-1 data to such timely topics as surface mining, Lake Erie water quality, and air pollution control practices received the priority efforts in this discipline area. Results of the analysis of ERTS-1 data for these environmental application areas are summarized below.

4.1.1 Surface Mining

Surface mining is the process of removing the so-called "overburden" consisting of vegetation, soil, and rocks from above the underlying mineral resource so that the mineral deposit can be readily extracted. Figure 18 depicts a typical cross section of an area after coal stripping, (a type of surface mining) has occurred. Needless to say, the strip mining process

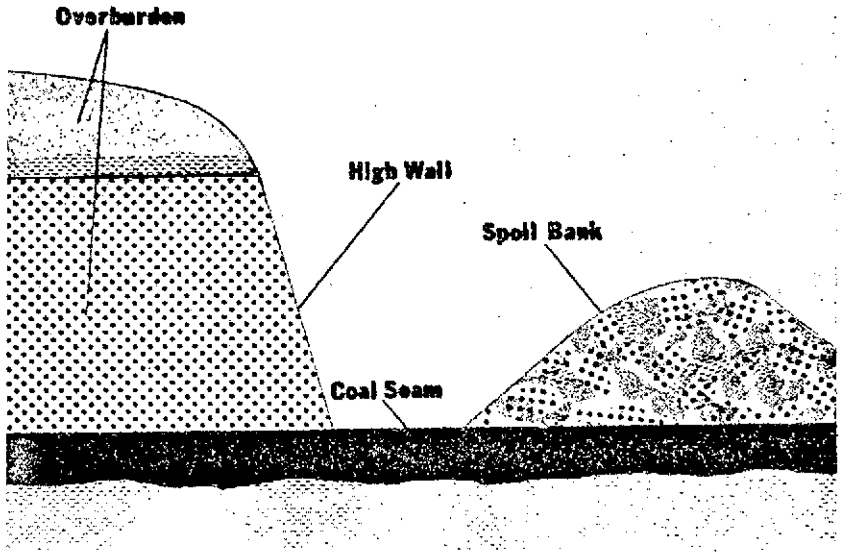

FIGURE 18. TYPICAL OHIO COAL STRIP MINE CROSS SECTION

presents many detrimental environmental consequences including topographic modification, erosion, unfertile lands and extensive scarring of the landscape.

Surface mining is a major industry in Ohio which has become a prime area of citizen and government concern as environmental and energy issues collide. Approximately 114,500 hectares (283,000 acres) of land in 23 eastern Ohio counties have been stripped for the mining of coal alone, according to the Ohio Department of Natural Resources.[12] The U.S. Bureau of Mines reports that in 1972, Ohio surface mined approximately more than 31 million metric tons of coal, placing it in second place in the nation only behind Kentucky. In addition, approximately 42 million metric tons of limestone and more than 38 million metric tons of sand and gravel were also mined in Ohio in 1971 according to the Ohio Division of Mines. In 1971, Ohio ranked fourth in the nation in land utilized for "all minerals" mining according to a recent U. S. Bureau of Mines study.[13]

In April 1972, responding to overwhelming public sentiment, the Ohio legislature passed a bill placing very stringent controls on coal strip mining in the state and in May 1974, the legislature passed an all minerals bill placing similar stringent controls on all surface mining operations in Ohio. These laws place many new reclamation requirements on the operator, require extensive preplanning of surface mining operations and give the state power to deny licenses for surface mining under certain conditions. Reclamation is the process of returning the land to an original or predetermined contour and reestablishing vegetation on the barren land. Of the 114,500 hectares (283,000 acres) that have been strip mined in Ohio, the Ohio Department of Natural Resources reports that only about 77,683 hectares (192,000 acres) have been reclaimed to varying extents.[12]

The implementation of these laws is an enormous task which has not been totally achieved to date. The ability to detect, monitor, inventory, and map surface mining and surface mine reclamation efforts over large areas constitutes an urgent and immediate need in the State of Ohio. Until now such data had to be collected through painstaking ground surveys and/or relatively expensive air surveys such as in a recently completed Ohio Department of Natural Resources survey.[12] Therefore, an assessment of the relevance of repetitive ERTS-1 multiband imagery for the detection, monitoring and inventory of surface mined areas (as well as those areas previously mined and now undergoing reclamation) received the highest priority of program efforts within the Ohio ERTS-1 program.

Questions most frequently asked by Ohio researchers and planners regarding the applicability of ERTS data to surface mining parameters were:

(1) Does ERTS imagery show the presence of strip mines, especially those mined for coal?

(2) What is the smallest area undergoing strip mining that can be detected in ERTS imagery?

(3) How effectively can strip mining activities be monitored?

(4) What is the accuracy of strip mine inventories on a local, county, regional, and statewide basis? Can active strip mined areas be mapped to map scales of 1:100,000 to 1:24,000?

(5) Can strip mined areas undergoing reclamation be identified? How can the reclamation progress be measured and monitored using ERTS imagery?

(6) Can completely reclaimed strip mines be identified?

(7) Can spoil bank materials of varying composition be identified?

(8) Does ERTS provide the means to identify the location of all mineral surface mines, i.e., those where sand, gravel, and limestone are being mined?

State agencies interested in such ERTS-1 data applications include: The Ohio Department of Natural Resources, the Ohio Geological Survey, the Department of Economic and Community Development, the Ohio State University, the Wooster Agricultural Experiment Station and a number of out-of-state researchers from Kentucky, Tennessee, Florida, and Indiana.

The results of imagery analysis efforts to answer these questions are summarized below. Corresponding results of computerized analyses have been reported by Dr. W. Pettyjohn, et al.[14]

4.1.1.1 Analysis of Ohio Surface Mine Features With ERTS-1 Imagery. As soon as usable ERTS-1 imagery of Ohio became available in October, 1972, it became obvious that surface mining areas could readily be detected as can be seen in Figure 19. The area shown here was recorded by the ERTS Multiband Scanner System (MSS) on August 21, 1972, in southeastern Ohio.

On-site radiometric measurements made of strip mining features in southeast Ohio revealed that, in the visible portions of the electromagnetic spectrum (0.4 to 0.7 micrometers), the high wall and spoil bank material are 3 to 4 times more reflective of solar energy than the surrounding original vegetation. In the near infrared band, however, vegetation reflectes sunlight more effectively. The results of this phenomena were observed in enlargements of ERTS-1 imagery such as those in Figures 20a and 20b, which shows a strip mine in southeast Ohio of some 13 km (8 miles) in length and 1.6 km (1 mile) wide. A cursory examination revealed that, in ERTS MSS Band 5 (0.6 to 0.7 micrometers), strip mined areas appear very prominent, whereas in Band 7, (0.8 to 1.1 micrometers), bodies of water appear more prominent (very dark) because infrared radiation is readily absorbed in the first few layers of water. ERTS multiband photography thus provided a means for detection and interpretation of surface mining features not possible through broad band photography.

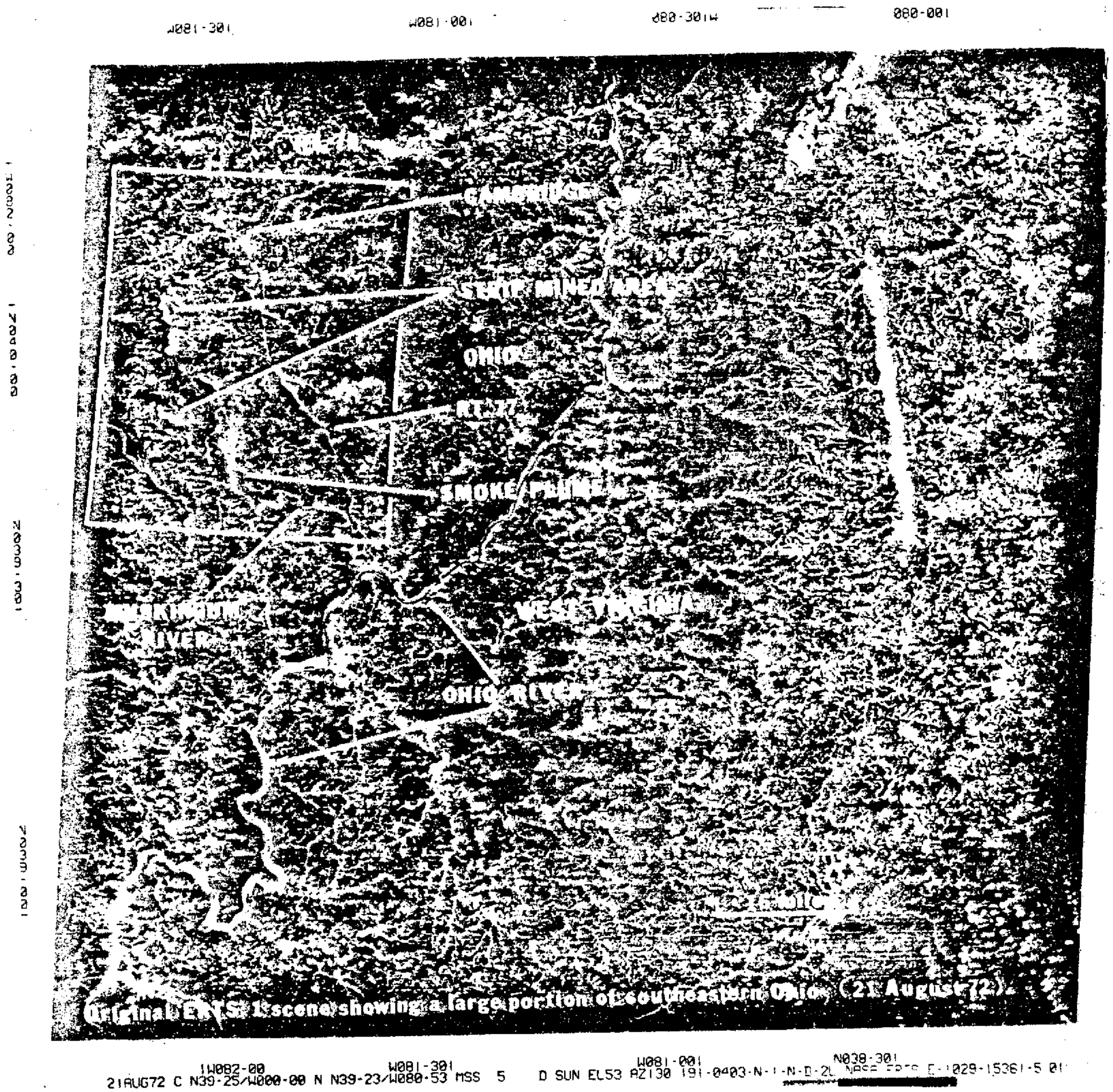

FIGURE 19. ERTS-1 MSS BAND 5 IMAGE SHOWING SURFACE MINING AREAS IN SOUTHEASTERN OHIO. August 21, 1972 Scale 1:1,000,000

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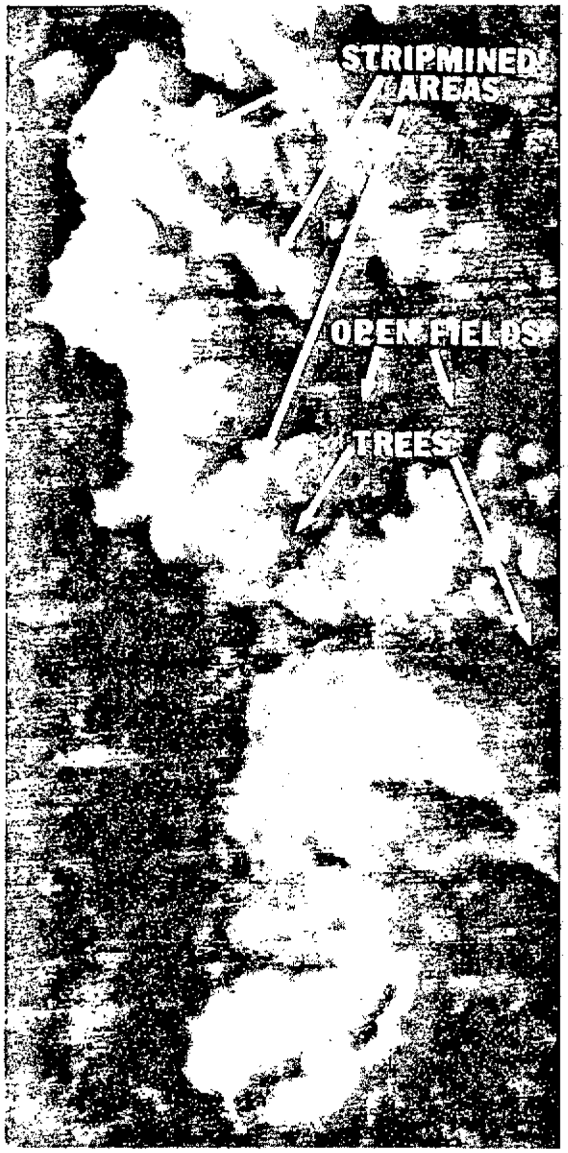

Fig. 20a. ERTS-1 MSS Band 5

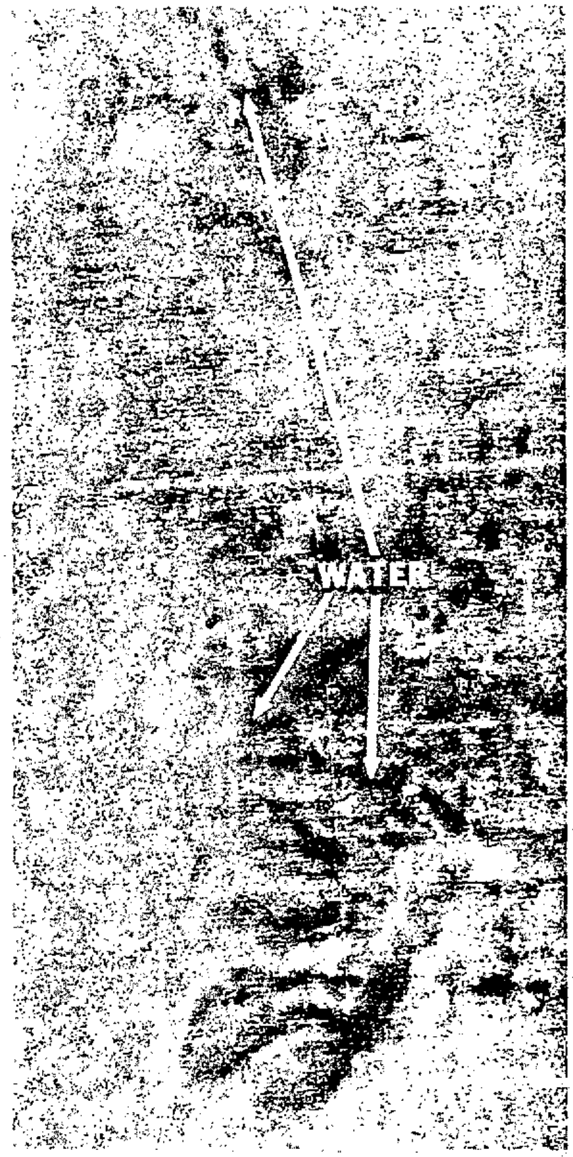

Fig. 20b. ERTS-1 MSS Band 7

FIGURE 20. STRIP MINED AREA IN SOUTHEASTERN OHIO RECORDED BY ERTS-1 MSS BAND 5 (VISIBLE SPECTRUM) AND MSS BAND 7 (NEAR INFRARED SPECTRUM) (AUGUST 21, 1972) Original Scale 1:163,360

Band 5 shows stripped land most vividly, whereas Band 7 is useful for showing standing bodies of water within strip mined areas.

4.1.1.1.1 Identification of Active and Unreclaimed Coal Strip Mines. Extensive examination of active and unreclaimed areas on ERTS imagery revealed that such areas always appeared most prominent in ERTS-1 Band 5 (0.6 to 0.7 micrometers). Areas as small as 0.5 to 1 hectare were discerned on imagery obtained during Ohio's growing season (approximately April 15 through October 15th) during favorable atmospheric conditions.

However, coal strip mine areas of one hectare are not typical in Ohio. In one of the most active strip mine areas in the State (an area of 30 by 50 km) coal surface mines vary in size from 10 hectares to areas covering 35 square kilometers.

A spectral signature unique to surface mining was not found with the techniques used during this study. Areas undergoing development and construction appeared to have very similiar image densities to surface mines. However, the geographic location of construction sites and mining sites seldom made their misidentification probable. Surface mines do not appear in urban centers, and construction sites were, at most, several hectares in size. Also surface mines typically have spatial characteristics which make them readily discernible and identifiable even to a photo-interpreter with little training. Thus, the only features which tended to cause confusion were construction sites or 1 to 10 hectare sized surface mines near small communities. These features were properly identified through observation of multidate ERTS data over a 6 month period. More importantly, because of their relative small size, construction sites resulted in maximum errors of 1-2% in inventorying strip mines in county-sized areas.

To demonstrate the degree of image detail and area fidelity possible with ERTS-1 imagery to Ohio planners (who repeatedly ask: "How good are the satellite data and how accurately can I identify and measure my area of interest?"), a small area of strip mine land such as the one shown in the boxed area of Figure 21 was chosen. The particular area to be analyzed was always required to be of practical interest to the researcher. This particular area covers some 25 km^2 and was located close to the area in which the largest mining shovel in the world, the "Gem of Egypt" was

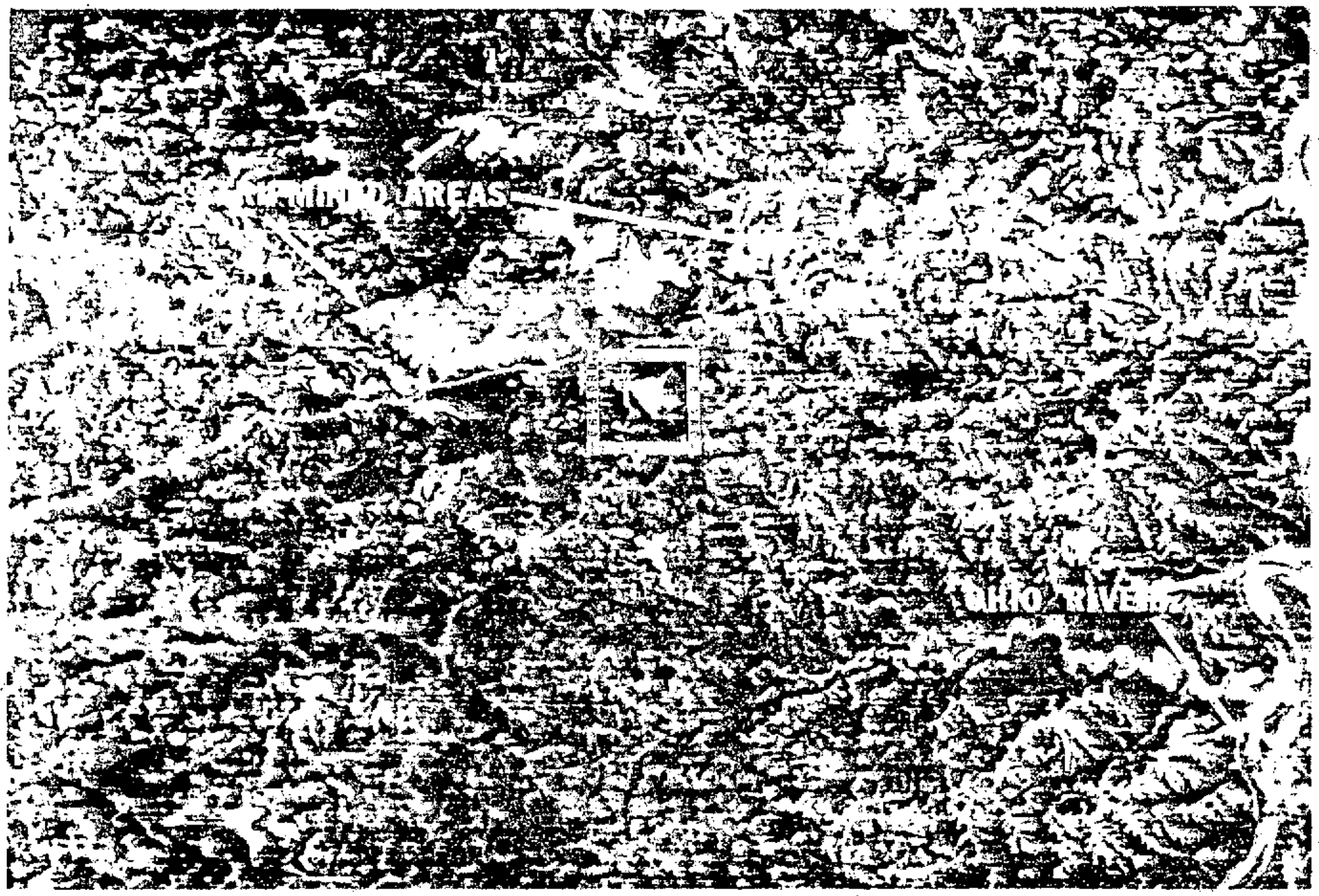

FIGURE 21. HEAVILY STRIP MINED AREA IN EASTERN OHIO, SHOWING PORTIONS OF BELMONT, GUERNSY, AND NOBLE COUNTIES (AUGUST 21, 1972). Original Scale 1:750,000

Boxed Area Represents Coal Strip Mining Study Area.

operating. The imagery was magnified on the Spatial Data Viewer more than 140 times from the original 70 mm negative. The greatly magnified image was then overlain alternately with (1) a standard USGS map sheet to show the scale 'fit' and (2) a 1:24,000 aerial photograph. (See Figure 22). The photograph provided a point by point comparison of areas being mined and the location of strip mine features such as spoil banks and highwalls. Most importantly, it provided the means to determine area accuracies using ERTS data. The map data, except for scaling purposes, was rarely useful because the ERTS data typically contained surface mine features which had not yet been included on the map, and perhaps will not be included for several years.

Fig. 22a.
1:24,000 USGS Topographic Map Sheet (Reduced by 1/2 Original Format).

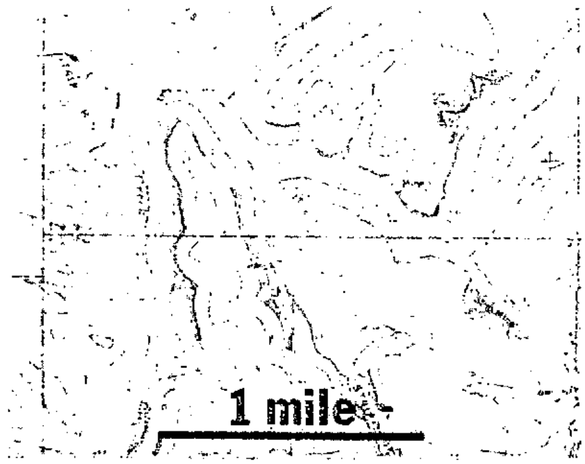

Fig. 22b.
1:24,000 Aircraft Photograph of Strip Mine Area Within the Boxed Area of Figure 21.

Photos such as these are used to show that ERTS imagery has sufficient image quality and area fidelity to perform strip-mine inventories (photo by NASA Lewis Research Center).

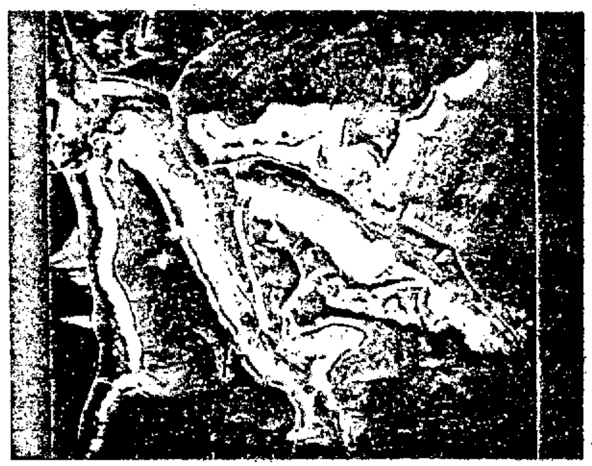

Fig. 22c.
Electronically Enhanced Image Shown in Figure 21. (Note similarity to aircraft photo in 22b).

The density slicing viewer (shown in Figure 16b) was used to distinguish the various gray levels in the photo. This technique was useful for distinguishing the highwall, spoil banks and the original vegetation in strip mine areas.

FIGURE 22. CORRELATIVE DATA FOR TYPICAL OHIO COAL SURFACE MINING ACTIVITIES

Correlation of ERTS-1 imagery and unrectified 1:24,000 aerial photography showed repeatedly that active and unreclaimed areas such as the one shown in Figure 22 could be measured with 95% accuracies using the electronic planimeter of the density slicing viewer and a Keuffel and Esser manual planimeter. The largest area inventoried during the program was an Ohio county of 104,387 hectares (258,000 acres). Results achieved are reported later in this report.

4.1.1.1.2 Monitoring of Strip Mining Progress Using ERTS-1 Temporal Data. Multidate ERTS-1 data of 23 Ohio counties where strip mining of coal was taking place provided a suitable area for monitoring mining progress. To demonstrate the utility of ERTS data, sample sites in areas familiar to Ohio planners were chosen. Using the multispectral viewer which can display and superimpose up to 4 images simultaneously, repetitive ERTS-1 data of MSS Band 5 were matched to scale and geographic position. The imagery was then transferred to the density slicing viewer by way of an auxiliary video camera. The video camera of the viewer was used to monitor an aerial photograph of the same strip mine area or a map of the area. Matching of scale was achieved by adjusting the camera to film plane distance. In this way a view of mining features to scales up to 1:24,000 appeared on the television monitor. Through density slicing techniques and through use of a built in electronic planimeter, (as well as standard planimetric techniques to check accuracy) a quantative evaluation of surface conditions before and after a given time interval was made.

A typical example was the controversial area in which two of Ohio's major mining shovels had moved during January 1973. A comparison was made of the boxed areas of Figures 23a and 23b of some 20 km^2 as recorded by ERTS-1 on August 21, 1972 and September 3, 1973. Primary analysis was performed on MSS Band 5 imagery. During the one-year period in this relatively small area alone, 400 hectares of new land had been stripped (See Figures 23 and 24).

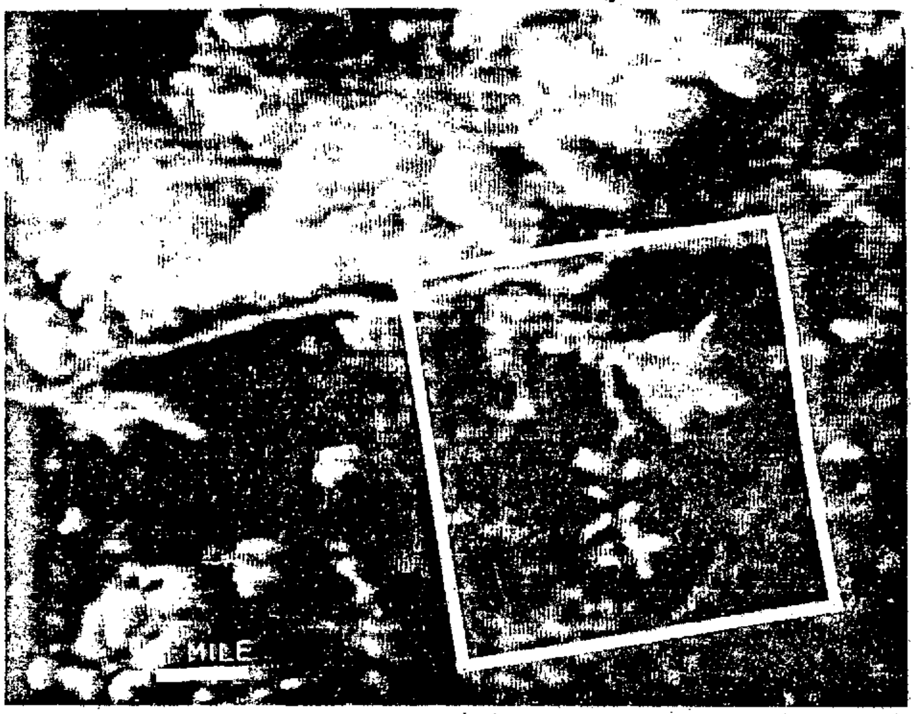

Fig. 23a. August 21, 1972, ERTS-1 MSS Band 5 Image

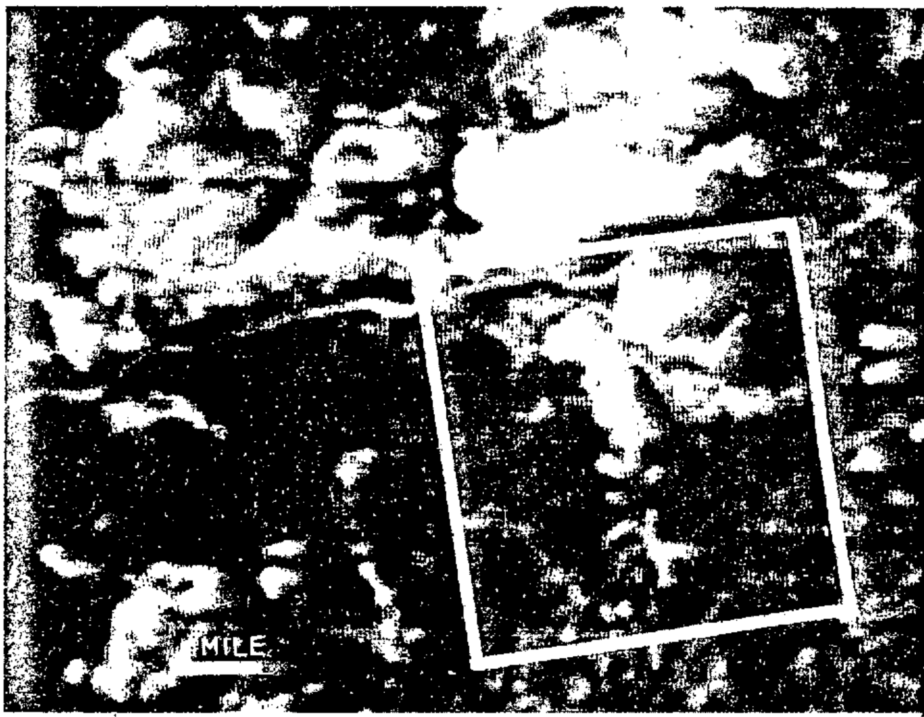

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Fig. 23b. September 3, 1973, ERTS-1 MSS Band 5 Image

FIGURE 23. EXTENT OF STRIP MINING OCCURRING DURING A ONE-YEAR PERIOD IN A HEAVILY STRIP MINED AREA OF EASTERN OHIO AS REVEALED BY ERTS-1

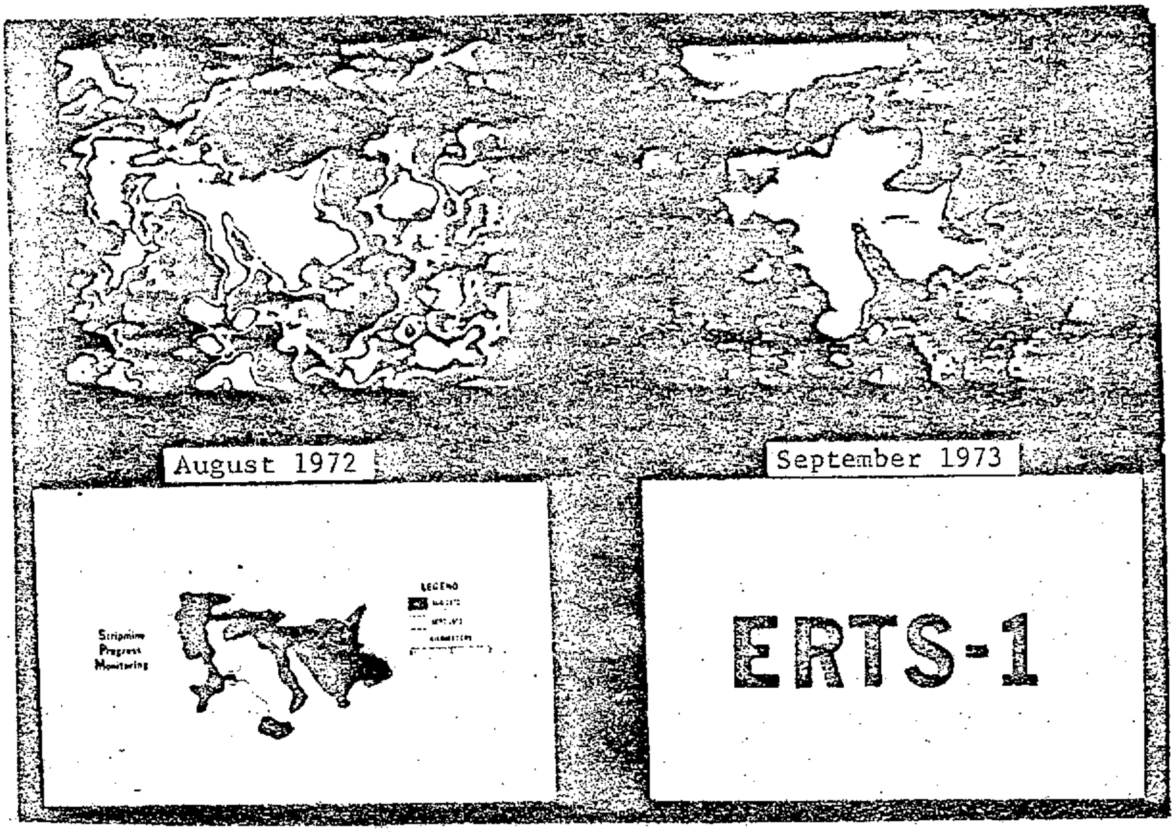

FIGURE 24. ELECTRONIC ENHANCEMENTS OF THE BOXED AREAS OF FIGURES 23a AND 23b, AND THE RESULTING STRIP MINING PROGRESS CHART.

This figure illustrates the use of multidate ERTS-1 data to monitor Ohio strip mining activities.

4.1.1.1.3 Inventorying of Strip Mines. With the ability to identify surface mine features with ERTS-1 imagery well established, Ohio ERTS-1 program efforts were then undertaken to show that the satellite data could be utilized to provide inventories of entire counties. Harrison County in eastern Ohio, which covers some 104,450 hectares (258,000 acres) was chosen as a study area. According to 1972 data from the Ohio Department of Natural Resources, approximately 7,130 hectares (17,600 acres) of strip mine land remained unreclaimed in Harrison County.

With the aid of the image enhancement viewer with a built-in planimeter, an effort was undertaken to demonstrate that (1) the unreclaimed surface mine areas could be enhanced to the exclusion of any other terrain feature using ERTS imagery, and (2) that an accurate area calculation was possible in a relatively short period of time. An August 21, 1972 ERTS-1 MSS Band 5 image was used for the study.

Figure 25 shows a topographic map of Harrison County; Figure 26 shows the total strip mined areas and Figure 27 shows an electronically enhanced image of those areas requiring reclamation. Table 4 lists the corresponding averages which compare quite favorably to Department of Natural Resources (DNR) data. The results showed agreement within 3 percent between data derived from ERTS-1 imagery and state figures in a county of 104,450 hectares (258,000 acres). ERTS-1 data showed a total stripped acreage of 18.4 percent (or 19,219 hectares/47,472 acres) as compared to the DNR value of 19.01 percent (or 19,864 hectares/49,064 acres). For unreclaimed areas the figures were 6.2 percent for ERTS-1 and 6.8 percent for DNR. Comparison with aircraft data and on-site inspections further substantiated the accuracy of this inventory. Actually, the lower figures derived from ERTS-1 data in this evaluation are partially due to the fact that some of the same areas of Harrison County have been mined more than once. In essence, more accurate acreage inventories than heretofore possible through more conventional means were obtained.

4.1.1.1.4 Identification of Old Reclaimed Surface Mined Areas. The most useful ERTS information for the detection and monitoring of strip mine areas which are undergoing reclamation was contained on MSS Band 7 imagery. Ohio researchers were interested in locating both areas which already had been reclaimed over a period of 30 to 45 years and areas which were undergoing reclamation. The capability of ERTS to detect areas mined many years ago was useful to the Ohio Geological Survey for estimating reserves of remaining unmined coal seams. In this research project, ERTS-1 imagery was used to determine if certain suspected areas had been strip mined many years ago, rather than conducting a time-consuming search of old permit records. Initial attempts to use the visible MSS Bands to locate reclaimed surface mine areas were unsuccessful because vegetation cover in these areas was indistinguishable from established vegetation communities in the areas surrounding old strip mine areas. However, the numerous small ponds closely grouped together, which remained in old strip mine areas even after a new vegetational community had established itself, made identification of reclaimed areas readily possible. These were vividly displayed in the

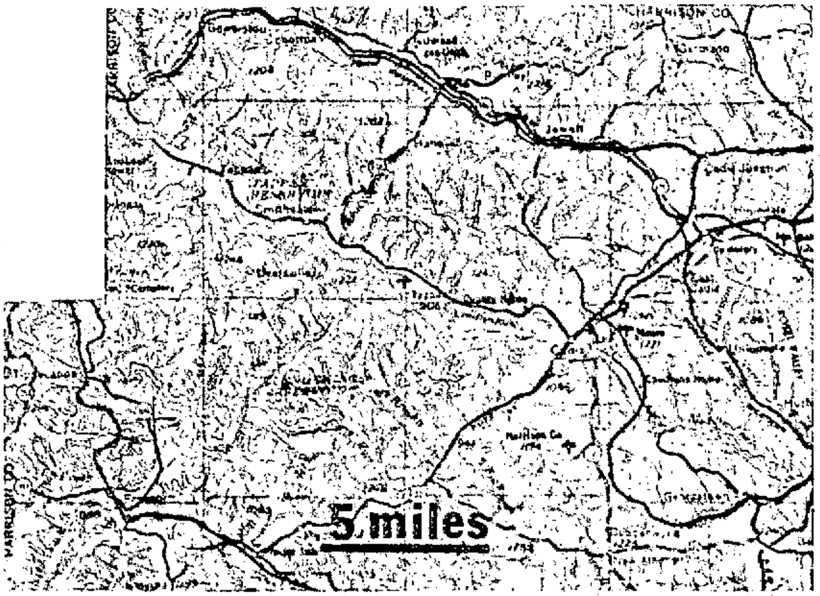

FIGURE 25. TOPOGRAPHIC MAP SHOWING HARRISON COUNTY, OHIO
Reduced From A 1:250,000 USGS Topographic Map

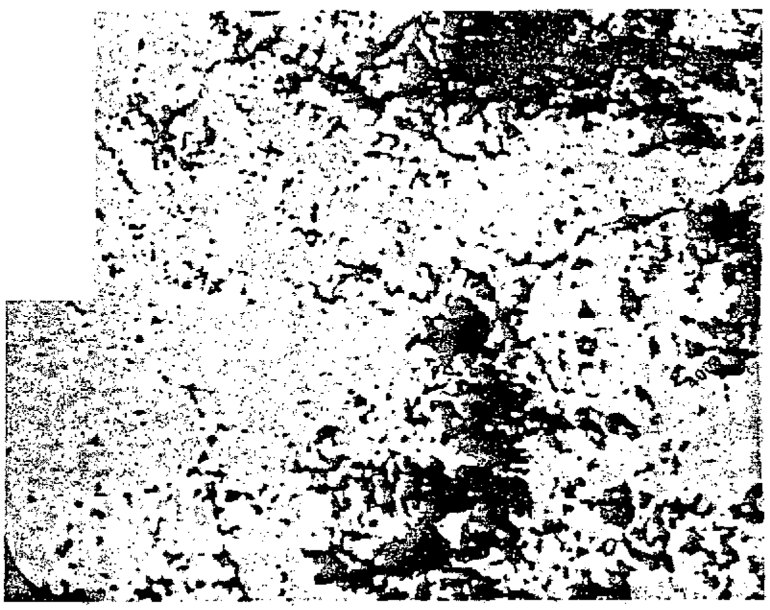

FIGURE 26. ENHANCED ERTS-1 MSS BAND 5 IMAGE OF AUGUST 21, 1972 SHOWING THE TOTAL STRIP MINED AREAS OF HARRISON COUNTY, OHIO.

Black Areas Represent the Total Strip Mined Areas as Displayed on the Spatial Data Density Slicing 32 Color Viewer

FIGURE 27. ENHANCED ERTS-1 MSS BAND 5 IMAGE OF AUGUST 21, 1972 SHOWING THE UNRECLAIMED STRIP MINE AREAS OF HARRISON COUNTY, OHIO

Unreclaimed Strip Mined Areas Are Shown in Black.

COMPARISON OF STRIP MINE AREA ESTIMATES FOR HARRISON COUNTY, OHIO		
Total Land Area -- 104,450 Hectares (258,000 Acres)		
	ODNR	ERTS-1
% of strip mined land	19.01	18.4
Area affected	19,864 hectares (49,064 acres)	19,219 hectares (47,472 acres)
% of unreclaimed strip mined land	6.8	6.2
Area unreclaimed	7,130 hectares (17,600 acres)	6,476 hectares (15,996 acres)

TABLE 4. COMPARISON OF ERTS-1 AND OHIO DEPARTMENT OF NATURAL RESOURCES DATA OF STRIP MINED LAND IN HARRISON COUNTY, OHIO.

MSS Band 7 imagery as dense black features surrounded by very bright areas indicative of the presence of live, healthy vegetation. Ponds as small as one hectare could be discerned in the imagery.

4.1.1.1.5 Identification of Strip Mines Undergoing Reclamation. Ohio planners expressed a need to have accurate data about strip mined areas being reclaimed. Primarily, the success of short- and long-term reclamation efforts is required by provisions of Ohio's surface mining laws. By Ohio law, surface mine operators are required to commence backfilling, grading and resoiling within three months after removal of the overburden. Planting of vegetation must take place no later than the next growing season. The seriousness of the reclamation problem has recently been quantified in a state study which found over 150,000 hectares (370,000 acres) of strip mined lands in Ohio requiring some form of reclamation at an estimated cost of \$290 million.[12] Figure 28 shows a typical example of a small strip mine area near Zaleski, Ohio which appears in the very initial stages of reclamation. Since a strip mined area is very prominent because of the removal of the so-called overburden or original vegetation, the restoration of such an area could be monitored by the increased vegetation recovering such bare areas.

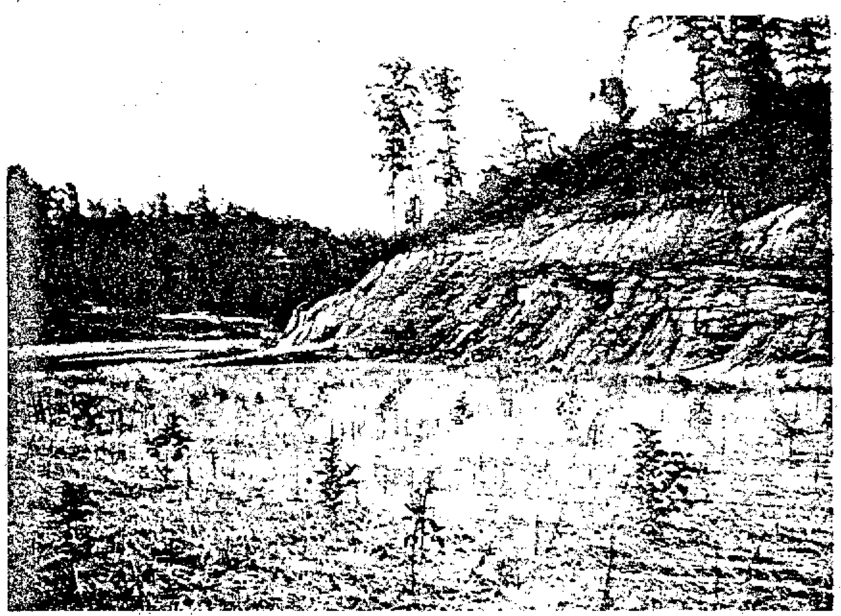

FIGURE 28. STRIP MINE AREA IN OHIO ZALESKI STATE FOREST, SHOWING RECENT RECLAMATION EFFORTS

Strip mine reclamation progress was evaluated by the restoration of a vegetation cover when analyzing MSS Bands 5 and 7. A comparison of the film density in the strip mine feature and the surrounding established vegetation served as a measure of reclamation. Areas were estimated to be reclaimed in four categories — 0-25 percent, 25-50 percent, 50-75 percent and 75-100 percent. An area was evaluated as being completely reclaimed if the vegetation density in the strip mine area matched that of the original surrounding vegetation. This method of evaluation was thought to be an acceptable way of measuring strip mine reclamation, even though it did not address itself to problems such as the ability to detect or measure grading and regrading in a strip mine area. If strip mine operators revegetate strip mined areas, the revegetation effort may be monitored successfully and repeatedly over hundreds of square kilometers within hours. However, ERTS data did not reveal if grading was performed prior to such planting and evaluation of reclamation efforts could only be made effectively with ERTS data acquired during the growing season.

4.1.1.1.6 Monitoring Strip Mine Reclamation Progress Using Temporal Data. The utility of ERTS-1 data to measure areas under reclamation in large areas has already been discussed. Another important use of ERTS data is the monitoring of reclamation progress achieved in a given area and the quality of success achieved within a given timeframe. This was successfully achieved through analysis of repetitive ERTS-1 MSS Band 5 imagery. Multidate comparison of areas of a surface mine under reclamation in the Zaleski study site showed little, if any, evidence of revegetation which was confirmed by on-the-ground observations over a period of 12 months (see Figure 29). In another area of Belmont County, which was observed during a 12-month time period, analysis of ERTS-1 imagery showed the apparently successful cultivation of a new grassy vegetation cover. Figure 30 shows the advances of reclamation efforts achieved by September 1973.

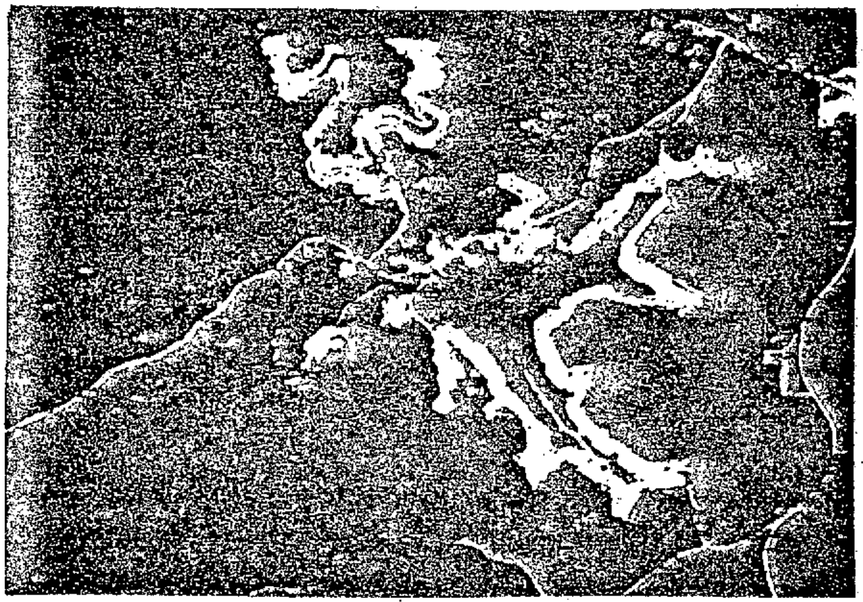

Fig. 29a. Aircraft Photograph

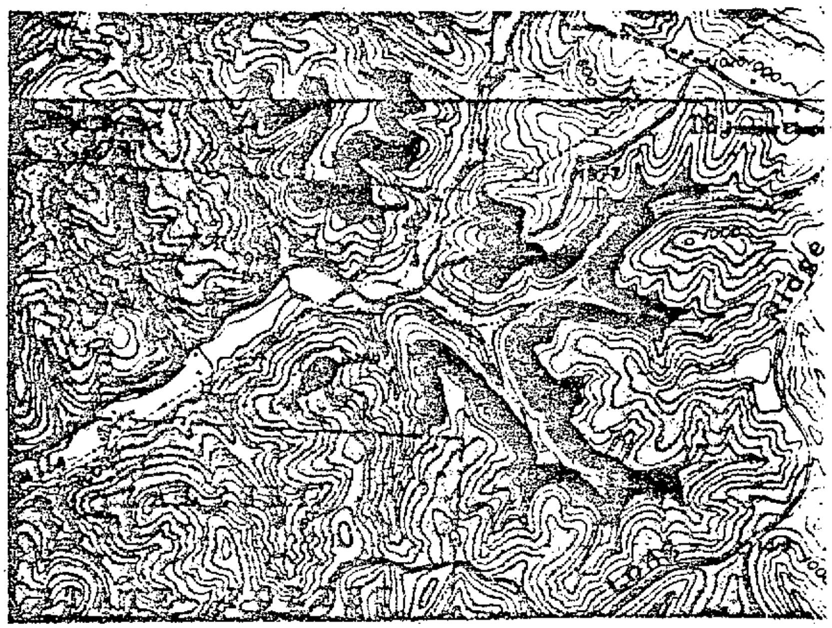

Fig. 29b. USGS 1:24,000 Topographic Map

FIGURE 29. AIRCRAFT PHOTOGRAPH AND USGS TOPOGRAPHIC MAP SHOWING A STRIP MINED AREA NEAR ZALESKI, OHIO

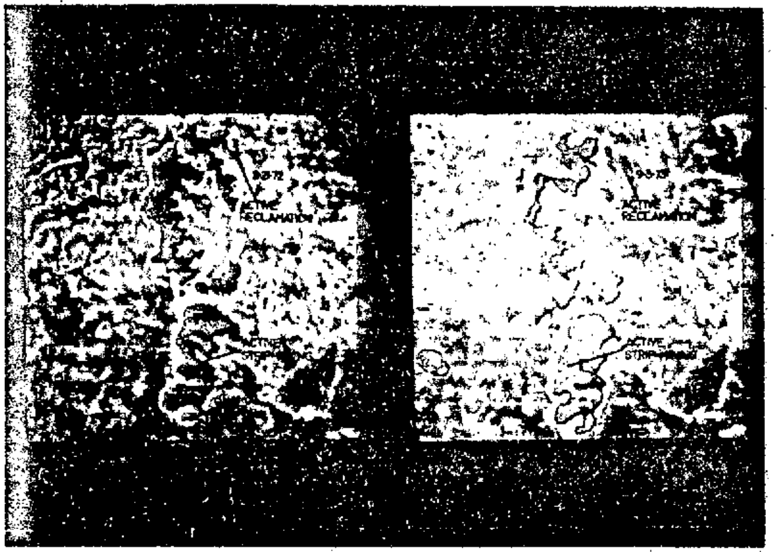

FIGURE 30. COMPARISON OF MULTIDATE ERTS-1 IMAGERY FOR DETECTING STRIP MINING PROGRESS AND RECLAMATION CHANGES.

4.1.1.1.7 Inventorying Reclaimed Strip Mines and Mines Undergoing Reclamation. An important question asked by Ohio researchers not only focused on the ability to monitor the success of reclamation of a strip mined area, but also how much area had been reclaimed. The survey of Harrison County showed that this could be done with acceptable accuracies. However, reclamation is a process which must be assessed by Ohio's planners to determine how much it will cost to fully restore the land. The importance of this knowledge is pointed out by the fact that Ohio recently supported an aircraft survey of all mined areas in Ohio and to determine the conditions of various surface mined areas and to estimate restoration cost.[12]

This experimentation showed that current ERTS-1 data were too general to monitor the quality of restoration. ERTS resolution did not suffice to distinguish subtle changes in strip mines such as occur in the quality of soil, water, and vegetation and topography.

4.1.1.1.8 Identification of "All Minerals" Surface Mines. As already indicated, the mining of gravel, sand and limestone exceeds that of coal in the State of Ohio. Although the size of the area affected by the quarrying of these minerals is not nearly as large as that of strip mining coal, pits formed by the extraction of these minerals have been readily detected as illustrated in Figure 31. Radiometric ground truth collected in limestone quarries, coal strip mines and gravel pits showed that the relative solar reflectance in these surface mines differs sufficiently to allow identification of the type of minerals mined (See Figure 32).

4.1.1.1.9 Conclusions. Surface mining was the most extensively researched application area in the Ohio ERTS-1 program. The program successfully demonstrated how ERTS data can be operationally useful for current Ohio monitoring and inventory needs. Specifically, it was found that:

1. ERTS-1 MSS Bands 5 and 7 provided the most useful data. ERTS Bands 4 and 6 were of very little value, and added only marginally useful data.

2. Only ERTS data collected during Ohio's growing season were useful. When the vegetation appeared dormant or dead or was snow covered in the imagery, strip mine features virtually blended with the background. The only exception was bodies of standing water in active mines or mines undergoing reclamation.

3. ERTS-1 data can be matched to map scales of 1;24,000 for the updating of strip mined features in a given locale. If Class A or B topographic mapping accuracies are not required then entire quadrangle maps may be updated. However, if map updating is required to accepted national map data, then bulk imagery should only be used to update limited areas of no more than 10 square km. This estimate is based on repeated experimentation when researchers wanted to have demonstrated strip mine feature changes on outdated 1:24,000 maps. ERTS data can be readily matched to map scales of 1:250,000 and smaller for areas covering several counties.

(These observations are based on the techniques associated with photo-opto-electronic techniques which lended themselves primarily to demonstrating feasibility, and were not designed for thematic and cartographic map production. It is expected that appropriate refined photogrammetric techniques will make possible the mapping of surface mine features of the entire state, at least to a map scale of 1:250,000.)

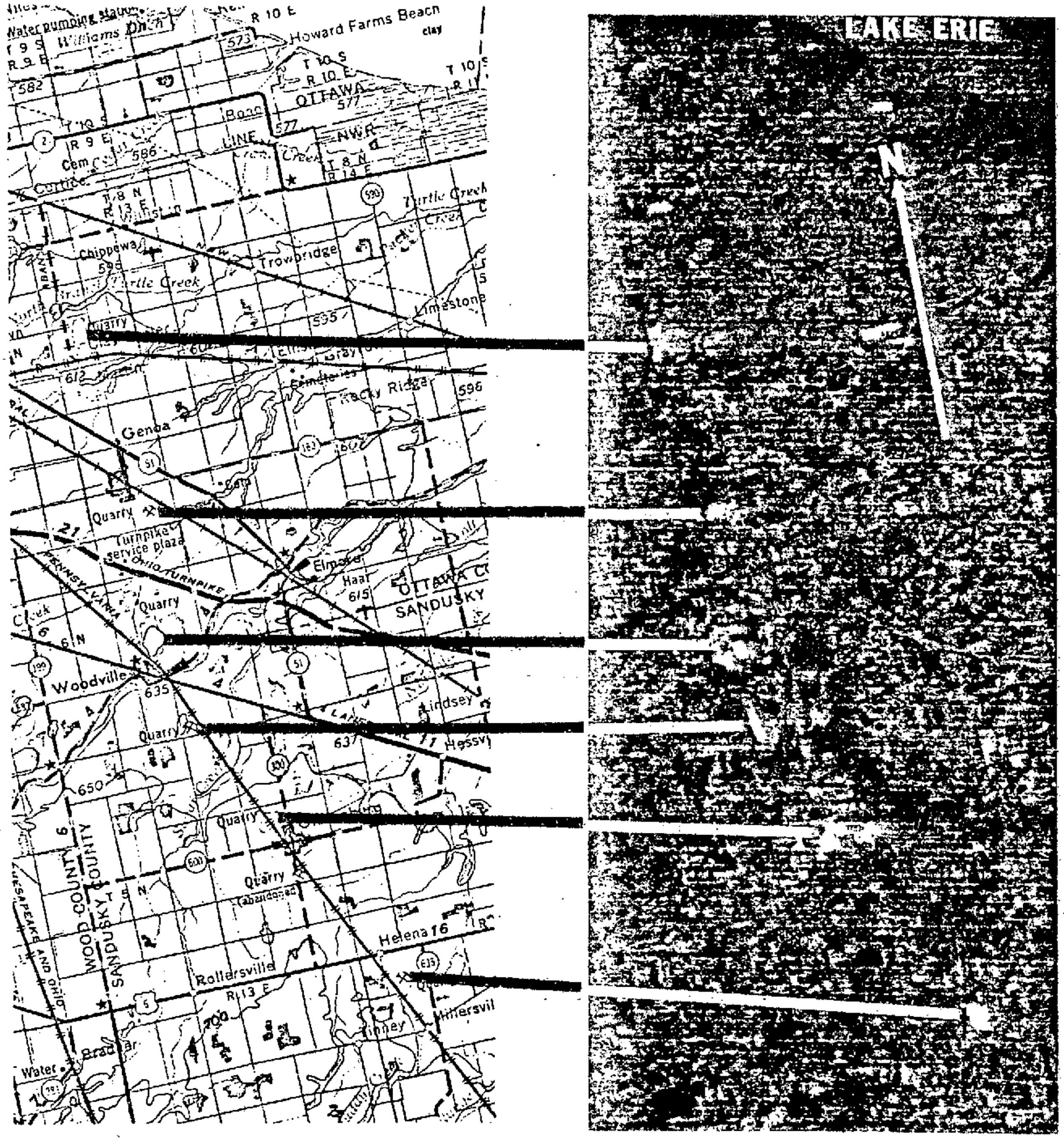

FIGURE 31. TOPOGRAPHIC MAP SHEET AND ENLARGED ERTS-1 MSS BAND 5 IMAGE OF MARCH 27, 1973, SHOWING LOCATION OF OHIO SURFACE MINES. (SCALE, 1:250,000)

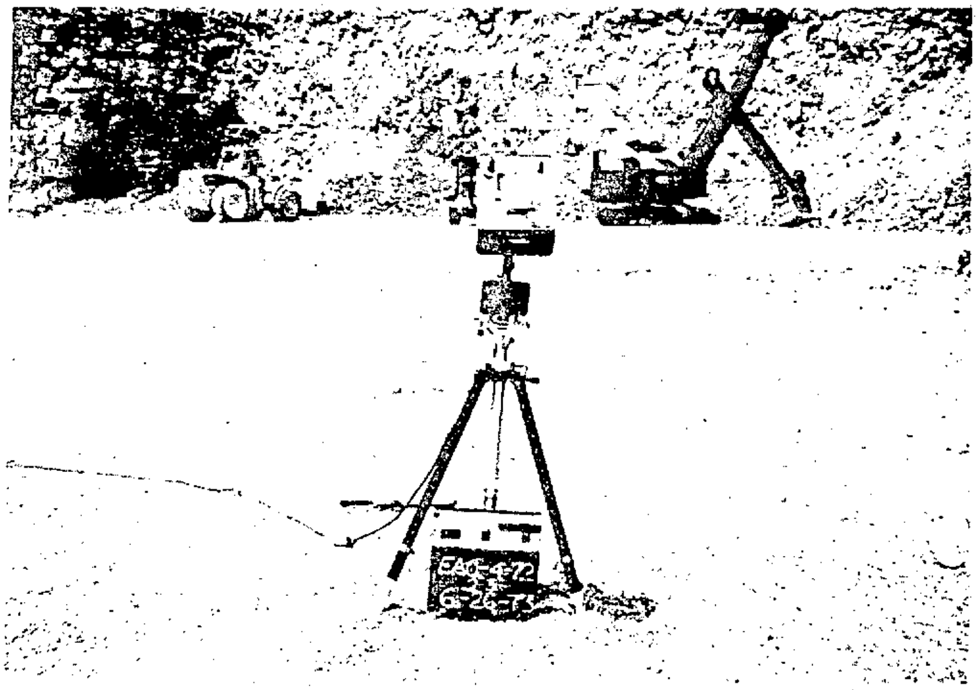

Fig. 32a. Radiometric Survey Being Conducted in a Limestone Quarry Within the East Liberty Study Site

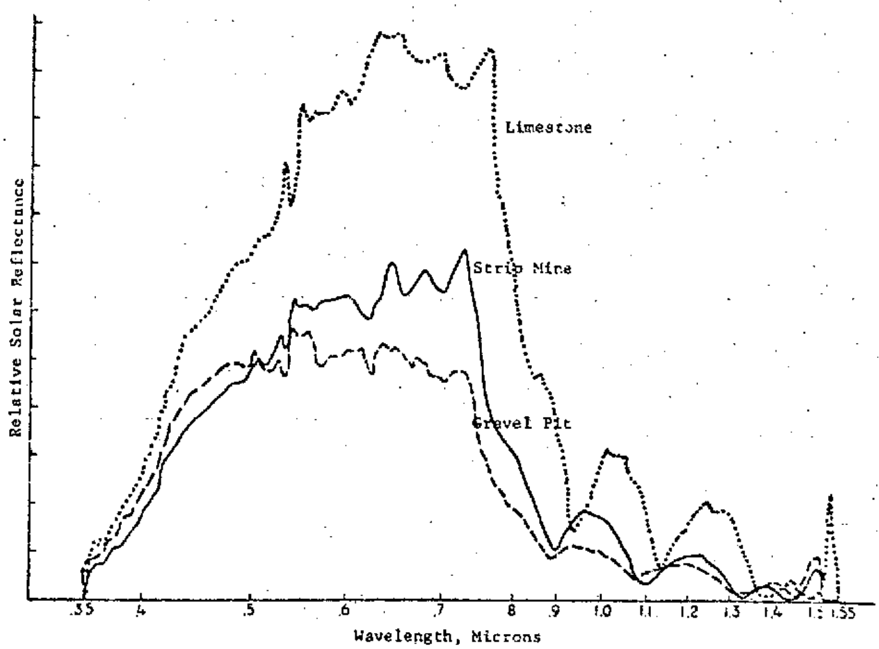

Fig. 32b. Comparison of Relative Reflectance Curves Of A Limestone Quarry, Gravel Pit, and Strip Mined Area

FIGURE 32. RADIOMETRIC DATA OF OHIO SURFACE MINES.

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4. Active unreclaimed strip mines are 98 percent identifiable. A 1 or 2 percent error can be caused by large construction sites which may be confused as small surface mines. Areas as small as 0.5-1.0 hectare can be identified.

5. Surface mine progress may be monitored by using multidate MSS Band 5 data. Only data recorded between April to November are usable.

6. Active unreclaimed strip mines may be inventoried in county sized areas with a 95 percent accuracy. This figure is based on comparison made with DNR data of 23 counties currently being mined.

7. Old reclaimed areas are most readily identifiable in ERTS-1 MSS Band 7 imagery.

8. Reclamation can be monitored during Ohio's growing season by determining the type and percent of density of vegetation cover as measured in MSS Band 5 and 7 imagery. Vegetation types such as grass, small tree stands and mature tree stands can be identified. Tree and grass species cannot be separated.

9. Impounded water bodies in old and new strip mines as small as one hectare can be identified.

10. The frequency of data collection is sufficient. However, some of the most active strip mined areas in Ohio were only recorded twice with sufficient image quality to provide a temporal comparison. Too many images contained haze or clouds. Thus, more frequent collection during May to November, and little, if any, during the remaining months would result in far better useful coverages in Ohio for surface mining studies.

11. For state monitoring and enforcement functions, improvement is resolution to 10-30 meters is required to determine certain strip mine features such as exposed coal seams, graded areas, and types of spoil banks.

4.1.2 Water Quality

The following paragraphs describe analytical findings relative to suspended sediments, currents, flooding and algae conditions in Lake Erie, reservoirs, and other large inland water bodies.

4.1.2.1 Lake Erie. Ohio EPA and the Ohio State University Center for Lake Erie Research personnel are enthusiastic about the potential use of satellite photography for Lake Erie water quality management practices. From a preliminary analysis of repetitive ERTS-1 scenes, OEPA personnel are optimistic that ERTS data can lead to a better understanding of the complex and dynamic characteristics of Lake Erie and thus make more accurate modeling possible. In addition to a more precise definition of nearshore and offshore developments, OEPA personnel are interested in evaluating such specific correlations as: littoral drift/lake dispersions, algae masses, temperature phenomena, water level and wave refraction.

ERTS-1 has provided an overview of Lake Erie sedimentation patterns heretofore unavailable. As can be observed in Figure 33, suspended sediments entering into the western basin of Lake Erie from many sources are readily noticeable. Examination of such a synoptic overview provided by ERTS-1 imagery quickly established that such problems of Lake Erie are truly multistate and multination in origin. Although detectable during the entire year, these suspended sediments were most readily noticeable on April and March imagery since this is the time of year that maximum water runoff from the land occurs. Runoff from recently plowed agricultural lands are especially a major source of sediment loads of the rivers and tributaries that enter Lake Erie. By utilizing changing suspended sediment patterns on repetitive ERTS-1 imagery, Ohio ERTS-1 program researchers were able to verify the existance of currents within Lake Erie in general.

The sediment patterns as observed in the Western basin of Lake Erie and along the entire southern shore of Lake Erie were discriminated into as many as 16-32 different density levels using ERTS-1 MSS Band 5 imagery. Future research may determine if the high number of density levels can be

Fig. 33a. ERTS-1 MSS Band 5 Image of March 27, 1973
Note that the Sandusky Bay land areas appear partially inundated (see Fig. 33b below for comparison)

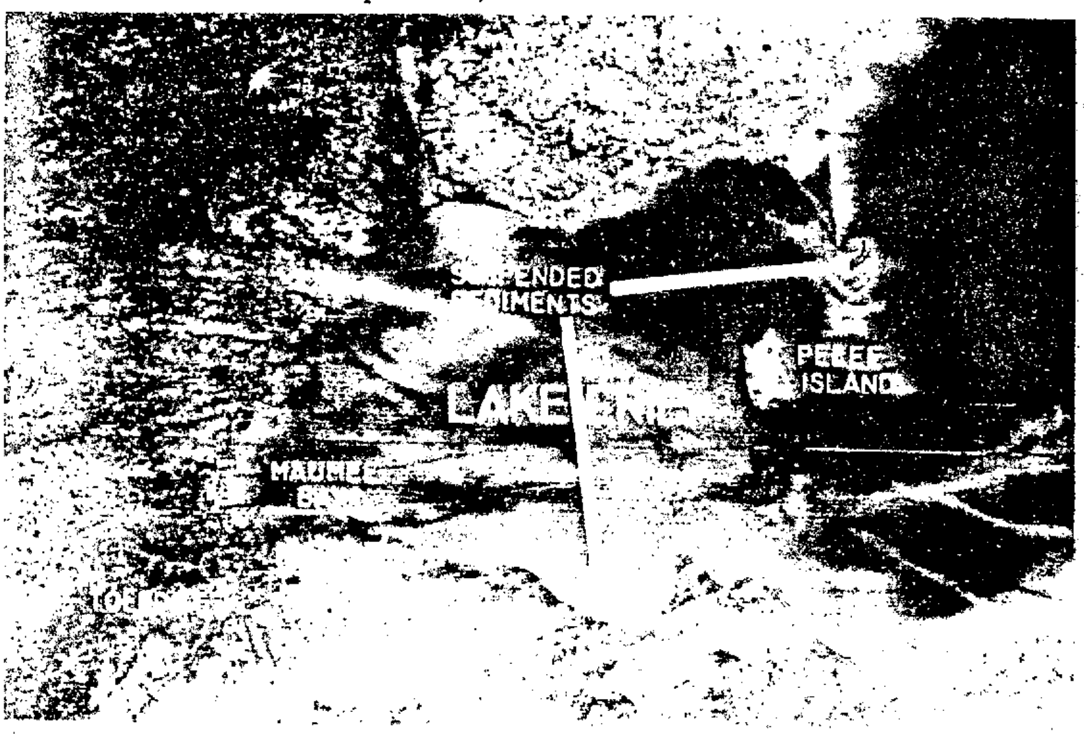


Fig. 33b. ERTS-1 MSS Band 5 Image of April 14, 1973

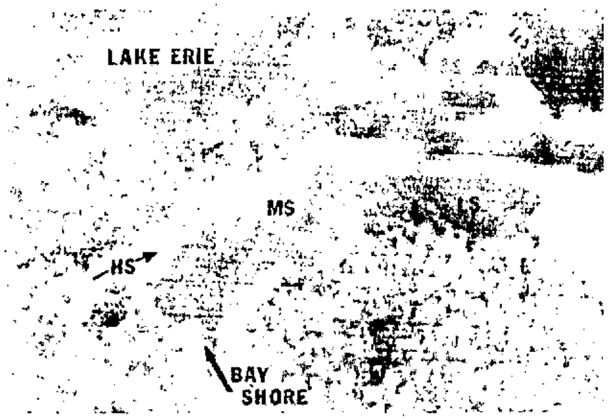
FIGURE 33. MULTIDATE ERTS-1 IMAGERY SHOWING SEDIMENTATION PATTERNS IN WESTERN LAKE ERIE

related to sediment concentration per unit volume, and type of suspended sediments. For example, it was found that outfalls of the Cuyahoga River have displayed an uncharacteristic, very dark color, which may be indicative of types of materials dumped into the river. Demonstration packages containing enlarged and color enhanced photos showing such sedimentation patterns in Lake Erie were made available to the personnel of the Ohio EPA, U.S. Corp of Engineers, U.S. Coast Guard, and to personnel of other interested agencies.

A study conducted to monitor Sandusky Bay sedimentation pattern utilized ERTS-1 data from November 3, 1972 to June 2, 1974. Differences in sedimentation levels throughout the bay and movement of sedimentation were observed on 11 ERTS-1 images and a Skylab photograph as shown in Figures 34, 35, and 36. The study determined that currents in the bay moved predominantly in a northeasterly direction and that sedimentation patterns appeared strongly affected by the strength of prevailing winds sweeping the bay. The ERTS-1 imagery provided an 18 month record which could not have been readily obtained through aerial photography because of timeliness and photographic perspective. This study showed that continuous ERTS-1 data provide a data base of current and sedimentation phenomenon never before available. This effort was undertaken in support of a site selection study conducted by Battelle for an Ohio utility company.

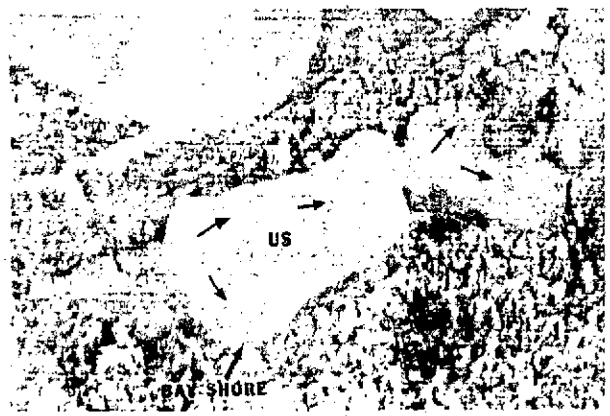
Flooding conditions along the Lake Erie coast line were similarly detected on ERTS-1 imagery (see Figure 33). However, the 18 day repetitive cycle of ERTS-1 permitted only coincidental analysis of flooding conditions and other natural disasters such as forest fires, wind damage, etc. Daily coverage of particular sites at higher resolution is required for detailed damage assessments.

Attempts to detect the presence of algae in Lake Erie and other water bodies did not prove fruitful. Algae blooms in Lake Erie occur only a few days during the year in certain locations, especially in July and early August around Kelley's Island. Perhaps, ERTS-1 orbital passes over Lake Erie and other reservoirs in Ohio were not coincidental with such algae blooms.

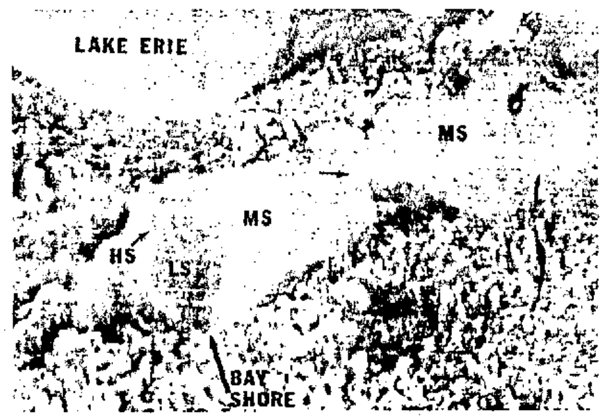


NOVEMBER 3, 1972 ERTS-1 PHOTOGRAPH
(Visible Band)

MARCH 8, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



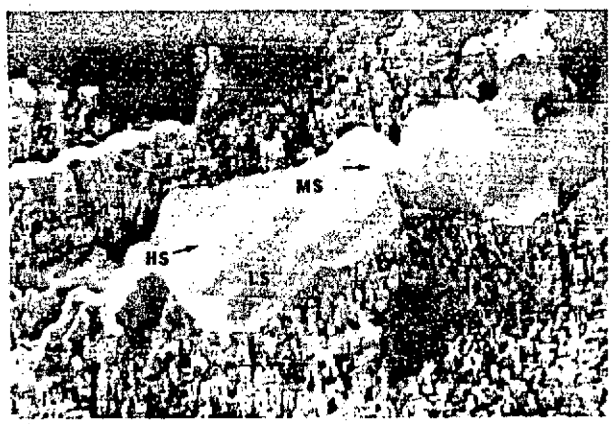
MARCH 27, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



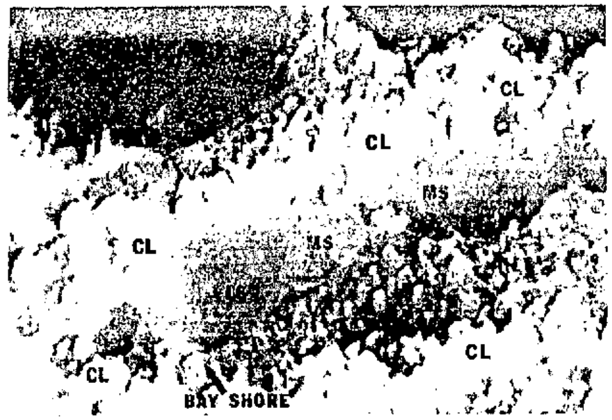
APRIL 14, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment
LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

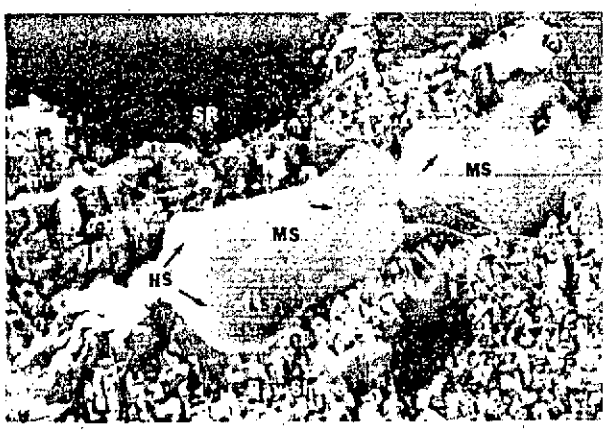
FIGURE 34. MONITORING SEDIMENTS IN SANDUSKY BAY FROM ERTS-1 (NOV. 1972 - APRIL 1973)



JUNE 7, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



JUNE 24, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

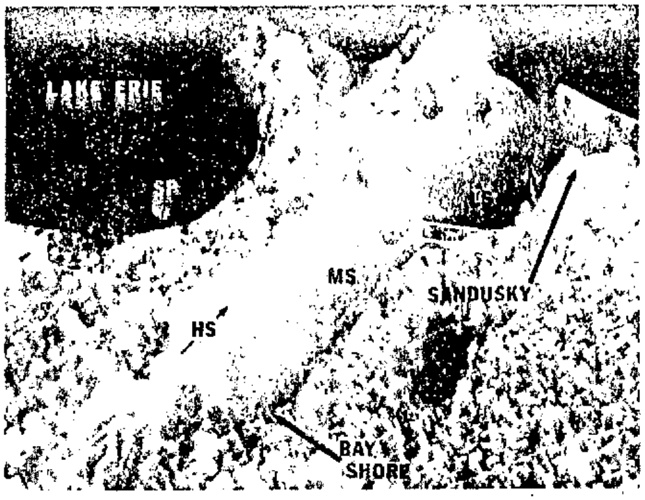


JUNE 25, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

JULY 13, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

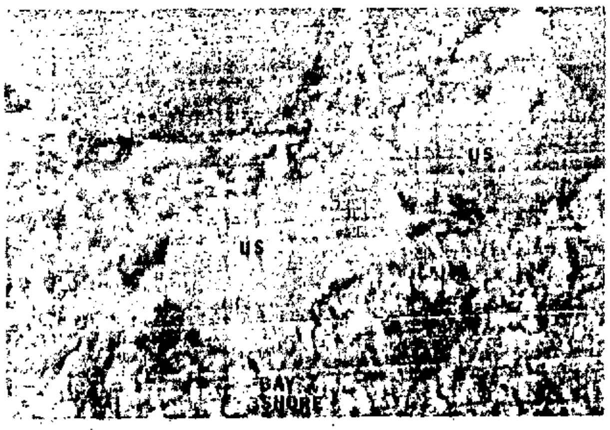
CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment
LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

FIGURE 35. MONITORING SEDIMENTS IN SANDUSKY BAY FROM ERTS-1 (JUNE 1973 - JULY 1973)



AUGUST 5, 1973 SKYLAB SL-3, S 190 A PHOTOGRAPH
(Visible Band)

AUGUST 18, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



SEPTEMBER 1973 ERTS-1 PHOTOGRAPH
(Visible Band)

JUNE 2, 1974 ERTS-1 PHOTOGRAPH
(Visible Band)

CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment
LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

FIGURE 36. MONITORING SEDIMENTS IN SANDUSKY BAY FROM SKYLAB AND ERTS-1 (AUGUST 1973 - JUNE 1974)

4.1.2.2 Reservoirs and Other Inland Water Bodies. Boundaries of water bodies appear very distinct in ERTS-1 MSS Band 7 imagery. As previously mentioned, small water impoundments as small as one hectare have been discerned. Using ERTS-1 data the general condition of the larger water bodies were assessed for suspended sediment content and water level. Also, through machine-added density analysis, delineations relating to the relative water depth were made.

4.1.3 Air Quality

The Ohio Environmental Protection Agency was established in October, 1972, to consolidate environmental quality protection activities in Ohio. It has prepared the implementation plan required by the Federal Clean Air Act to meet standards set by the Federal EPA. As part of the plan, officials are required to establish emission limitations for all significant state pollution sources. In an effort to determine the effect of pollution sources on air quality, the state has developed an air movement model.

As can be seen in Figure 37 the aerial extent of major smoke plumes were readily detected on ERTS imagery. The origin of the major smoke plume, shown on this ERTS-1 MSS Band 5 image of 21 August 1972, was along the Muskinghum River south of Zanesville where some major coal using industries are located. Similar smoke plumes were observed on many other repetitive ERTS-1 scenes of this area, the highly industrialized Ohio River Valley, and throughout the state. Dr. Wayne A. Pettyjohn of the Ohio State University also investigated ERTS-1 data for the detection of smoke plumes in Ohio.[16]

Since major smoke plumes from coal-fueled power plants and other smoke producing industries are readily discernible on repetitive ERTS scenes, the Ohio Environmental Protection Agency has expressed interest in utilizing ERTS data to show the location, movement and confluence of smoke plumes in testing computerized air motion models being developed for use in major statewide air pollution control practices. Also, preliminary analyses of ERTS-1 imagery showed that large scale

FIGURE 37. ERTS-1 MSS BAND 5 IMAGE OF AUGUST 21, 1972, SHOWING SMOKE PLUME IN SOUTHERN OHIO

Original Scale 1:250,000

vegetative damage caused by toxic air pollutants were identified sufficiently to provide gross estimates of the damage and to discern areas where ground surveys were required to further evaluate the effects of air pollution on vegetation.

Thirteen metropolitan areas in Ohio have been designated as Air Quality Maintenance Areas by the EPA. The designation means these areas may exceed existing standards by 1980 unless control of growth, development, and land use are exercised. Potentially, ERTS type data may be useful in developing and implementing statewide plans for preventing violation of established federal standards.

4.2 Land Use

Ohio, like many other places in the United States and other countries, is beginning to experience the pressures of too little land. Conflicting demands over the use of limited land resources are placing severe strains upon economic, social and political decision making. Likewise, the lack of physical resource data and means to analyze the data have hindered the formulation of sound comprehensive policies, the effectiveness of regional planning and management concepts, and the evaluation of individual projects. Also, one feature common to many of the proposed Congressional bills relating to national land use policy requirements is that, to qualify for federal funding, the states will have to include "the preparation and continuing revision of a statewide inventory of the land and natural resources of the state" as a part of their land use planning process. However, any improvement in national land use practices will require more knowledgeable and coordinated decision making of land use related problems such as unplanned growth, land misuse and deteriorating environmental quality at the state level.

In response to these land use issues, Ohio has taken steps to insure the wise and balanced use of its remaining land resources. In 1972 the Ohio Environmental Protection Agency was established by the General Assembly and became operational. Likewise, new legislation has been passed concerning the surface mine reclamation of coal and all minerals. Flood plain management legislation is now under consideration by the General Assembly. Most recently, a multiagency task force has been established to formulate a statewide land use policy and to establish associated information needs. Accordingly, a high-priority State interest exists relative to the extent, accuracy and cost of using orbital survey earth resources data for periodically updating land use information.

The major concern expressed by state, regional and local planners was whether sufficient detail could be discerned in ERTS-1 imagery to satisfy current and anticipated land use information needs. Analytical procedures and results of project efforts in response to this land use concern follow.

4.2.1 Identification of Land Use Features Using ERTS Imagery

The identification of land use features in the Ohio program was governed by two criteria: (1) What nationally accepted land use schemes are currently being used? and (2) How can the needs of the Ohio land use planner be accomodated most effectively with ERTS-1 data? These criteria were selected so that the success achieved in the Ohio ERTS-1 program could be measured against that achieved in other land use programs by other researchers throughout the nation. It also avoided the temptation to develop individual local schemes which may not be responsive to federally recommended land use schemes being planned for operational usage.

As a result the land use scheme developed by the U. S. Geological Survey was adopted.[15] All evaluations of ERTS-1 data were made with respect to this scheme. It soon became clear that the multispectral ERTS-1 data suggested the classification of schemes in spectral classes. While such a classification would have merit, it would have required a continuous interpretation of spectral to real data. By using the USGS scheme, the photo analyst or the computer technician was forced to provide the interpretation, without confusing the user with intermediate information.

All ERTS-1 data were evaluated in two stages dictated by the scheme as Level I or Level II. The primary areas analyzed were Columbus, Cleveland and East Liberty.

The most useful information was derived from ERTS-1 MSS Bands 5 and 7. Band 5 was well suited for delineating cultural or culturally affected features such as mixed urban centers, suburbs, old and new population centers, airports, transportation networks, parks, forests, and open fields. MSS Band 7 was especially useful for delineating bodies of water and urban density. Table 5 shows specifically the classes of Ohio land use features successfully discerned on ERTS-1 imagery acquired between May and November on relatively cloud-free and haze-free days.

A practical limitation encountered when identifying and extracting land use data from ERTS-1 70-mm and 240-mm imagery formats was simply that a single scene covers more than 34,000 km^2. Thus, any analysis, whether performed through human, human-machine aided or computerized techniques, required the selection of smaller portions of Ohio real estate, typically 1/10, 1/30, and as little as 1/50 of one frame. Franklin County, which is mainly comprised of the City of Columbus, was contained within 1/32 of an ERTS-1 frame. Efforts to determine the accuracy of land use interpretations during demonstration exercises required comparisons with two map scales 1:24,000 and 1:250,000 or underflight photography. Nevertheless, the synoptic overview provided by ERTS-1 imagery readily permitted analysis of large areas and comparison of smaller areas separated by a distance since the imagery was acquired over the larger area simultaneously under similar atmospheric effects, lighting conditions, etc.

A 4 to 10 X magnification was sufficient to identify Level I features, and magnifications from 10 to 41.7 X were required (1:1,000,000 to 1:24,000) to identify Level II features. Magnifications beyond 45 X were useless, as no further improvement in spatial resolution resulted. However, photographic treatment of ERTS-1 imagery to enhance cultural features improved interpretation capabilities to a limited extent. For example, high contrast printing of the Columbus area resulted in a crisp delineation of land use features not observable on the original imagery.

TABLE 5. OHIO LAND USE FEATURES DISCERNIBLE ON ERTS-1 IMAGERY.

USGS Land Use Classification System for Use With Remote Sensor Data (15) Level I	Level II	Features Discernible
01. Urban and Built-up Land		
	01. Residential	No
	02. Commercial and Services	No
	03. Industrial	No
	04. Extractive	Yes
	05. Transportation, Communications, and Utilities	Yes
	06. Institutional	No
	07. Strip and Clustered Settlement	Yes *
	08. Mixed	Yes*
	09. Open and Other	Yes
02. Agricultural Land		
	01. Cropland and Pasture	Yes
	02. Orchards, Groves, Bush Fruits, Vineyards, and Horticultural Areas	No
	03. Feeding Operations	No
	04. Other	
03. Rangeland		
	01. Grass	N/A**
	02. Savannas (Palmetto Prairies)	N/A
	03. Chaparral	N/A
	04. Desert Shrub	N/A
04. Forest Land		
	01. Deciduous	No
	02. Evergreen (Coniferous and Other)	No
	03. Mixed	Yes*
05. Water		
	01. Streams and Waterways	Yes*
	02. Lakes	Yes*
	03. Reservoirs	Yes*
	04. Bays and Estuaries	Yes
	05. Other (Ice and Snow)	Yes
06. Nonforested Wetland		
	01. Vegetated	Yes
	02. Bare	Yes
07. Barren Land		
	01. Salt Flats	N/A
	02. Beaches	No
	03. Sand Other Than Beaches	No
	04. Bare Exposed Rock	No
	05. Other	
08. Tundra		
	01. Tundra	N/A
09. Permanent Snow and Icefields		
	01. Permanent Snow and Icefields	N/A

* Included CCT Analysis Also.
** N/A = Classification not applicable to Ohio.

Identification of land use features from ERTS-1 imagery was performed for Ohio researchers and planners through a variety of techniques, governed by the need to (1) identify the data correctly, (2) compare it to existing data, and (3) transfer the data to a map. Among these techniques were:

- Photographic techniques to produce 100-cm x 100-cm map overlays with selected land use catagories.
- Superimposition of density sliced ERTS imagery onto USGS and Ohio Transportation maps through a two way mirror system.
- Superimposition of density sliced ERTS imagery onto USGS and Ohio Department of Transportation and other land use and thematic maps through use of a dual TV monitor system attached to the Spatial Data Viewer. (See Figure 17) The combined superimposed image was then photographed on 35-mm and 70-mm film. Analysis was performed at scales of 1:24,000, 1:63,360, 1:50,000, 1:250,000, 1:500,000 and 1:1,000,000.
- Overlaying transparent maps onto the screen of the Spatial Data Viewer.
- Superimposition of photographed maps (to scale) and ERTS-1 data in the four channel multispectral viewer. This arrangement facilitated the comparison of data taken at three different dates with aircraft underflight data or the map data. (See Figure 17).
- Through computerized techniques using (1) spectral and (2) spectral and spatial data. These were done at average map scales of 1:24,000 to pixel sized resolutions (minimum area on the ground approximately 0.6 hectare).

4.2.2 ERTS-1 Land Use Data Applications

Utilizing the Spatial Data image enhancement viewer with a built-in electronic planimetric device, acreages of various land use and percent changes over time were derived. The accuracy of land use measurements was dependent upon such parameters as the size of the particular surface feature that was being inventoried and its interrelationship with adjacent surface features.

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4.2.2.1 Statewide Applications. A statewide inventory of the land uses in Ohio was the objective of a 1960 Ohio land use study. Utilizing existing 1940 to 1960 data and USGS 1:24,000 topographic maps, the study produced tabulated land use data and generalized 1:250,000 scale land use maps and the 1:500,000 scale land use map shown in Figure 38. The land use maps were then compared to aerial photographs collected from 1958 to 1964 for accuracy determination. The 1960 Ohio land use study and maps were completed over a three-year period at a cost of approximately $110,000, excluding the costs of obtaining the aerial photography. Although the tabulated land use data provided a much needed detailed land use information base, the study and particularly the maps have been found to be inaccurate in numerous areas. Accordingly, a high priority State interest exists relative to the extent, accuracy and cost of using ERTS data to periodically update such land use information, especially in a much shorter time frame. The preparation of a statewide land use map has been proposed as part of the follow-on Ohio ERTS-B program.

However, there are some critical tradeoffs involved by utilizing synoptic orbital survey data rather than data obtained from conventional sources. For example, the 1960 study was done at a scale of 1:24,000 and then combined and generalized to arrive at the 1:250,000 and 1:500,000 maps. Thus, detailed land use work sheets were available as backups and for use by planners requiring detailed information. Using ERTS imagery, detailed backup work sheets are not available except for cases wherein detailed land use maps are made for selected areas of the state. Also, the possibility exists that future operational earth resource survey satellites may have the capability to obtain higher resolution photography for selected "high interest" development areas on a less frequent basis, e.g., once or twice a year coincident with low cloud cover conditions.

As illustrated in Figure 39 several black-and-white mosaics and a color mosaic of the entire State of Ohio from 100 cm x 100 cm ERTS-1 MSS Band 5 imagey were assembled by the Department of Transportation and the Department of Economic and Community Development. The

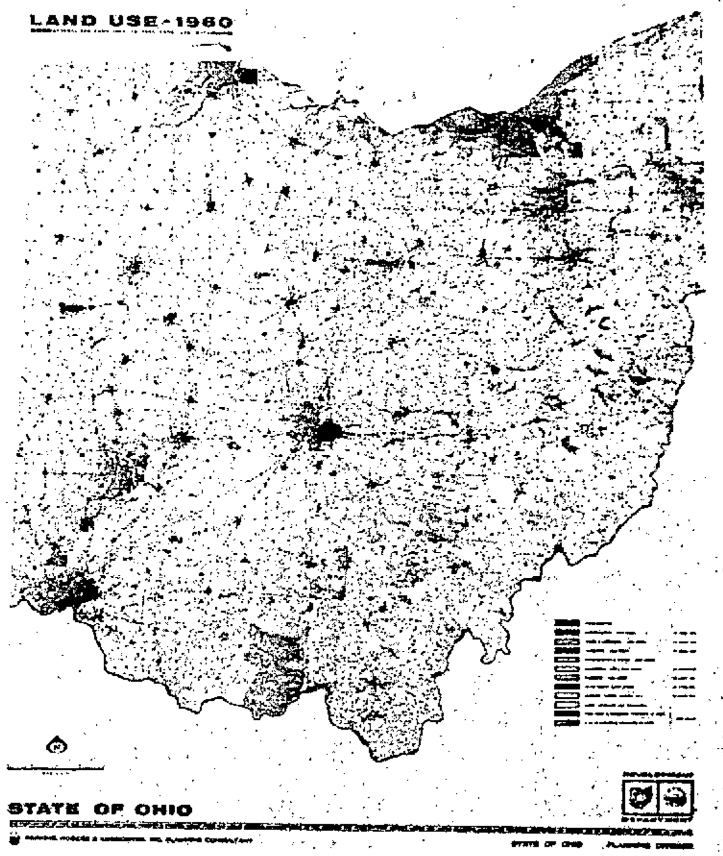


FIGURE 38.
1960 GENERALIZED LAND
USE MAP OF OHIO

Original scale: 1:500,000.

FIGURE 39.
ERTS-1 MSS BAND 5
PHOTOMOSAIC OF THE
STATE OF OHIO

Original scale:
1:250,000

mosaics have been placed in several departments of the state as a communicative aid for state planning and management activities. The significance of the mosaics is, that for the first time, a comprehensive/synoptic overview of Ohio's many diverse environmental, natural and cultural surface features and their interrelationships can be viewed simultaneously. Also, significant is the fact that the ERTS-1 imagery required to complete the mosaics became available in less than a year.

4.2.2.2 Regional Applications. The ability of using ERTS data for discerning various land uses at the regional level in a photographic format is illustrated in Figures 40 to 43. An existing land use map of the Columbus/Franklin County, Ohio, area, an enlargement of a July 30, 1973, ERTS-1 MSS Band 5 imagery of the area, and a manual grey-level density interpretation of the enlarged ERTS-1 scene in which ten different land uses have been distinguished are shown in Figures 40, 41, and 42 respectively. Figure 43 provides a comparison of the manual vs. machine analysis by showing a series of enlarged and density-sliced ERTS-1 images of the Franklin County/Columbus, Ohio, metropolitan area. Figure 43 shows the total urbanized area, recent urban growth that has principally occurred over the last 10 years, and the distribution of tree stands, parks and wood lots present in the approximately 1300 square km Franklin County/Columbus region. These photos are enhancements of October 15, 1972, MSS Band 5 ERTS-1 imagery. In general, machine aided illustrations presented much clearer and sharper distinctions among land use than did manual illustrations.

4.2.2.3 Local Applications. At more of a micro scale, the feasibility of using ERTS-1 data to discern land use changes and update land use maps in both computer and photographic formats is illustrated in Figures 44 and 45. At a 1:24,000 scale, ERTS-1 data are compared to aircraft and USGS topographic map data of the Huber Ridge subdivision area in the northeastern sector of the Columbus metropolitan area.

FIGURE 40. EXISTING 1964 LAND USE MAP OF COLUMBUS/FRANKLIN COUNTY, OHIO (Courtesy of the Mid Ohio Regional Planning Commission)

Original Scale 1:63,360

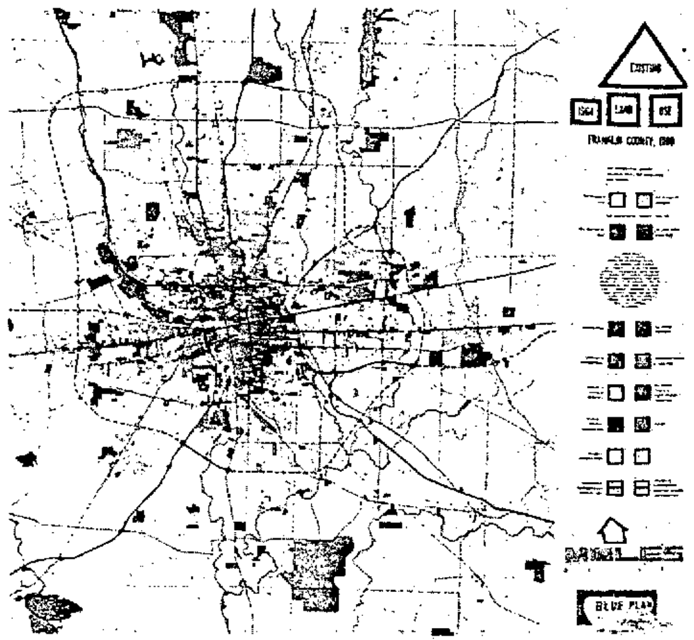
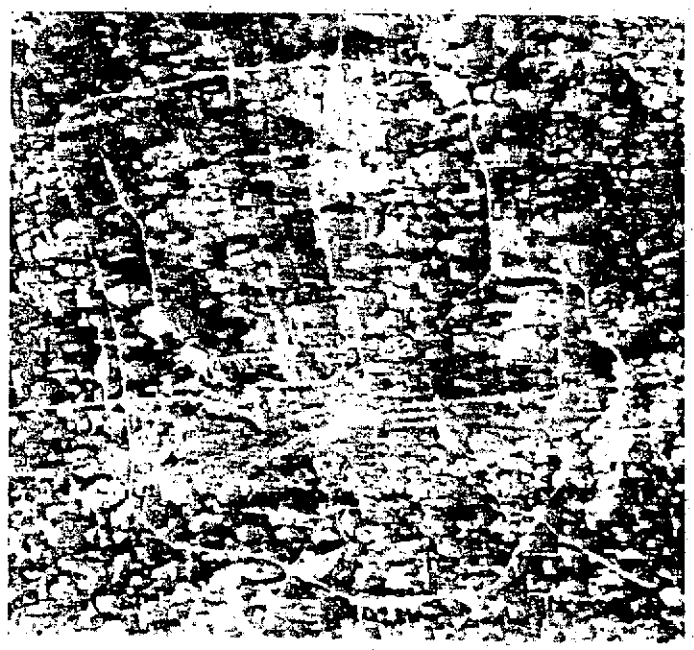


FIGURE 41. ERTS-1 MSS BAND 5 ENLARGEMENT SHOWING THE COLUMBUS/FRANKLIN COUNTY, OHIO, STUDY SITE (July 30, 1973)

Original Scale 1:1,000,000



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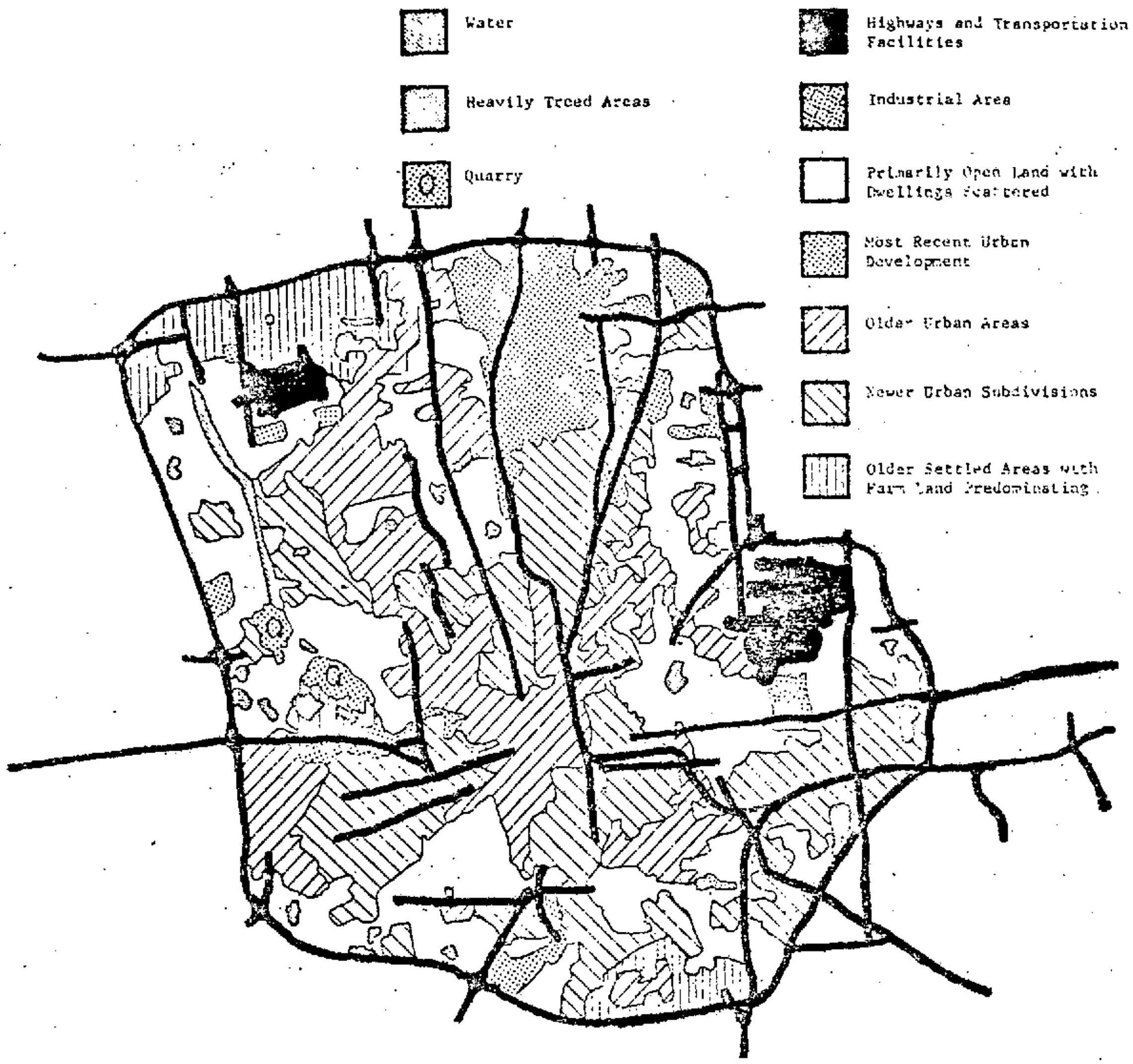


FIGURE 42. LAND USE MAP OF COLUMBUS/FRANKLIN COUNTY, OHIO, DERIVED BY MANUAL ANALYSIS OF AN ENLARGEMENT OF THE ERTS-1 MSS BAND 5 IMAGE OF JULY 30, 1973

Original Scale ~ 1:125,000

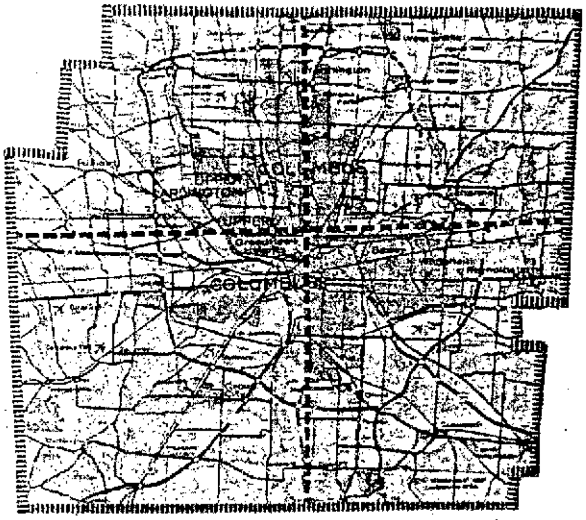


Fig. 43a. USGS Topographic Map

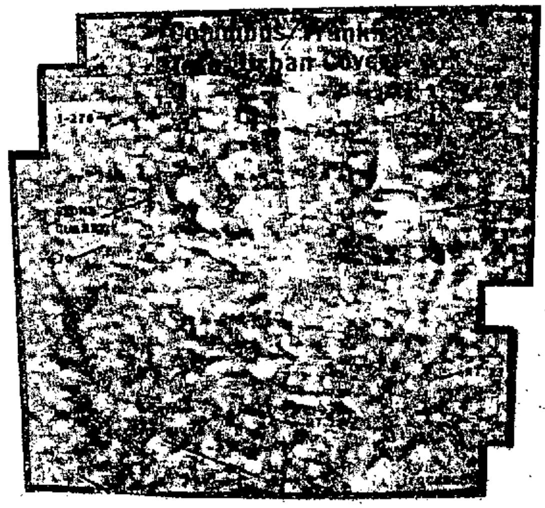


Fig. 43b. Total Urban Coverage

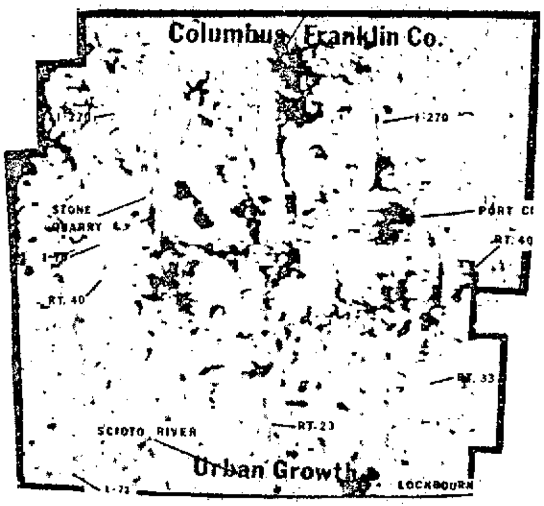


Fig. 43c. Urban Growth Areas

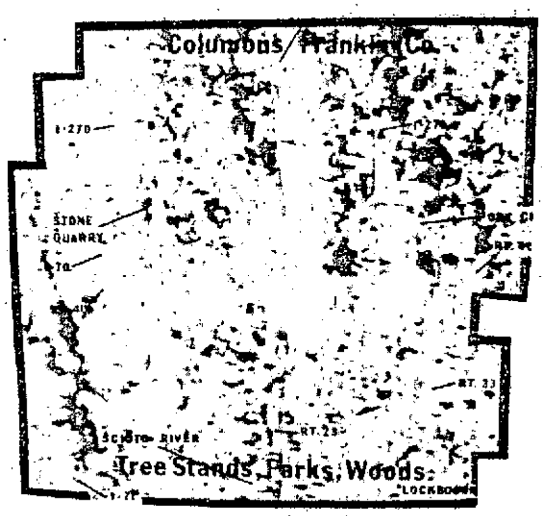


Fig. 43d. Tree Stands, Parks, Woods

FIGURE 43. ENHANCEMENTS OF COLUMBUS/FRANKLIN COUNTY, OHIO, LAND USE FEATURES DISCERNIBLE ON ERTS-1 IMAGERY (OCTOBER 15, 1972)

Original Scale 1:250,000

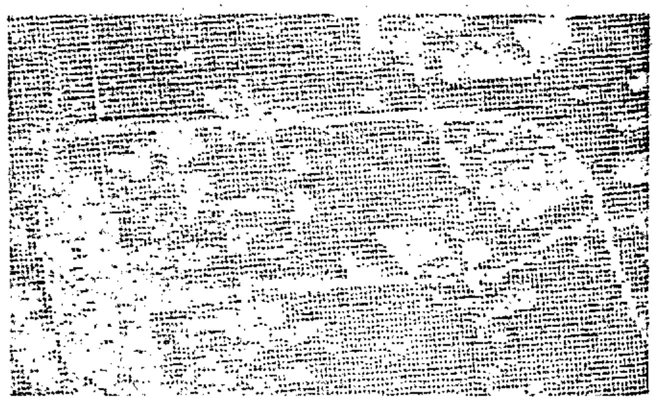
44a. 1:48,000 Aircraft Index Photo Sheet of April 17, 1972, of a Recently Urbanized Area in Northeastern Columbus, Ohio

44b. An Electronically Magnified Portion of an ERTS-1 MSS Band 5 Photograph of November 3, 1972, of the Area Highlighted to Illustrate New Urban Areas and Major Highways

44c. Magnified and Color Enhanced Portion of an ERTS-1 MSS Band 5 Photograph of Nov. 3, 1972, Superimposed on a 1964 1:24,000 USGS Topographic Map Sheet of the Area

The recently urbanized areas are highlighted to illustrate the capability of ERTS imagery to accurately identify land use changes.

44d. An Eight-Character Grey-Level Computer Printout Derived From the ERTS-1 MSS Band 5 Computer Compatible Tape of November 3, 1972.



C-43

FIGURE 44. PHOTOGRAPHIC AND COMPUTERIZED EXAMPLES OF ERTS-1 DATA FOR LOCAL LAND USE APPLICATIONS

Fig. 45a. Eight Character Grey-Level Computer Printout of ERTS-1 MSS Band 5.

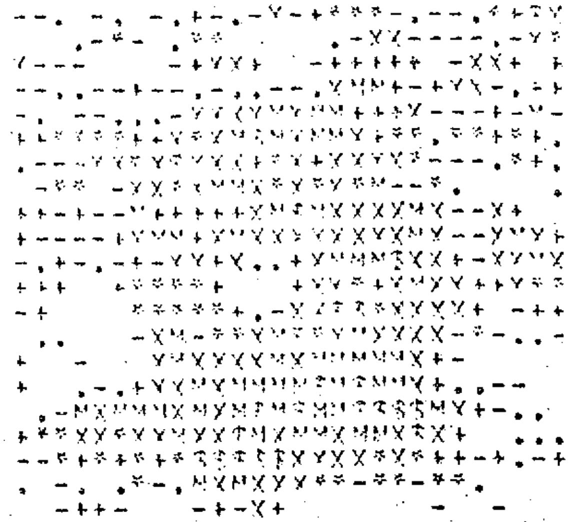


Fig. 45b. Multiband Land Use Computer Classification Printout of All Four ERTS-1 MSS Bands.

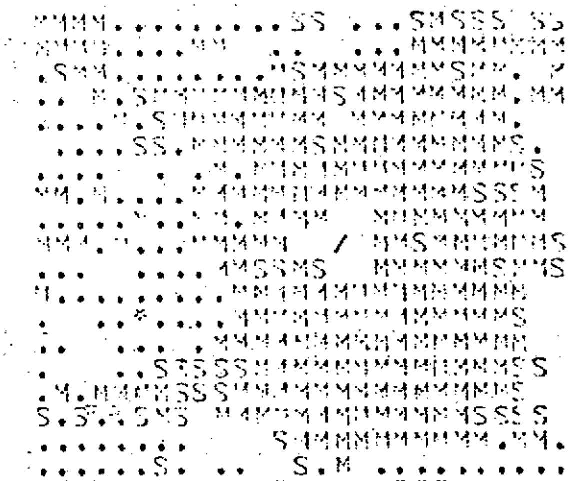


Fig. 45c. High Altitude Aerial Photograph Taken March 15, 1973.

Original Scale: 1:24,000

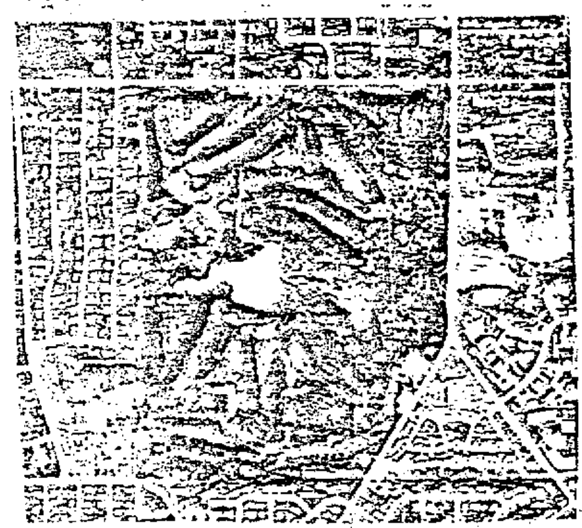


FIGURE 45. COMPARISON OF COMPUTERIZED GREY-LEVEL AND MULTIBAND LAND USE CLASSIFICATION PRINTOUTS DERIVED FROM THE ERTS-1 COMPUTER COMPATIBLE TAPE OF NOVEMBER 3, 1972, WITH A RECENT AERIAL PHOTOGRAPH

The area shown is approximately 1.8 Km x 1.8 Km and is located in northwest portion of Columbus, Ohio. The Ohio State University Golf Course is the dominant land use in the area.

The grey level print-outs shown in Figures 44d and 45a were derived by dividing the spectral information as stored on the ERTS-1 MSS Band 5 computer compatable tapes into 8 equal spectral ranges with each character representing one spectral range. Any one character on the grey level print-out, therefore, does not necessarily represent any one natural or cultural feature. In contrast, the computer classification shown in Figure 45b was derived by classifying certain individual land use features by their spectral characteristics in each of the four ERTS-1 MSS Bands, programming the computer to recognize the feature and similar features, and then programming the computer to print-out the selected features. In the print-out shown in Figure 45b the following characters represent the corresponding land use features:

Character	Feature
/	Water
*	Road
M	Grassy areas
o	Urbanized without any wooded areas
S	Lightly wooded areas
$	Heavily wooded areas.

An aircraft photograph of The Ohio State University golf course area is shown in Figure 45c for reference and comparison.

Each character on all of the computer printouts are representative of the dominant feature on approximately 0.6 hectares (1.4 acres) of land. These illustrations clearly provide a comparison of the degree of feature detail and change that may be extracted from ERTS data through magnification and electronic enhancement of imagery and limited computerized multiband processing.

<u>4.2.2.4 Specific Applications</u>. In addition to detecting, inventorying, mapping and monitoring natural and cultural surface features at state, regional and local scales; ERTS data were found appropriate for monitoring specialized activities such as siting and development of

nuclear power facilities; transportation facilities; reservoirs, parks and recreational facilities; prime agriculture lands and areas of environmental concern; urban growth and development; and extractive industries such as surface mining. Figure 46 highlights some of the major land use changes associated with the developments which have occurred in the area where the U. S. Army Corps of Engineers is currently constructing a multipurpose dam on Alum Creek just north of Columbus in Delaware County.

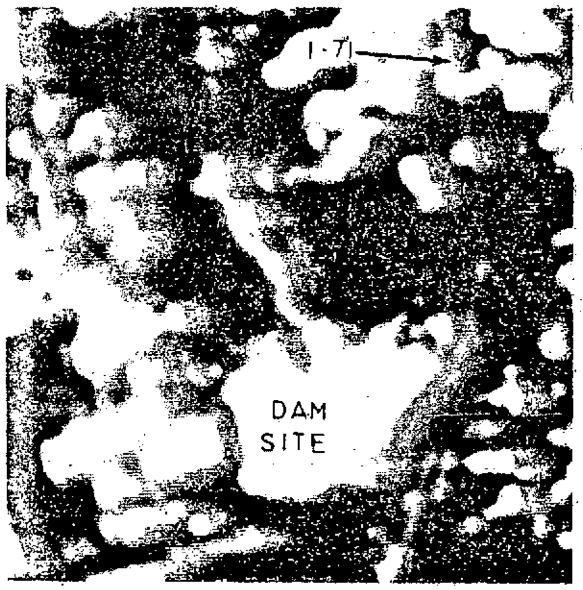


FIGURE 46. ENLARGEMENT OF THE ERTS-1 MSS BAND 5 IMAGE OF JULY 13, 1973, ENHANCED TO HIGHLIGHT LAND USE CHANGES RELATIVE TO CONSTRUCTION ACTIVITIES OF THE ALUM CREEK DAM IN DELAWARE COUNTY, OHIO

Original Scale 1:125,000

4.2.2.5 Multidate Applications. The following illustrations of the Ohio Transportation Research Center illustrate the capability of ERTS-1 to monitor land use changes over time which was possible because of the sun-synchronized 18-day repetitive overpasses of ERTS-1. With the creation of the Ohio Transportation Research Center near East Liberty, Ohio, the area is undergoing a rapid transition from primarily agriculture uses to a built-up area. As seen by comparing Figures 47a and 47b, ERTS-1 imagery has monitored the construction of the 12 km Oval Speed Test Track and other surrounding land use changes in the area. Likewise, the ability to obtain data at various seasons of the year was extremely valuable in land use information collection activities, especially for vegetation studies. It is hoped that orbital survey programs will continue to provide imagery of Ohio areas so that comparisons of longer time spans can be made as development occurs in and around the Research Transportation Center, as impounded water accumulates in the Alum Creek Dam, and as land use patterns change in other areas.

4.2.3 Significance of ERTS Data to Land Use Planning, Administrative and Legislative Applications

ERTS data provide the means for fulfilling the long standing planning professional's quest for synoptic vision, since innumerable implications are afforded planners by an orientation and understanding of the spatial context and contents of the area under evaluation. An integrated view of each land use pattern and the surrounding dynamic land use interrelationships often served to clarify planning problems and suggest possible solutions. Likewise, as a communication device, ERTS-1 data products displayed more informatively the data requirements of a given situation, especially, in a regional context. Thus, ERTS data aided in bridging the gap between the planner's information base and perceptions with those of his audiences.

4.2.4 Conclusions

Most Ohio land use features are identifiable in ERTS-1 MSS Band 5 imagery. Bodies of water, and urban densities are best identified on MSS Band 7 imagery. All five Level I USGS land use catagories applicable to Ohio (urban and build-up, agricultural, forest, water, nonforested and wet land) can be identified in photoscales as small as 1:1,000,000. Fourteen out of twenty-three Level II land use catagories have been

Fig. 47a.
Enlargement of the ERTS-1 MSS Band 5 Image of November 3, 1972

Original Scale: 1:42,000

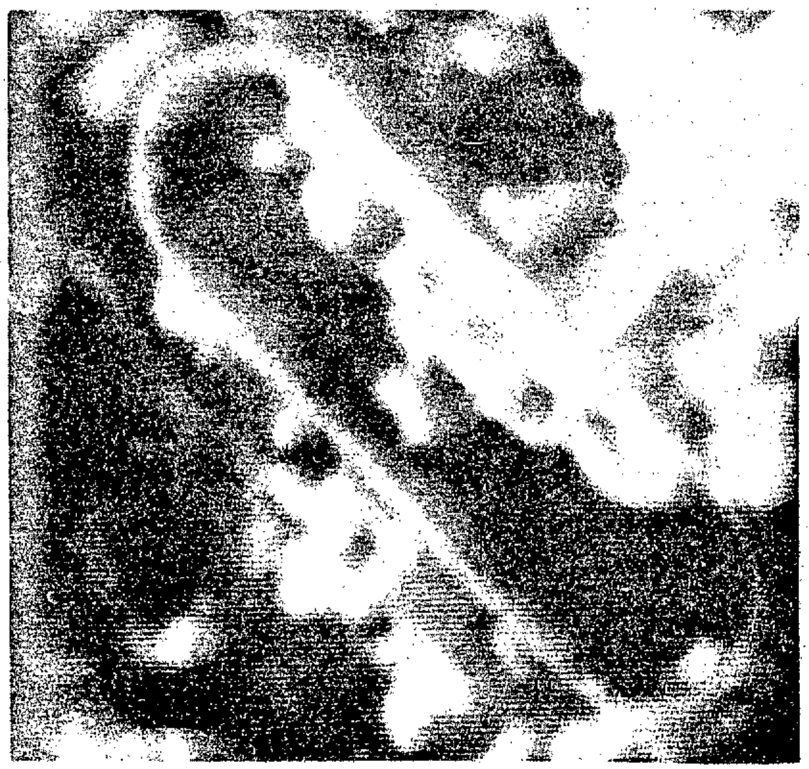


Fig. 47b.
Enlargement of the ERTS-1 MSS Band 5 Image of July 13, 1973

Original Scale: 1:42,000

FIGURE 47. ERTS-1 MSS BAND 5 ENLARGEMENTS HIGHLIGHTING LAND USE CHANGES ASSOCIATED WITH THE CONSTRUCTION OF THE OHIO TRANSPORTATION RESEARCH CENTER NEAR EAST LIBERTY, OHIO

identified through machine aided techniques. Several Level III catagories, such as types of extractive industries and types of agricultural were identified.

ERTS-1 bulk MSS data were used to update thematic and cataographic maps of 1:250,000 and smaller. The degree of feature detail achievable using ERTS-1 imagery greatly exceeded that shown in current maps. Machine-aided analysis of ERTS-1 imagery has shown that boundaries of natural and cultural features appear more distinguishable with details approaching that of USGS 1:24,000 topographic map data. ERTS-1 data have also provided information which map makers have either left off by mistake or which did not get printed in the process of making the map.

However, to the dismay of planners, the spatial and/or spectral resolution of ERTS-1 MSS imagery does not permit the distinction of individual dwelling units, commercial, and industrial structures.

In general, the most useful ERTS-1 data for land use applications in Ohio were collected between April and November. The reason is simply that healthy vegetation provided a high image contrast ratio between cultural and natural features which readily permitted a distinction to be made between features. Concrete-covered transportation networks, for example, virtually vanished in ERTS imagery taken during the winter months. Non-concrete transportation networks within the urban areas, however, remained visible. Also, small streams were identified in a snow covered scene which were not observed under any other seasonal condition.

The frequency and scale of ERTS-1 data for general statewide land use application in Ohio were adequate. Increased spatial resolution to 10 to 30 meters would significantly improve regional land use applications. Local land use applications in rapidly developing, high density urban areas require data collection at present frequencies with improvements to 10 meter spatial resolution.

4.3 Resource Management

The wise management and use of Ohio's diverse natural resources is considered an important component of governmental programs and activities throughout the State. Ohio ERTS-1 program efforts relating to Ohio's mineral water, air and land resources were discussed in preceeding paragraphs. Program efforts relating to Ohio's forest and agricultural resources are summarized in the following paragraphs.

4.3.1 Forestry

Approximately 24 percent of Ohio is forested and 94 percent of the forest land is privately owned. Ohio's climate and soils are ideal for the production of fine quality hard woods and about 96 percent of Ohio's woodlands are deciduous stands. Ohio ERTS-1 program forestry analysis efforts are described in the following paragraphs.

4.3.1.1 Forest Inventories. Forest inventories ranked high on the interest list of Ohio's planners since Ohio's map makers have simply not been able to cope with the problem of updating the many changes which have occurred in Ohio's forests. One of the most repeated demonstrations in the Ohio program involved the discernment and inventory of forest features covering tracts of 25 km^2 to 30,000 km^2. Ohio researchers showed a keen interest in the capacity of ERTS-1 imagery to show forest covers and differences between ERTS-1 data and the most recent map data at scales of 1:250,000 and 1:24,000. Principal interested researchers were staff members of the Ohio Biological Survey who, during 1973, conducted an environmental analysis of the entire Scioto River Valley watershed for the Huntington District, U. S. Army Corps of Engineers. The prime objective of the Scioto River Valley study was to inventory and evaluate the environmentally important physical, biological, and cultural resources of this Central Ohio Water Development Region. The region covers 26 percent of Ohio or 28,500 km^2.

A major problem early in the Scioto River Valley study was the need to procure a general, inexpensive and accurate map distinguishing the wooded areas in the region. Topographic maps of the area were outdated and recent aerial photographs of the area simply were not available. Using a density slicing photographic process, two 100 cm by 100 cm square transparent overlays were prepared from two adjacent ERTS-1 MSS

Band 5 scenes and placed over 1:250,000 USGS topographic maps as shown in Figure 48. The process required cloud free ERTS-1 images since cloud shadows and forest features can not be distinguised in the photographic process. Features as small as 10 hectares were recorded, which provided even more detail than was necessary for the Scioto River Valley study. The validity of the density slicing process was checked by comparing forest features of 20-25 km^2 in particular areas where aerial photographs or valid 1:24,000 maps existed. During the process, it was noted that the ERTS-1 imagery reproduced forest cover detail with a fidelity approaching that of 1:24,000 maps and exceeded the map data observable on 1:250,000 maps which were updated in 1968. The USGS topographic maps contained forested areas approximately 10 km^2 in size. In some cases areas of this size and larger were actually omitted simply because of the printing or drawing process. The density slicing experiment showed that ERTS-1 imagery is very well suited for thematically updating 1:250,000 maps.

4.3.1.2 Other Forestry Applications. Other Ohio governmental agencies, such as Crossroads Resource Conservation and Development Organization, were also intensly interested in tree species, forest types, and disease and insect damage. Tree species and forest types could not be identified with ERTS-1 data. Ohio simply does not have large tracks of deciduous and coniferous forests. Most pine stands are relatively small in Ohio's mixed forests which include oak, hickory, maple, beach and ash. Also, tree damage due to any cause could not be readily detected. The validity of any tree damage evaluations could not be verified since available aircraft data of pine tree damage in Ohio were four years old. What could be consistently observed in ERTS-1 imagery, however, were such parameters as forest cover, maturity and forest density.

4.3.1.3 Conclusions. ERTS-1 data can be used for updating general forest cover with an accuracy approaching that of 1:24,000 USGS maps. The ERTS-1 data products reflect forest cover more accurately

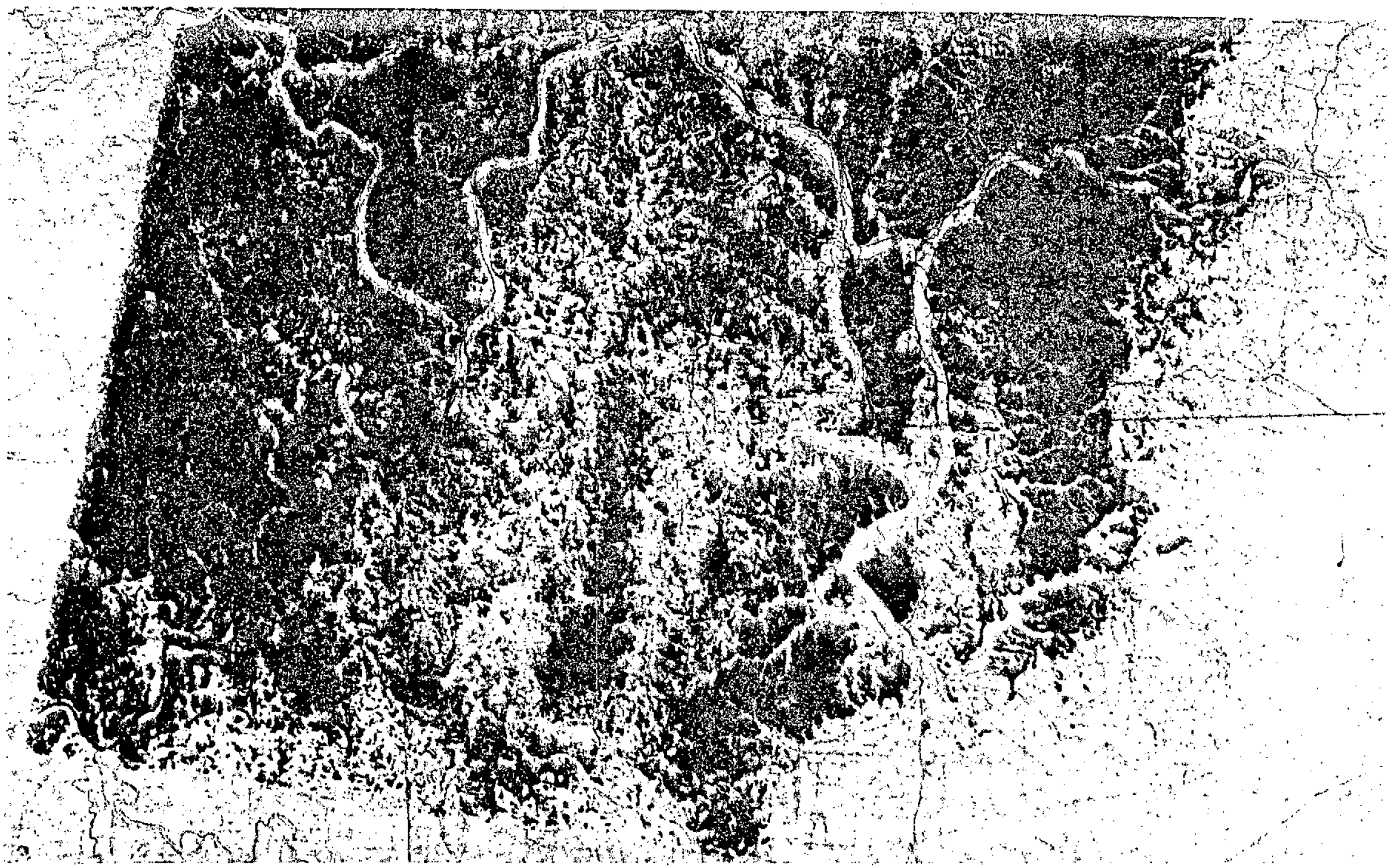


FIGURE 48. THEMATIC TRANSPARENCY OF FORESTED AREAS IN SOUTHEASTERN OHIO DERIVED FROM ERTS-1 MSS BAND 5 IMAGE OF OCTOBER 15, 1972. (Overlaid Onto Existing 1:250,000 USGS Topographic Maps)

than existing USGS maps (1:250,000) of Ohio. Forest species have not been distinguishable on Ohio ERTS-1 imagery. Use of ERTS-1 data for assessing forest damage may be possible, but the lack of underflight data prohibited such detailed analysis during the Ohio ERTS-1 program.

4.3.2 Agriculture

Ohio has a combination of fertile soils and a climate favorable for excellent farming. Throughout history Ohio has been a leader in various agricultural efforts. The principal crops to be found in Ohio are corn, soybeans, wheat, oats and hay. The following paragraphs describe Ohio ERTS-1 program analysis efforts relating to the identification of major crop types in Ohio.

4.3.2.1 Identification of Major Crop Types in Ohio. ERTS-1 imagery provided an excellent overview of Ohio's agricultural patterns and prime agricultural lands were clearly and comprehensively identified. Therefore, primary state concern was to determine if ERTS-1 data could be used to identify dominant crop types and acreages associated with each crop. Such a capability would permit statewide agricultural inventories never before possible.

A photomosaic of the entire state clearly shows that the prominent agricultural patterns are located in the relatively flat terrain of northern, northwestern, western, southwestern, and central portions of the state (see Figure 39). These are areas affected by the most recent glaciation in Ohio. The unglaciated eastern, southeastern, and southern portions of Ohio are predominately covered by forests and display limited agricultural features.

By analyzing ERTS-1 MSS Band 7 imagery of the state acquired in a time period from August 21, 1972, to June 3, 1974, a pattern of agricultural practices was observed which may eventually be related to methods of inventorying major crop types in Ohio. Although ground truth observations and the collection of radiometric crop signatures were extensive in the Ohio ERTS-1 program, the spectral differences as seen on ERTS-1 MSS imagery were not sufficient by themselves to distinguish among various crop types. This fact was not too surprising since the analysis of high resolution color and IR color and multispectral underflight data yielded only very small measurable density differences. Therefore, the key to agricultural analysis in Ohio apparently must lie in the use of temporal ERTS data in conjunction with underflight and ground-truth data. Such an analysis was performed in a 93 sq km area in Franklin and Madison County, and in the East Liberty study site area.

In these areas the primary crop types are winter wheat, corn and soybeans. Using NASA underflight data obtained in August 1973, corn and soybeans were identified with near 100 percent accuracy. ERTS-1 MSS Band 5 and 7 data obtained in June, July, August and September were then examined. Only on September 3, 1974 ERTS-1 data was a differentiation between corn and soybeans noticeable. Identification was limited to field sizes of 3-4 hectares. While smaller fields were distinguishable, no accurate boundaries could be drawn around them to provide an area measurement. Identification of corn and soybeans on ERTS-1 imagery of 30 fields yielded a 70 percent correct identification. Most identifications were made in ERTS-1 MSS Band 7.

Winter wheat appeared as a very prominent signature in ERTS-1 MSS Band 5 and 7 imagery. The acreages covered by wheat in Ohio were estimated by correlating areas which were plowed in the fall with the appearance of the relatively strong spectral signatures of the riping wheat fields in June to early July. Winter wheat acreages inventoried in the East Liberty study site area resulted in 80 percent correct identification (see Figure 49).

<u>4.3.2.2 Conclusions</u>. Agricultural crop inventories in Ohio may achieve 70 to 80 percent accuracy with current capabilities to correlate ERTS-1 MSS data with multispectral aerial photography and ground-truth data. Farm land of less than 4 hectares was usually not distinguishable. Winter wheat, corn, and soybean inventories may be made by using temporal data obtained in the fall, spring, and summer of each year.

Fig. 49a. ERTS-1 Image of Portion of East Liberty Study Site. Light Areas are Recently Plowed Fields

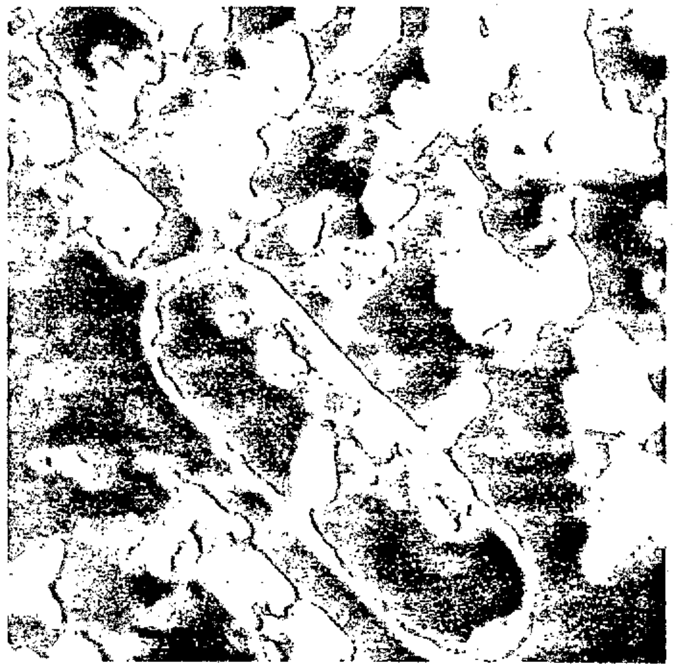


Fig. 49b. Enhancement of Fig. 49a Outlining Newly Plowed Fields and Recent Construction on the Ohio Transportation Research Center

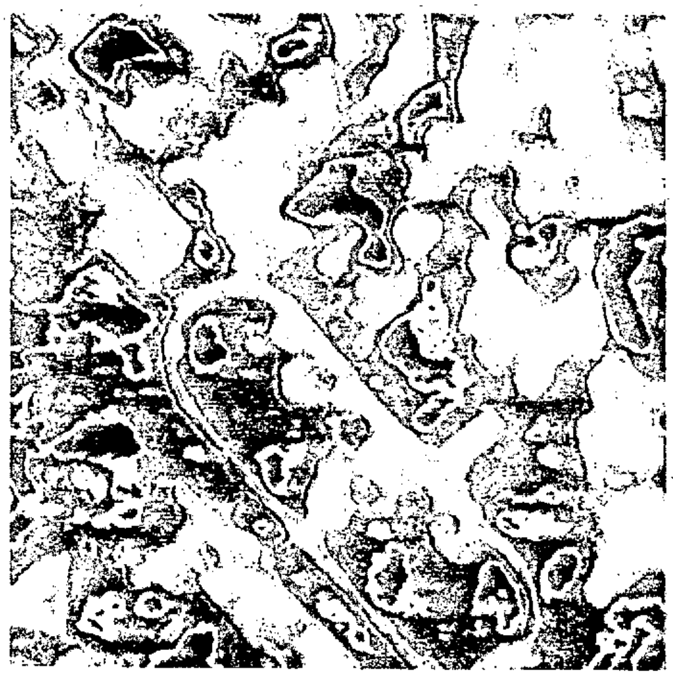


Fig. 49c. Enhancement of Figure 49a Showing Forested Areas (Very Dark) and Open Fields and Pasture (Dark Grey)

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FIGURE 49. ENHANCEMENTS OF AN ERTS-1 MSS BAND 5 IMAGE OF JULY 7, 1974 SHOWING AGRICULTURAL AREAS WITHIN EAST LIBERTY STUDY SITE

4.4 Other

Other significant ERTS-1 data analysis activities of the Ohio ERTS-1 program related to underground mines, sanitary landfill and Lake Erie ice interests. The results of these brief analysis efforts are summarized in the following paragraphs.

4.4.1 Underground Mine Detection

The Department of Natural Resources also has begun studies on the seepage of surface water into old underground mines in southeastern Ohio and the resulting acid mine water pollution. ERTS-1 imagery has been used to detect possible wet areas in which surface water is prominent by vegetative patterns and vegetation differences which may be caused by adverse effects of such pollution.

4.4.2 Landfill Task

Recently amended sections of the Ohio Revised Code prohibit open dumping of refuse in Ohio and require the use of sanitary landfills. The Ohio EPA has estimated that there are 1,400 illegal dumps still remaining in the state and has been searching for a method of locating these operations.

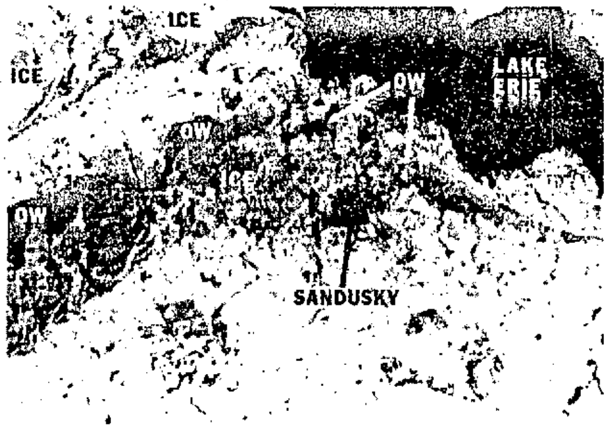
At the request of OEPA personnel a preliminary assessment of the ability of ERTS-1 MSS imagery to provide an inventory of sanitary landfills throughout the state was undertaken. However, the resolution of ERTS-1 imagery was found inadequate for this application.

The OEPA is drafting strong solid waste management legislation which could require landfill operators to formulate plans to terminate sites, maintain them for five years after closing and post bond to guarantee restoration similar to bonding now required for strip mining. Potentially ERTS type data could be significant to the passage and enforcement of such preliminary legislation.

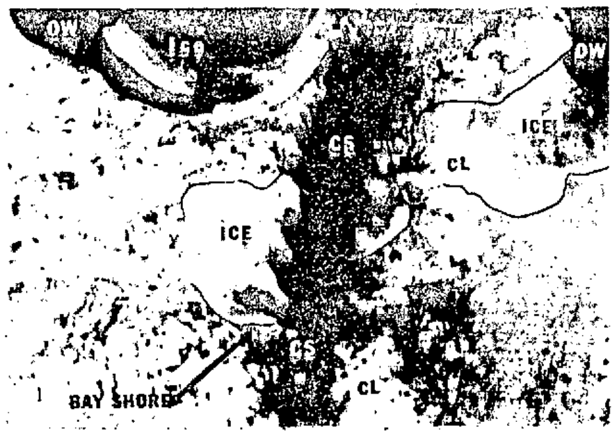
4.4.3 Lake Erie Ice Monitoring

Synoptic winter-time imagery provided by ERTS-1 has likewise provided a new insight into the characteristics of Lake Erie ice conditions. Because of ice conditions, shipping activities on Lake Erie are limited to the nine warmer months of the year. However, as illustrated in Figure 50, ERTS-1 imagery acquired during the winter months revealed that shipping on Lake Erie could possibly occur on a year-wide basis with some assistance by ice cutters. The Ohio Departments of Transportation and Economic and Community Development are pursuing this interest.

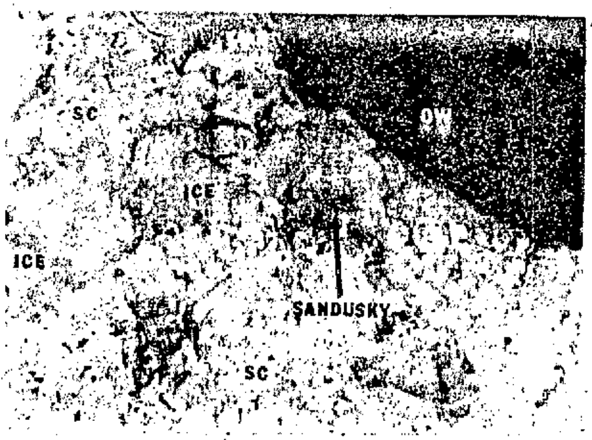
By using multidate ERTS-1 MSS Band 5 and 7 data, ice features such as cracks, open water, and relative ice thickness were derived. Correlation with large scale aircraft and ground truth data was very important for correctly identifying ice features since winter ERTS-1 scenes were rarely cloud free over Lake Erie. Preliminary stereo examination of ice on Lake Erie revealed differential movements of Lake Erie ice flows; but, in general, the 18 day time interval for repeative coverage was too large to provide meaningful velocity or trajectory values.



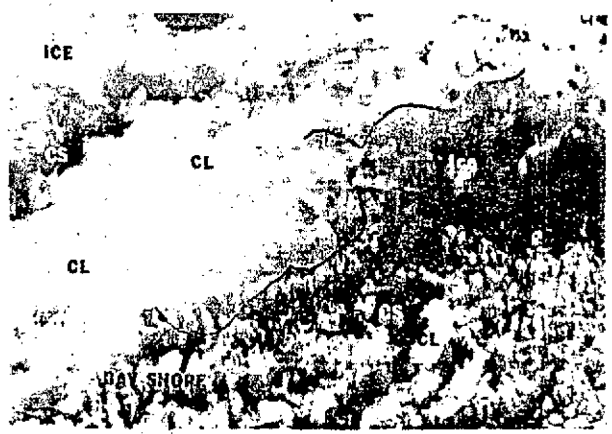
FEBRUARY 18, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



DECEMBER 22, 1973 ERTS-1 PHOTOGRAPH
(Visible Band)



JANUARY 8, 1974 ERTS-1 PHOTOGRAPH
(Visible Band)



FEBRUARY 14, 1974 ERTS-1 PHOTOGRAPH
(Visible Band)

CL - Cloud
CS - Cloud Shadow
HS - Heavy Suspended Sediment
LS - Light Suspended Sediment
MS - Moderate Suspended Sediment
OW - Open Water
SC - Snow Cover
SP - Sediment Plume
US - Uniform Suspended Sediment

FIGURE 50. ENHANCEMENTS OF MULTIDATE ERTS-1 MSS IMAGERY SHOWING VARYING ICE CONDITIONS IN SANDUSKY BAY

5.0 UTILITY ASSESSMENT

Assessment of the potential utility/relevance of ERTS-1 data to Ohio was based on a combination of (1) specific ERTS-1 applications identified and/or demonstrated in the laboratory, (2) user attitudes expressed while directly participating in laboratory problem-solving exercises and (3) user comments recorded on questionnaires during the Ohio ERTS/Skylab Data User Workshop. User views as to the operational implications of initial program results were also solicited. These utility/relevance assessment topics are discussed below.

5.1 Applications Assessment

Experimental findings as to the potential use of ERTS-1 data for environmental quality, land use, and resource management in Ohio were summarized in Section 4.0. Land use and surface mining applications were specifically described in separate demonstration products[7,8]. These results when integrated with Ohio data use possibilities were ranked as (1) appropriate for routine use, (2) requiring further analyses, (3) requiring initial analysis, and (4) unapplicable based on current ERTS data capabilities. The specific applications designated under each of the four categories were:

I. Applications for routine use

- Surface mining (Progress monitoring and mapping)
- Smoke plume (Detection/modeling)
- Lake/Resevoir sedimentation monitoring
- Forests/Timber general surveys/inventories (all species)
- Land-use mapping/thematic mapping
- Land use/capability data base
- Development trends monitoring

II. Applications requiring further analysis, verification and/or demonstration

- Transportation planning and route selection
- Agricultural surveys
- Surface mining (reclamation monitoring)

- Wetlands mapping/monitoring
- Lake ice monitoring
- Soil studies (moisture/types/associations)
- Vegetation studies/environmental damage assessment
- Lake Erie water quality modeling

III. Applications requiring initial analysis

- Flood plain monitoring
- Air quality index monitoring
- Sub-surface water detection/exploration
- Recreation site selection/monitoring
- Disaster assessment (floods, drought, hail, frost, tornados)
- Lake shore erosion monitoring

IV. Applications not feasible

- Sanitary land fills (illegal site detection, new site selection, and approved site monitoring)
- Lake Erie (algae) monitoring
- Forest species surveys/fruit (orchard) surveys
- Forest/vegetation condition monitoring.

Applications judged as appropriate for routine use were those in which the available ERTS-1 data were analyzed and formated in such a way as to be responsive to information needs of one or more on-going state programs. Further studies are required, however, to assess the time saving and economic relevance of these application candidates and to develop user operational plans. Applications listed as requiring further analyses were those in which the linkage between the ERTS-1 data and user data requirements appears to be compatable, but more detailed evaluation of procedures and accuracies are required. Applications in the third group were those containing significant potential, but not examined. Applications in the final category were researched to varying degrees but were found inappropriate either because of analytical processing limitations or spatial, spectral and/or temporal data demands posed by the potential user(s).

An assessment of the potential relevance of the ERTS-1 data to major issues and/or items of concern that confronted State of Ohio decision makers during the ERTS-1 period is contained in Table 6. Included are representative natural, environmental, political, cultural, legislative and industrial items.

TABLE 6. ERTS-1 RELEVANCE TO CURRENT OHIO ITEMS OF CONCERN

Major Issues/Items of Concern in Ohio During ERTS-1 Period	Estimate of Potential Value of ERTS-1 Data			
	None	Low	Medium	High
• Natural Items				
(1) Lake Erie shore erosion and flooding			●	
(2) River flooding				●
(3) Tornado			●	
(4) Drought during agricultural growing season				●
(5) Rain surplus during planting and harvesting season		●		
(6) Frost damage to orchards	●			
• Environmental Items				
(1) Illegal sanitary land fills		●		
(2) Smoke plumes confluence studies				●
(3) Water quality modeling				●
(4) Scenic area preservation			●	
(5) Vegetation effects of air pollution				●
(6) Vegetation effects of surface mining drainage				●
(7) Surface mining erosion monitoring			●	
(8) Pollution damage to wildlife		●		
• Political Items				
(1) Redistricting				●
(2) Reorganization (New department/agency creations)			●	
(3) Revenue sharing			●	
(4) Appalachia programs			●	
(5) Governor's Task Force Formulation of Ohio Land Resources Program (Statewide)				●
• Cultural Items				
(1) Energy crisis				●
(2) Economic depression in Southeastern Ohio		●		
(3) Developmental conflicts			●	
(4) Daylight Savings Time	●			
(5) Highway data base and network planning			●	
(6) Extension of transporting season on Lake Erie				●

TABLE 6. (Continued)

Major Issues/Items of Concern in Ohio During ERTS-1 Period	Estimate of Potential Value of ERTS-1 Data			
	None	Low	Medium	High
• Legislative Items				
(1) Coal surface mining law (passed 1972)				●
(2) All minerals law (passed 1974)				●
(3) State land use policy (under study)				●
(4) Tax Issue I (passed 1973)			●	
(5) Flood plain regulation (pending)				●
(6) Solid waste control bill (scheduled 1975)		●		
• Industrial Items				
(1) Lake Erie navigation extension				●
(2) Power siting				●
(3) Mineral exploration		●		

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5.2 Relevance Assessment

Relevance assessments of the potential utility/relevance of ERTS-1 data to Ohio expressed by users while directly participating in laboratory problem-solving exercises and user assessments recorded on questionnaires during the Ohio ERTS/Skylab Data User Workshop are discussed in the following paragraphs.

5.2.1 User Views

The comments and recommendations noted in this section concerning ERTS-1 data are based upon the synergistic reflections of applications and needs as expressed in a statewide user community. This statewide user community consists, organizationally, of two major divisions: (1) State agencies (i.e. DECD, DNR, EPA, ODOT), and (2) regional, local, and special planning organizations. Each user division can, in turn, be subdivided according to data needs and applications.

The utility of ERTS-1 data in terms of satisfying user data needs is inherent in the data itself. A cursory review of the subject data provided by ERTS-1 readily alerts potential users of the data value to his needs. However, the integration of these data with operational program activities quickly illuminates numerous data limitations that are determined by the context of application rather than the data itself. Therefore, user utility may be limited not only by the type of data generated by ERTS-1, but also by the functional nature of user organizations. Throughout Ohio the various planning disciplines operate in the public sector or are largely dependent upon public funds for support. This funding mechanism limits data analysis and application efforts to those programs specifically designated in budget requests. Once these funds are released only a few very large user organizations would be capable of developing new data processing capabilities for the accommodation of ERTS-type data. This limitation is also felt at the state agency level where small or routine information needs are satisfied through conventional methods. The responsibiliites of state agencies, however, also require smaller scale, comprehensive inventories of state resources, and in this context the technical and cost appropriations of ERTS-1 data have been favorably demonstrated. Therefore, the key in determining the user cost-benefit of ERTS data is based upon: (1) the geographical size of the application area, and/or (2) the volume of routine small scale data needs. Both factors are reflected in the functional nature of the potential user organization.

Given a segment of ERTS-1 data considered to have value to a user in an application context, the actual data benefit will be influenced by three general parameters. The first user consideration is data collection and analysis cost. Although the dissemination of ERTS-1 data via Souix Falls has provided an inexpensive outlet for raw data, the processing requirements (either optic or digital) have precluded most second-division users such as regional and local agencies from participating in the use of such data because of cost and expertise limitations. Thus potential users in these categories are currently bound to handling data by conventional methods. The temporal nature of program funding places many potential users in a position of 'do it now or not at all'. Therefore, if relevant ERTS-1 data are available to the user at the time of program initiation, the probability of data application is high, and if the data are not immediately available, the user will look to more immediate data sources.

The third parameter affecting ERTS type data applications is immediate-response oriented users. Air and water contamination alerts are monitored by the hour. Thus relevant data may not have an application utility because of current limitations on data delivery time, or because of relatively long processing and analization requirements. Organizations affected by this immediate data availability requirement are, generally, those agencies with regulatory and enforcement responsibilities, or those concerned with extraordinary natural phenomena such as weather, water, and fire and biological.

Given the preceeding parameters, ERTS-1 data utility, in an application context can be viewed as a function of data processing and analyzation time and costs, and legislative and administrative priorities as reflected by programmatic funding and data availability. Organizationally agencies concerned with regional and/or statewide inventories of natural and cultral surface features have been found the most congruent with the application parameters. This user group consists mainly of state and federal agencies charged with the execution of comprehensive studies. These studies frequently are precipitated by national issues and priorities and are funded partially or wholly by federal sources. The comprehensive scope and funding level of such programs determines their overall nature as 'one time' or infrequent application subjects. For example, the Ohio Department of Economic and Community Development completed a statewide land use mapping effort in 1964. Since that completion date the state land use map has not been updated. Although it is highly probable that such an updating will eventually occur, and, in fact, has frequently occurred on a local basis, it is clear that such large-scale programs, singularly, occur on an infrequent and irregular schedule. This situation makes in-house data handling capabilities uneconomical on a per agency basis.

Many regional, local, and special planning interests lacking comprehensive federal and/or state fiscal support, generate a larger volume of moderate and small data applications than the larger, first division users. This local type of user, in aggregate, represents potentially the most consistent demand for ERTS type data and data applications. The "trade off" between the infrequent, large scale user, and the smaller, more routine user rests with two primary determinents.

The first "trade off" consideration is the data analization load factor and project expertise and funding levels. Programs suited for ERTS data applications decrease in funding levels and they increase in frequency. This inverse relationship is also present in the second "trade off" determinent concerning data capabilities. As potential user applications became more local and frequent in scope, ERTS type data become less useful. Therefore, those programs most frequently in need of ERTS type data are the least able to support data analization costs, and these programs are also the most likely to require greater resolution capabilities.

5.2.2 Workshop Questionnaire Responses

Responses to the questionnaire distributed during the Ohio ERTS/Skylab Workshop (see Appendix E) provide an insight as to current views of a broad spectrum of potential users at state, regional and local levels.

Of the twenty-five questionnaires completed, two-thirds represented potential users from agencies currently involved in data collection and analyses activities. In assessing current data needs, responses were nearly equally divided as to adequacy in terms of timeless, detail provided, format utility and cost incurred. The majority, however, considered that current manpower allocations were too high. Many normally utilized existing maps and published data such as census data. Only in a few selected cases were supplementary data such as aerial photography required. Data requirements varied between daily and weekly, and map scales utilized were primarily 1:50,000 and larger. Actual use was dictated by the functional responsibilities of the agency.

Estimates as to actual budget savings that may be possible utilizing ERTS varied from 1 to 25% in the case of data collection to 1 to 50% for data analysis. The later was contingent upon the success of CCT interpretation and the availability of cost share user incentive programs.

In comparing ERTS to conventional data sources respondees consistently judged ERTS data as more comprehensive, more timely, more uniform, but less accurate. The need for additional investigations as to potential uses of ERTS data was expressed 2 to 1.

Recommendations for improving future satellite earth resources survey systems unanimously favored increased resolution, about one-half supported adding thermal IR capabilities, and one-third expressed an interest in acquiring data in shorter time frames.

As to funding parameters, the majority expressed a willingness to participate in satellite data use programs on a cost share basis with the federal government. About one-half also expressed an interest in group program participation, but one volunteered to be a single sponsor. All were affirmative as to the value of the workshop and the majority indicated they would attend other such workshops.

5.3 Operational Assessment

The emergence of satellite survey data as a potential routine data source for expanding state needs in the environmental quality, land use and resource management areas is timely. Ohio, like other states, stands to benefit significantly if data acquisition and interpretation measures are responsive to operational data needs. Based upon the results of this program, a preliminary assessment of the optimum data capabilities (spectral, spatial, and temporal) required to fulfill data needs involved in state research, planning, management, policy formulation and legislative enforcement on a routine basis is provided in Table 7. The recommendations are a combination of technical findings and expressed views of numerous user personnel participating in the program.

Of major operational importance is the optimism with which potential user personnel are currently viewing satellite earth resource data use. Considerable staff-time commitments and some state funds were allocated for exploring ERTS-1 data application opportunities in on-going programs. However, the development of useful and cost-competitive products remains a major challenge to the routine use of ERTS-1 data analysis techniques. Additionally, in-depth research programs of both technical and economic nature are necessary before routine utilization of ERTS type data is possible.

Efforts to improve and refine two general program areas could greatly expedite the operational acceptance of ERTS data in multidisciplinary resource management activities. The first area is concerned with data availability and data processing procedures. Environmental regulation and enforement activities must have immediate data delivery in terms of days rather than months, before ERTS data will supplant on-site inspection as a routine operational procedure. Following data receipt, there is an obvious need to centralize

TABLE 7. OPERATIONAL SATELLITE EARTH RESOURCES SURVEY DATA REQUIREMENTS FOR STATE-LEVEL ENVIRONMENTAL QUALITY, LAND USE, AND RESOURCE MANAGEMENT APPLICATIONS

State Function	Product Types	Data Requirements: Spectral Range	Spatial Resolution (in Meters): State	Regional	Local	Temporal Range
Research/Education/Communications	Maps, photographic and digital displays, and models	Multispectral (all bands visible to microwave)	80	80	80	Periodic 18 days
Planning (Data Collection and Analysis)	Maps, photographic and digital displays, and models	Multispectral (visible to thermal IR 4 to 7 bands)	<80	30	10	Seasonal to daily
Management/Decision Making	Output from planners	Multispectral (visible to thermal IR)	30	10	10	Seasonal to daily
Policy Formulation/Legislation	Output from Managers-Dept. Directors	Multispectral (visible to thermal IR)	30	10	10	Yearly
Enforcement (Surveillance/Monitoring)	Computerized to detect changes	Multispectral (visible - thermal - microwave plus DCS/DCP)	10	10	10	18 days automatically to daily on demand

data analization and product dissemination to allow for an economical start-up and processing cost amoritization. In Ohio the operation of such a facility would be incumbent mainly upon the state government. However, the resources necessary for the creation of such a structure need not be entirely a state responsibility. Within the boarders of a state such as Ohio are numerous levels of governmental agencies requiring significant amounts of data that could be supplied by ERTS. Many federal agencies such as EPA, DOT, USDA, HUD, and the US Army Corps of Engineers activity undertake comprehensive projects within the state that lend themselves to ERTS data use. Other organizations within the state that are heavily supported by federal funds for various land resources projects include private research organizations, municipalities, and industry. Therefore, with numerous organizations in the state responding directly or indirectly to federal priorities and issues that deal with state resources, it is evident that these potential users would also benefit from a centralized data storage, analization, and dissemination center. Given the degree of effort necessary for such a system, it is doubtful if Ohio could adequately accomplish such a task without considerable assistance from the previously identified potential user agencies.

The second area requiring improvement is the data itself. All users, especially urban planners, expressed a desire for higher resolution. Ten meter maximum resolution is the pervasive limit for optimum data utility based upon a multidisciplinary user audience. In conjunction with increased resolution is the need for thermal IR data. Particularly in the measurement of water related parameters, thermal IR data could supply a needed dimension for the accurate measurement of many surface feature properties that, as contributory data, would enhance the discernment and rapid analization of environmental anomalies.

6.0 USER AWARENESS

To maximize end-user familiarization with multispectral data from aircraft and spacecraft and with earth resources survey discipline developments in general, many communicative techniques were explored during the course of the Ohio ERTS-1 program. The major user awareness technique employed and the one found most effective involved laboratory demonstrations which illustrated what ERTS-1 data revealed in magnified, color composited and enhanced, and digitized formats. During the nearly two-year program, over 1,000 visitors were exposed to ERTS-1 data during visits to Battelle's Remote Sensing Applications Laboratory. Many of the visitors represented working-level planners and decision makers from the various participating state agencies who made repeated visits to jointly analyze ERTS data in regard to a variety of state data requirements. Other visitors included educators and students, regional and city planners, and interested researchers from other states and countries.

To supplement user awareness communicative efforts via telephone and personal visitations, an Ohio ERTS Data User Handbook was prepared and distributed to key people with resource management responsibility throughout Ohio governmental agencies. The handbook contained tutorial information about the ERTS-1 system and potential uses along with sample data products. Since the handbook appeared to have limited value relative to the cost of photographically reproducing useable ERTS-1 scenes, initial plans for periodically up-dating the handbook were not realized. Instead, the handbook effort was replaced by the preparation of explicit and detailed demonstration products in specific application areas such as surface mining[7] and land use.[8] The demonstration products were widely distributed to many more potential ERTS data users. The demonstration products proved much more effective than the user handbook in communicating with potential end users.

Near the end of the program, as a response to almost daily requests from various governmental personnel throughout Ohio to have ERTS-1 capabilities and data use possibilities explained and demonstrated, and to assist the state in making the final utility assessment, the Ohio Department of

Economic and Community Development in conjunction with Battelle's Columbus Laboratories sponsored an Ohio ERTS/Skylab Data User Workshop in March 1974. The workshop agenda has been included in Appendix B of this report. Approximately 100 land use, resource, and environmental planners from all sections and levels of government and private sectors participated in this two day workshop. While serving basically as another user awareness activity, the workshop was also tailored to solicit user views as to the potential usefulness and/or limitations of data and data products obtainable from satellite surveys. The major results derived from this workshop were summarized in Section 5.2.2 of the Data Utility Assessment. The workshop, took place outside the laboratory, and more successful than other Ohio ERTS outside-the-laboratory meetings and seminars, mainly because some equipment for analyzing the data were transported to the workshop location (See Figure 51).

As planned, other communicative efforts were expended in additional public awareness activities. Most significant were the following:

- An exhibit describing the Ohio-ERTS program was prepared for the Governor's booth at the 1972 Ohio State Fair (see Figure 52). The exhibit/display also contained a short film describing the ERTS-1 program and a pamphlet describing the Ohio ERTS-1 program specifically. Similar displays were also prepared for the 1973 and 1974 Ohio State Fairs by the Ohio Department of Transportation.
- On December 21, 1972, a press announcement was made and a statewide news conference was arranged to describe Ohio's optimistic reaction to initial ERTS-1 imagery on Ohio. The news conference was held in Battelle's Remote Sensing Applications Laboratory and demonstrated the ability of ERTS-1 MSS imagery to provide the means for detecting and mapping strip mined areas in southeastern Ohio, detecting power-plant smoke plumes and providing the data necessary to compile up-to-date land-use maps. The electronic and newspaper coverage of this conference was assessed as exceptional by state officials.

- On May 16, 1973, the Battelle Remote Sensing Applications Laboratory and the multidisciplinary Ohio ERTS and Skylab programs were the subject of an electronic news conference which resulted in a four-minute special feature during the local CBS TV evening news broadcast.
- On June 14, 1973, the Professional Land Surveyors of Central Ohio held their monthly meeting at Battelle's Remote Sensing Applications Laboratory at which time the Ohio ERTS-1 project was reviewed and a laboratory demonstration provided.
- The Ohio ERTS program was featured in a full-page article written by William McCann in the August 20, 1973, edition of the Cleveland Plain Dealer.
- Press coverage of the program activities occurred at various times and extensive coverage resulted from the Ohio ERTS/Skylab Data User Workshop held on March 4-5, 1974.

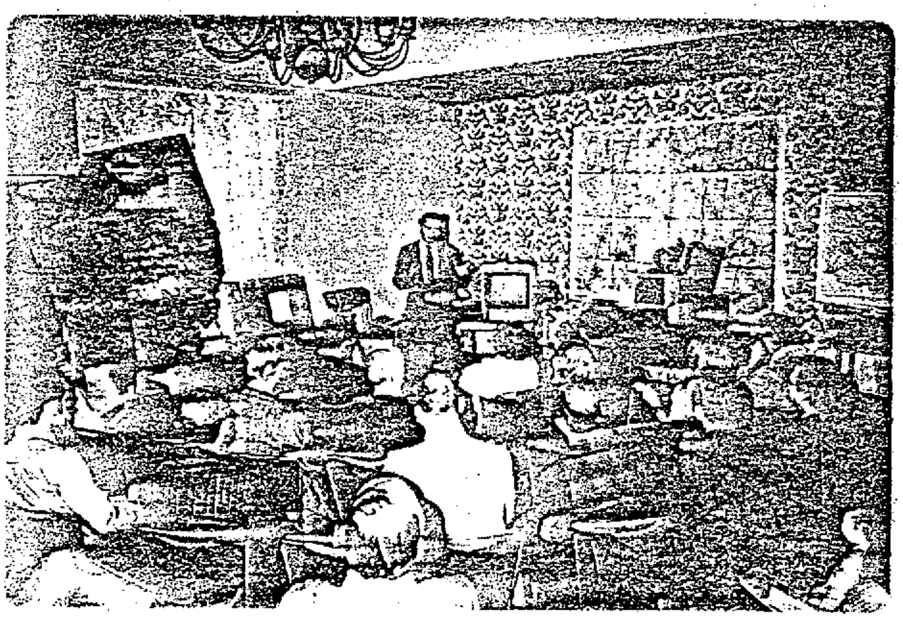

FIGURE 51. EQUIPMENT AND DISPLAYS AT THE OHIO ERTS/SKYLAB DATA USERS WORKSHOP, STOUFFER'S UNIVERSITY INN, COLUMBUS, OHIO, MARCH 4-5, 1974

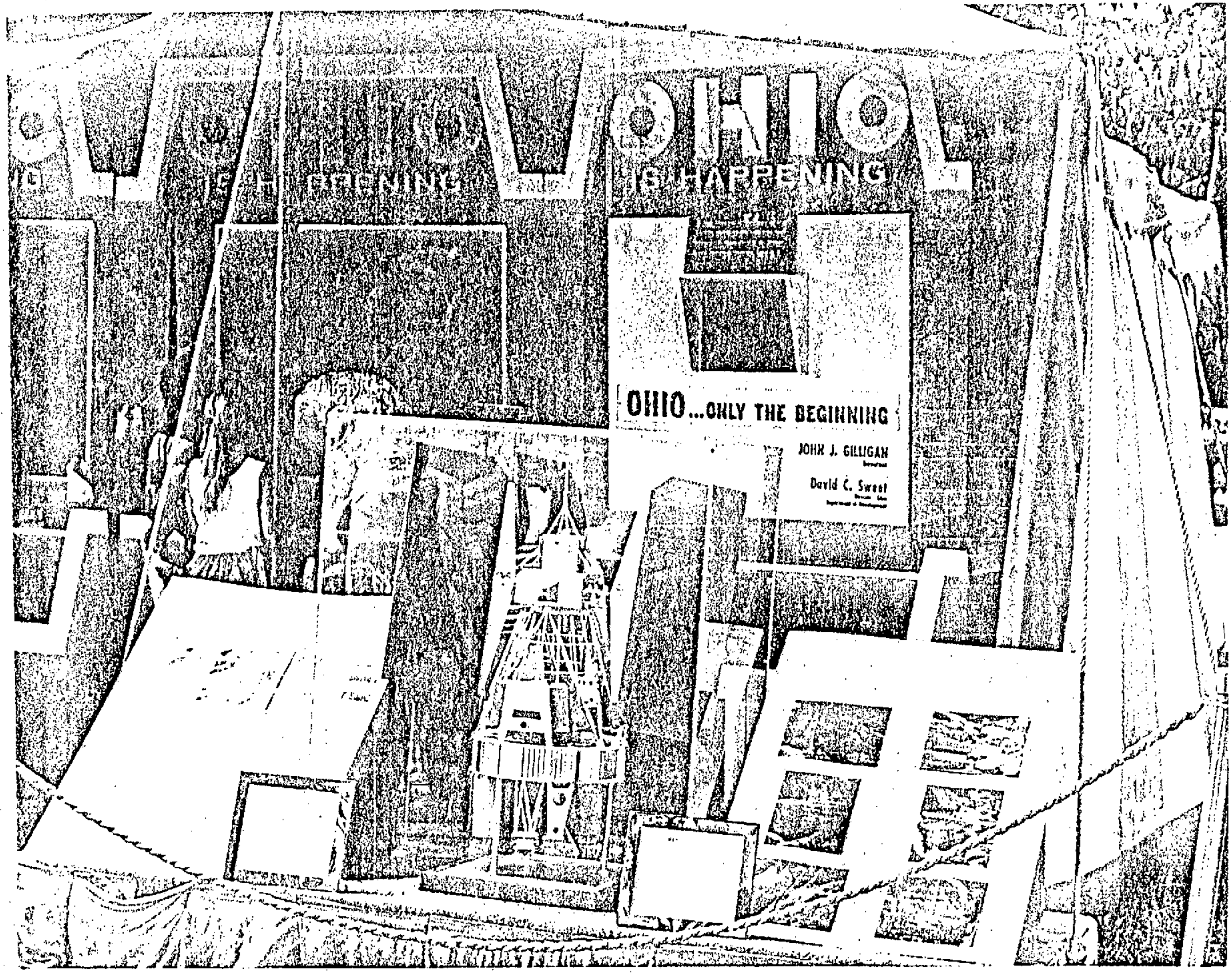

FIGURE 52. OHIO ERTS PROGRAM EXHIBIT AT THE 1972 OHIO STATE FAIR

7.0 MISCELLANEOUS

Ohio ERTS-1 program efforts relating to education, NASA, and professional coordination are summarized below.

7.1 Education

Ohio ERTS-1 program efforts have also contributed to the pursuit of the educational implications of this new technology. Close cooperation was maintained with the Committee on Remote Sensing at The Ohio State University which is providing academic leadership locally in this area.

During the week of October 23-27, 1972, some ten State of Ohio and Battelle staff members participated in the remote sensing short course held at The Ohio State University which was supported in part by the Ohio Department of Economic and Community Development. The course covered all aspects of the theory and practice of remote sensing of potential importance to the resource manager. A second similar short course is planned for late 1974. At the request of the Remote Sensing Committee of The Ohio State University, interdepartmental graduate-level seminars on the analysis and multidisciplinary applications of ERTS-1 data were conducted by the Ohio ERTS-1 project staff as part of a course taught in the Spring of 1973 and 1974. The seminars at The Ohio State University were followed by two-hour, in-the-laboratory seminars at Battelle's Remote Sensing Applications Laboratory. In addition to the seminars, several students were assisted in their educational pursuits during the Ohio ERTS-1 program. This assistance included consultations and graphic products for graduate theses. The Committee on Remote Sensing has recently completed plans for establishing a formal undergraduate degree program in remote sensing at The Ohio State University.

At the request of the Cooperative Extension Service of The Ohio State University, Ohio ERTS-1 project staff members discussed land use applications of ERTS data and the Ohio orbital survey programs at the Cooperation Extension Services' Land Use Planning Workshop held on September 12, 1973, at The Ohio State University. Later that day at

Battelle's Remote Sensing Application Laboratory, land use applications of ERTS-1 data were demonstrated to more than thirty of the extension agents participating in the two-day workshop.

7.2 NASA and Professional Coordination

State of Ohio and Battelle representatives attended the NASA meeting describing the preliminary findings from analysis of ERTS-1 observations held at Goddard Space Flight Center on September 29, 1972, and selected sessions of the Eighth International Symposium on Remote Sensing of the Environment that followed.

Mr. George Wukelic and Mr. Joachim Stephan of Battelle Columbus Laboratories and Mr. Terry Wells of the State of Ohio attended the ERTS-1 Symposium held by NASA at the Sheraton Motor Inn in New Carrollton, Maryland, on March 5-9, 1973. Mr. Wukelic presented the paper entitled "Resource Management Implications of ERTS-1 Data to Ohio".(3)

State and Battelle personnel assisted NASA Lewis officials in formulating a presentation for a Governors' conference on ERTS data use. Thirty-five mm slides of Ohio orbital survey data, data acquisition and analysis equipment and orbital survey demonstration products were given to the NASA Lewis staff for their presentations. Also, cloud free ERTS-1 MSS Band 5 70-mm negatives were provided to NASA Lewis Research Center for constructing a photo mosaic of the entire State of Ohio for education/public relation purposes.

In an effort to inform the Office of Management and Budget of Ohio's interest in satellite survey opportunities and concern regarding recent ERTS/Skylab funding decisions, a letter prepared by Governor John J. Gilligan of Ohio, was sent to Director Roy Ash of the Office of Management and Budget. A letter also was sent from Governor John J. Gilligan of Ohio to Mr. Richard Fairbanks, Associate Director of President Nixon's Domestic Council which noted the potential relevance of the ERTS program to Ohio's resource management, planning and legislative activities and expressed concern of the lack of funding incentives for state users.

On October 30, 1973, Paul Pincura and Terry Wells representating the State of Ohio and Joachim Stephan of Battelle Columbus Laboratories presented a forty-five minute review of the Ohio ERTS-1 program to a NASA Earth Resources Discipline Panel at Goddard Space Flight Center. As a result of the NASA discipline panel reviews, a summary of the Ohio ERTS-1 Program was presented at the Third ERTS-1 Principal Investigator's Symposium sponsored by Goddard Space Flight Center which was held during the week of December 10 to December 13, 1973, in Washington, D. C.(5) During this conference The Honorable Charles A. Mosher of Ohio, Chairman of the U. S. House of Representatives' Committee on Science and Astronautics, was briefed by Paul Pincura of the Ohio Department of Economic and Community as to the relevance of the ERTS program to Ohio.

Also, on October 30, 1973, Mr. Clem Meier of the Ohio Department of Natural Resources presented a similar paper written by State of Ohio and Battelle-Columbus personnel titled "Application of Remote Sensing to Resource Management at the State Level" at the symposium on Management and Utilization of Remote Sensing Data at Sioux Falls, South Dakota.(4) This paper summarized and pictorally displayed the usefulness of orbital survey data to comtemporary resource management problems faced by various departments and agencies of the State government in Ohio.

On November 1 and 2, 1973, State and Battelle personnel reviewed Ohio's orbital survey programs with Mr. Alexander J. Tuyahov, an associate of the Earth Satellite Corporation (EARTHSAT) and Mr. David W. Stroh, an associate of the Development Research Associates, who were conducting an ERTS benefit analysis study for the United States Department of Interior.

The Ohio ERTS/Skylab earth resources survey program was the subject of a paper titled "Multidisciplinary Applications of ERTS and Skylab Data in Ohio" which was presented at the Ninth International Symposium on Remote Sensing of Environment held on April 15-19, 1974, in Ann Arbor, Michigan.(6)

On June 25, 1974, Mr. Paul G. Pincura, Ohio Department of Economic and Community Development (ODECD), presented a review of the Ohio ERTS and Skylab program to educational representatives attending a workshop at the NASA Lewis facilities.

8.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the results of the Ohio ERTS-1 user program and contains conclusions and recommendations important to improving future earth resource satellite survey programs.

8.1 Summary

This program has successfully established an ERTS data analysis facility, a valuable photographic and radiometric data base on Ohio, and a core team of technical and administrative experts familiar with the opportunities and limitations of current orbital survey data. Participants from state, regional and local levels contributed to this preliminary utility assessment. In almost all cases, actual Ohio ERTS-1 program activities followed those proposed. As planned, data collection efforts included on-site photographic and radiometric surveys as well as multispectral aerial underflight photography. These correlative data inputs were extremely valuable for determining and verifying ERTS-1 data applications and accuracies in the areas of environmental quality, land use and resource management.

Although a drain on available and limited resources, a variety of user awareness activities were conducted to precipitate the technology transfer process. Techniques found most effective were those in which potential users, technical specialists, and data analysis equipment capable of displaying ERTS data in enlarged and color-encoded formats were brought together either in the laboratories or in a workshop environment. The procedure also facilitated the experimental testing of the practical use of ERTS data for near real-time problem-solving situations.

Most analyses of the multispectral and multidata ERTS imagery were performed by especially designed electro-optical equipment. Computer tape analysis was done primarily to demonstrate results obtainable by using the ERTS digitized data. Negative atitudes resulted in most cases where potential user/user groups were exposed to only ERTS-1 imagery in the original small scale format.

Considering the experimental nature of the initial ERTS-1 effort and the limited remote sensing experience of most of the participants, program results are considered quite successful. Specific data application possibilities in each of the three discipline areas researched have been identified and ranked according to user relevance and operational promise. Based on current ERTS-1 data limitations, other use possibilities have been evaluated and rejected or identified as requiring additional analysis. Finally conclusions and recommendations important for improving the state level utility of future earth resources satellite systems have resulted from this experimental effort. These are provided below.

8.2 General Conclusions and Recommendations

1. ERTS type data can be of significant practical value to on-going and anticipated statewide environmental and resource management programs. Recommendation - NASA and Department of Interior continue to develop earth resources satellite systems responsive to state-level user needs.
2. State-level ERTS-1 data utilities are of two distinct types; routine and as needed (mostly one-time) uses. Recommendation - NASA/Department of Interior should recognize and foster both data use opportunities.
3. States with little remote sensing experience/capabilities can effectively participate in satellite data utility activities if available research and planning personnel are educated as to ERTS data products and capabilities. Recommendation - A series of ERTS user assistance programs for identifying, educating and assisting potential state user(s) should be established.
4. State, regional and local governments, as well as private interests in using satellite acquired data are steadily growing but immediate major investments for routine use of such data will be slow in materializing. Recommendation -

Clarification of federal goals/objectives in the earth resources orbital survey applications area is required as well as an initiation of a formal cost-sharing incentive program for motivating participation of potential user groups.

5. Most major benefits associated with state government use of ERTS type data relate to law enforcement functions. Unfortunately, current ERTS capabilities are not adequate for most state enforcement data requirements. Recommendation - Serious consideration should be given to providing specialized orbital payloads having spectral, spatial and temporal data capabilities commensurate with state legislation enforcement needs, particularly in the environmental area.

6. ERTS activities are suffering from the "solution looking for a problem" syndrome that is adversely affecting user support of this new technology. Recommendation - Separate ERTS program activities should be initiated in the areas of (1) education, (2) research, (3) application demonstration, and (4) end-users.

7. Aircraft underflight data and on-site ground surveys are necessary to identify application avenues, to establish interpretation accuracies, and to verify procedures for routine/operational uses. Recommendation - More time and dollars should be expended on ground truth and aircraft data acquistion, data correlation and extension analyses before extensive state-level operational uses are expected.

8. The acceptance of remote sensing technology as a tool for state-level problem solving and decision making will be paced more by analysis and product development progress, rather than satellite system remote sensing capability improvements. Recommendation - More effort should be expended on identifying and developing procedures and products responsive to user capabilities and needs at the state, regional and local levels.

9. Numerous domestic and foreign ERTS-1 investigators are generating results of potential significance to end users. Because of the similarity in problems, analyses techniques and applications analyzed, better communications, particularly among user participants, are required to avoid unnecessary duplication of efforts. Recommendation - More "user oriented" publications, meetings and programs should be supported in addition to the broad "discipline oriented" meetings currently being held.

10. State-level assessments of satellite data utility are at such a preliminary stage that realistic time and cost savings estimates can not be derived. Future state program participation, justification and investment options will be influenced by the generation of reliable estimates and adversely affected by undocumented claims. Recommendation - Effort expended in the ERTS cost-benefit area should be directed at fewer but more realistic cases in which adequate data exist to permit their documentation.

8.3 Specific Conclusions

1. Initial research indicates that multispectral and multidate satellite data such as ERTS will be of practical value to state agencies in planning, monitoring, and controlling surface mining activities. Satellite coal strip mining progress monitoring in Ohio is currently a prime candidate for becoming a routine application. The extendability of this capability to other surface mining activities in Ohio requires further analyses and evaluation. Similarly, further research is required to determine the extent that satellite data can be used routinely and economically by states such as Ohio for surface mining (all minerals) reclamation monitoring functions. Certainly increased resolution (to 10-30 meters), the addition of a thermal infrared channel and more frequent coverage would increase the value of future satellite surveys for surface mining applications.

2. Large smoke plumes such as from power plants have been readily discerned which can potentially contribute to statewide air quality modeling and and to studies of the distribution and confluence of smoke plumes in critical environmental areas.

3. The lack of ERTS-1 MSS imagery for stereoviewing was a major disadvantage. Stereoscopic viewing of adjacent ortho traces revealed only "noise", except as related to actual displacement of ground feature images. Since the images are formed under computer control, NASA should consider processing a second frame with the image displaced by a parallax proportional to terrain height for stereoviewing and interpretation.

In many applications ERTS-1 MSS images were found to be true orthophotos since the verticality was closely controlled and the coverage was less than 6° as compared to common mapping photography with 90° coverage. Since ERTS-1 images are corrected in processing for scale and position, they were well suited for simple map inspection and gross planimetric revision. For example, a simple overlay of USGS 1/250,000 map transparencies onto a 1/250,000 ERTS mosaic of Ohio revealed the long overdue need of revision of the USGS map series. However, ERTS-1 MSS image resolution was not sufficient for the actual revision since the pixel size was too large to achieve national map accuracies for large scale maps.

4. Ohio ERTS-1 program efforts evaluated and demonstrated the types of imagery and digital satellite survey data analysis techniques and products that can be produced on a routine basis for land use parameters. Evaluations indicated that ERTS data are more than adequate for periodically mapping and inventorying major natural and cultural surface features at scales smaller than 1:24,000 and at less cost and with better accuracies than with previous techniques.

5. For selected study-site areas, thematic transparencies from ERTS-1 imagery are over 95 percent accurate for mature forested areas in excess of 10 hectares (25 acres), and although the accuracy has not as yet been determined for extrapolated regions, it appears comparable to the USGS 1:24,000 maps and more accurate than the 1:250,000, especially for urbanized areas.

6. ERTS-1 scale imagery does not provide for sharp delination of geometric configurations at relative low contrast ratios. The identification and inventorying of features with similar tones such as those found in midwest agriculture (e.g., corn and soybean) are difficult because of this spatial limitation. Also, ERTS-1 spectral resolution is not adequate to provide routine separation of midwestern crops having similar spectral signatures. As a result, temporal analysis procedures are extremely important to the successful application of ERTS-1 data for agricultural surveys in Ohio.

7. Providing ERTS data on a more frequent basis during the winter season could improve the operational potential for using such synoptic data for extending the navigation season on Lake Erie. Also, a more frequent cycle would permit stereo determinations of ice flow velocities and trajectories.

8. The single Ohio data collection platform demonstrated the capability of ERTS-1 to relay environmental quality data several times a day when functioning properly. However, Ohio EPA personnel consider sensors, especially water quality monitoring sensors, too complex to be operated remotely in conjunction with a data collection platform. Experience to date with remotely sensed data indicated that frequent in-the-field service requirements were as expensive as periodic sampling by field personnel.

9. The most significant program result was the swiftness with which remote sensing from space captured the interest and confidence of potential state and local user groups, in spite of their limited experience in the application of remote sensing technology. Many user agency personnel are now knowledgeable and qualified in applications of ERTS-1 and other remotely sensed data.

10. The program experimentally verified that multispectral and multidate satellite imagery has definite utility in planning and management functions of various Ohio governmental agencies, in designing and enforcing legislation, and in achieving Ohio environmental protection and resource management goals. As a direct short-term spin-off, the State of Ohio further benefited from participation in the ERTS program by the strengthening of relations between and among major state agencies, especially in the area of functional planning assistance and coordination.

11. The development of a completely state-supported operational program for utilizing experimentally demonstrated ERTS-1 data applications will be a difficult task for the State of Ohio or any single unit of government to accomplish without federal resource assistance.

12. Continuing research programs aimed at using orbital survey data for resource management problem solving in Ohio are viewed as desirable, both from the viewpoint of benefiting the citizens of the State of Ohio as well as providing the necessary experience for developing statewide capabilities for the routine use of such data in the future.

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APPENDIX A

COVERAGE AND QUALITY OF OHIO ERTS-1 DATA

APPENDIX A

COVERAGE AND QUALITY OF OHIO ERTS-1 DATA (BY ORBITAL TRACE)

Date	Time	Area	Quality Comments*
		TRACE 1	
8/21/72	15353	Eastern Lake Erie	Very good
8/21/72	15354	Eastern Ohio and Pennsylvania	Very good
8/21/72	15361	SE Ohio and West Virginia	Very good
9/8/72	15355	NE Ohio and Pennsylvania	Very poor
9/8/72	15362	SE Ohio and 90% West Virginia	Poor
9/26/72	15361	SE Ohio and 90% West Virginia	Poor
10/14/72	15354	NE Ohio and Lake Erie	Good
10/14/72	15361	Eastern Ohio and Pennsylvania	Good
10/14/72	15363	SE Ohio and 90% West Virginia	Poor
12/7/72	15362	NE Ohio and Pennsylvania	Very poor
12/7/72	15364	Eastern Ohio	Excellent
12/7/72	15371	SE Ohio and 90% West Virginia	Poor
1/12/73	15355	NE Ohio and Pennsylvania	Good
1/12/73	15362	Eastern Ohio and Pennsylvania	Good
1/12/73	15364	SE Ohio and 90% West Virginia	Good
2/17/73	15362	NE Ohio and Pennsylvania	Excellent
2/17/73	15365	Eastern Ohio, West Virginia, & Pennsylvania	Excellent
2/17/73	15371	SE Ohio and 90% West Virginia	Good
2/17/73	15374	SE Ohio, West Virginia, & Kentucky	Very good
3/7/73	15375	SE Ohio and West Virginia	Fair
3/25/73	15375	SE Ohio and West Virginia	Fair
4/12/73	15364	NE Ohio and Western Lake Erie	Fair
4/30/73	15363	NE Ohio and Western Lake Erie	Fair
5/18/73	15362	NE Ohio and Western Lake Erie	Fair
5/18/73	15365	Eastern Ohio and Pennsylvania	Fair
5/18/73	15371	SE Ohio and West Virginia	Good
5/18/73	15374	SE Ohio, West Virginia, & Kentucky	Good
6/5/73	15361	NE Ohio and Western Lake Erie	Good
6/5/73	15363	Eastern Ohio and Western Pa.	Fair
6/5/73	15370	SE Ohio and West Virginia	Fair
6/5/73	15372	SE Ohio, West Virginia, & Ky.	Fair
6/23/73	15360	NE Ohio and Western Lake Erie	Fair
6/23/73	15365	SE Ohio and West Virginia	Fair
7/29/73	15353	NE Ohio and Western Lake Erie	Poor
7/29/73	15355	Eastern Ohio and Western Pa.	Very poor
7/29/73	15362	SE Ohio and West Virginia	Very poor
7/29/73	15364	SE Ohio, West Virginia, & Ky.	Poor
8/16/73	15351	NE Ohio and Western Lake Erie	Fair
8/16/73	15354	Eastern Ohio and Western Pa.	Poor

* Quality relates to general cloud cover condition over area covered by satellite photography.

Date	Time	Area	Quality Comments*
		TRACE 1 (Continued)	
9/3/73	15350	NE Ohio and Western Lake Erie	Excellent
9/3/73	15352	Eastern Ohio and Western Pa.	Excellent
9/3/73	15355	SE Ohio and West Virginia	Excellent
9/3/73	15361	SE Ohio, West Virginia, and Ky.	Excellent
9/21/73	15343	NE Ohio and Western Lake Erie	Fair
9/21/73	15350	Eastern Ohio and Western Pa.	Fair
10/9/73	15340	NE Ohio and Western Lake Erie	Poor
10/9/73	15343	Eastern Ohio and Western Pa.	Very poor
10/9/73	15345	SE Ohio and West Virginia	Very poor
10/9/73	15352	SE Ohio, West Virginia, & Ky.	Poor
10/27/73	15334	NE Ohio and Western Lake Erie	Fair
10/27/73	15340	Eastern Ohio and Western Pa.	Fair
10/27/73	15343	SE Ohio and West Virginia	Excellent
11/14/73	15333	NE Ohio and Western Lake Erie	Good
12/2/73	15332	NE Ohio and Western Lake Erie	Excellent
12/2/73	15335	Eastern Ohio and Western Pa.	Excellent
12/2/73	15341	SE Ohio and West Virginia	Excellent
1/25/74	15320	NE Ohio and Western Lake Erie	Excellent
1/25/74	15322	Eastern Ohio and Western Pa.	Good
1/25/74	15325	SE Ohio and West Virginia	Good
2/12/74	15315	Eastern Ohio and Western Pa.	Fair
2/12/74	15322	SE Ohio and West Virginia	Very Good
3/20/74	15305	NE Ohio and Western Lake Erie	Excellent
3/20/74	15312	Eastern Ohio and Western Pa.	Excellent
3/20/74	15314	SE Ohio and West Virginia	Fair
5/31/74	15302	Eastern Ohio and Western Pa.	Poor
5/31/74	15304	SE Ohio and West Virginia	Poor
		TRACE 2	
8/22/72	15405	NE Ohio, Lake Erie, and Canada	Poor
8/22/72	15412	North from Salt Fork Lake	Poor
8/22/72	15414	East of Columbus, North of boot	Poor
8/22/72	15421	South of Ohio River boot	Poor
9/9/72	15411	NE Ohio, Lake Erie, and Canada	Poor
9/9/72	15414	East of Columbus	Poor
9/9/72	15420	SE Ohio and Kentucky	Fair

* Quality relates to general cloud cover condition over area covered by satellite photography.

Date	Time	Area	Quality Comments*
		TRACE 2 (Continued)	
10/15/72	15413	NE Ohio, Lake Erie, and Canada	Very poor
10/15/72	15415	East of Columbus	Fair
10/15/72	15422	SE Ohio and Kentucky	Fair
11/20/72	15420	NE Ohio, Lake Erie, and Canada	Very poor
1/13/73	15413	NE Ohio, Lake Erie, and Cleveland	Good
1/31/73	15415	NE Ohio, Lake Erie, and Cleveland	Very good
1/31/73	15422	East of Columbus	Very good
1/31/73	15424	SE Ohio and West Virginia	Very good
1/31/73	15431	South from Ohio River boot	Good
2/18/73	15421	NE Ohio, Lake Erie, and Cleveland	Very good
2/18/73	15423	East of Columbus	Good
2/18/73	15430	SE Ohio and Kentucky	Good
2/18/73	15432	South from Ohio River boot	Fair
3/8/73	15422	NE Ohio, Lake Erie, & Canada	Excellent
3/8/73	15424	Columbus and Eastern Ohio	Excellent
3/8/73	15431	SE Ohio	Excellent
3/8/73	15433	SE Ohio and Kentucky	Good
4/13/73	15422	NE Ohio, Lake Erie, and Canada	Good
4/13/73	15425	Columbus and Eastern Ohio	Fair
4/13/73	15431	SE Ohio	Poor
4/13/73	15434	SE Ohio and Kentucky	Very poor
5/1/73	15424	NE Ohio, Lake Erie, and Canada	Very poor
5/1/73	15430	Eastern Ohio	Very poor
5/1/73	15433	SE Ohio and Kentucky	Very poor
6/24/73	15414	NE Ohio, Lake Erie, and Canada	Poor
6/24/73	15420	Columbus and Eastern Ohio	Fair
6/24/73	15423	SE Ohio	Very good
6/24/73	15425	SE Ohio and Kentucky	Good
7/12/73	15415	Columbus and Eastern Ohio	Fair
7/12/73	15422	SE Ohio	Excellent
7/12/73	15424	SE Ohio and Kentucky	Excellent
7/30/73	15411	NE Ohio, Lake Erie, and Canada	Poor
7/30/73	15414	Columbus and Eastern Ohio	Fair
7/30/73	15420	SE Ohio	Good
7/30/73	15423	SE Ohio and Kentucky	Fair
8/17/73	15410	NE Ohio, Lake Erie, and Canada	Fair
8/17/73	15412	Columbus and Eastern Ohio	Fair
8/17/73	15415	SE Ohio	Poor

* Quality relates to general cloud cover condition over area covered by satellite photography.

Date	Time	Area	Quality Comments*
		TRACE 2 (Continued)	
9/4/73	15404	NE Ohio, Lake Erie, and Canada	Excellent
9/4/73	15410	Columbus and Eastern Ohio	Excellent
9/4/73	15413	SE Ohio	Excellent
9/4/73	15415	SE Ohio and Kentucky	Excellent
9/22/73	15404	NE Ohio, Lake Erie, and Canada	Poor
9/22/73	15410	Columbus and Eastern Ohio	Poor
9/22/73	15412	SE Ohio	Poor
10/10/73	15394	NE Ohio, Lake Erie, and Canada	Good
10/10/73	15401	Columbus and Eastern Ohio	Fair
10/10/73	15403	SE Ohio	Fair
10/10/73	15410	SE Ohio and Kentucky	Fair
12/3/73	15391	NE Ohio, Lake Erie, and Canada	Excellent
12/3/73	15400	SE Ohio	Excellent
12/3/73	15400	SE Ohio	Excellent
1/8/74	15382	NE Ohio, Lake Erie, and Canada	Good
1/8/74	15384	Columbus and Eastern Ohio	Good
1/26/74	15374	NE Ohio, Lake Erie, and Canada	Poor
2/13/74	15371	NE Ohio, Lake Erie, and Canada	Very Good
2/13/74	15374	Columbus and Eastern Ohio	Good
2/13/74	15380	SE Ohio	Poor
2/13/74	15383	SE Ohio and Kentucky	Fair
3/3/74	15381	SE Ohio	Fair
		TRACE 3	
9/28/72	15465	Toledo and Detroit	Poor
11/3/72	15473	NW Ohio, Lake Erie, and Toledo	Poor
11/3/72	15480	Columbus, SW Ohio, and East Liberty	Fair
11/3/72	15482	Southern Ohio and Kentucky	Very good
11/21/72	15474	NW Ohio, Lake Erie, and Toledo	Very poor
11/21/72	15474	NW Ohio	Very Poor
11/21/72	15483	Southern Ohio and Kentucky	Very Poor
12/27/72	15480	NW Ohio	Very poor
12/27/72	15482	Southern Ohio and Kentucky	Very poor
1/14/73	15481	Southern Ohio and Kentucky	Good
2/1/73	15480	NW Ohio and Lake Erie	Very poor
2/1/73	15474	NW Ohio	Very poor
2/19/73	15484	Southern Ohio and Kentucky	Fair
3/9/73	15480	NW Ohio, Lake Erie, and Canada	Very poor
3/9/73	15485	SW Ohio	Very poor
3/27/73	15481	NW Ohio, Lake Erie, and Canada	Excellent
3/27/73	15483	Columbus and Western Ohio	Excellent
3/27/73	15490	SW Ohio, Indiana, and Kentucky	Excellent

* Quality relates to general cloud cover condition over area covered by satellite photography.

Date	Time	Area	Quality Comments*
		TRACE 3 (Continued)	
4/14/73	15480	NW Ohio, Lake Erie, and Canada	Excellent
4/14/73	15483	Columbus and Western Ohio	Excellent
4/14/73	15474	SW Ohio, Indiana, and Kentucky	Excellent
5/2/73	15480	NW Ohio and Lake Erie	Very poor
5/2/73	15482	Western Ohio	Very poor
5/20/73	15475	NW Ohio, Lake Erie, and Michigan	Fair
6/7/73	15474	NW Ohio and Lake Erie	Excellent
6/7/73	15480	Columbus and Western Ohio	Good
6/7/73	15483	SW Ohio, Indiana, and Kentucky	Good
6/25/73	15472	NW Ohio and Lake Erie	Excellent
6/25/73	15475	Columbus and Western Ohio	Excellent
6/25/73	15481	SW Ohio, Indiana and Kentucky	Excellent
7/13/73	15471	NW Ohio and Lake Erie	Excellent
7/13/73	15474	Columbus and Western Ohio	Excellent
7/13/73	15480	SW Ohio, Indiana, and Kentucky	Excellent
8/18/73	15464	NW Ohio and Lake Erie	Good
8/18/73	15471	Columbus and Western Ohio	Good
8/18/73	15473	SW Ohio, Indiana, and Kentucky	Fair
9/5/73	15465	Columbus and Western Ohio	Poor
9/5/73	15471	SW Ohio, Indiana, and Kentucky	Poor
9/23/73	15460	NW Ohio and Lake Erie	Excellent
9/23/73	15462	Columbus and Western Ohio	Excellent
9/23/73	15465	SW Ohio, Indiana, and Kentucky	Good
10/11/73	15453	NW Ohio and Lake Erie	Excellent
10/11/73	15455	Columbus and Western Ohio	Excellent
10/11/73	15462	SW Ohio, Indiana, and Kentucky	Excellent
12/22/73	15443	NW Ohio and Lake Erie	Poor
12/22/73	15450	Columbus and Western Ohio	Poor
12/22/73	15452	SW Ohio, Indiana, and Kentucky	Poor
2/14/74	15430	NW Ohio and Lake Erie	Very Good
2/14/74	15432	Columbus and Western Ohio	Fair
2/14/74	15435	SW Ohio, Indiana, and Kentucky	Poor
3/4/74	15433	SW Ohio, Indiana, and Kentucky	Poor
3/22/74	15422	NW Ohio and Lake Erie	Good
3/22/74	15424	Columbus and Western Ohio	Excellent
3/22/74	15431	SW Ohio, Indiana, and Kentucky	Excellent
5/15/74	15410	NW Ohio and Lake Erie	Fair
5/15/74	15413	Columbus and Western Ohio	Poor
5/15/74	15415	SW Ohio, Indiana, and Kentucky	Very Poor
6/2/74	15403	NW Ohio and Lake Erie	Excellent
6/2/74	15405	Columbus and Western Ohio	Excellent
6/2/74	15412	SW Ohio, Indiana, and Kentucky	Excellent

*Quality relates to general cloud cover condition over area covered by satellite photography.

APPENDIX A. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 4	
8/24/72	15532	SW Ohio, Indiana, and Kentucky	Very poor
8/24/72	15523	Toledo and area to the West	Poor
10/17/72	15532	Western Ohio and Eastern Indiana	Poor
10/17/72	15535	SW Ohio, Indiana, and Kentucky	Very good
12/28/72	15541	SW Ohio, Indiana, and Kentucky	Very good
1/15/73	15533	Western Ohio and Eastern Indiana	Very poor
2/2/73	15532	NW Ohio, Michigan, and Indiana	Very poor
2/2/73	15535	Western Ohio and Eastern Indiana	Very poor
3/10/73	15541	Western Ohio and Eastern Indiana	Very poor
3/10/73	15544	SW Ohio, Indiana, and Kentucky	Fair
3/28/73	15535	NW Ohio	Very poor
4/15/73	15544	SW Ohio, Indiana, and Kentucky	Poor
5/3/73	15543	SW Ohio, Indiana, and Kentucky	Very poor
5/21/73	15533	Southern Michigan and NW Ohio	Good
5/21/73	15540	Western Ohio and Eastern Indiana	Very good
5/21/73	15542	SW Ohio, Indiana, and Kentucky	Very good
6/8/73	15532	NW Ohio, Michigan, and Indiana	Excellent
6/8/73	15534	Western Ohio and Eastern Indiana	Very good
6/8/73	15541	SW Ohio, Indiana, and Kentucky	Good
7/14/73	15525	NW Ohio, Michigan, and Indiana	Fair
7/14/73	15532	Western Ohio and Eastern Indiana	Fair
8/19/73	15531	SW Ohio, Indiana, and Kentucky	Fair
9/6/73	15520	NW Ohio, Michigan, and Indiana	Good
9/6/73	15523	Western Ohio and Eastern Indiana	Poor
9/6/73	15525	SW Ohio, Indiana, and Kentucky	Poor
9/24/73	15514	NW Ohio, Michigan, and Indiana	Very Good
9/24/73	15520	Western Ohio and Eastern Indiana	Very Good
9/24/73	15523	SW Ohio, Indiana, and Kentucky	Good
10/12/73	15511	NW Ohio, Michigan, and Indiana	Poor
10/12/73	15513	Western Ohio and Eastern Indiana	Poor
10/12/73	15520	SW Ohio, Indiana, and Kentucky	Poor
11/17/73	15505	NW Ohio, Michigan, and Indiana	Very Good
11/17/73	15511	Western Ohio and Eastern Indiana	Very Good
11/17/73	15514	SW Ohio, Indiana, and Kentucky	Very Good

* Quality relates to general cloud cover condition over area covered by satellite photography.

APPENDIX A. (Continued)

Date	Time	Area	Quality Comments*
		TRACE 4 (Continued)	
12/5/73	15501	NW Ohio, Michigan, and Indiana	Very Poor
12/5/73	15510	Western Ohio and Eastern Indiana	Very Poor
12/5/73	15512	SW Ohio, Indiana, and Kentucky	Very Poor
1/28/74	15495	SW Ohio, Indiana, and Kentucky	Very Good
2/15/74	15484	NW Ohio, Michigan, and Indiana	Excellent
2/15/74	15490	Western Ohio and Eastern Indiana	Excellent
2/15/74	15493	SW Ohio, Indiana, and Kentucky	Excellent
3/5/74	15482	NW Ohio, Michigan, and Indiana	Very Good
3/5/74	15485	Western Ohio and Eastern Indiana	Fair
3/5/74	15491	SW Ohio, Indiana, and Kentucky	Fair
5/16/74	15471	Western Ohio and Eastern Indiana	Poor
5/16/74	15473	SW Ohio, Indiana, and Kentucky	Poor
6/3/74	15461	NW Ohio, Michigan, and Indiana	Excellent
6/3/74	15464	Western Ohio and Eastern Indiana	Excellent
6/3/74	15470	SW Ohio, Indiana, and Kentucky	Excellent

* Quality relates to general cloud cover condition over area covered by satellite photography.

APPENDIX B

OHIO ERTS SKYLAB DATA USER WORKSHOP AGENDA AND QUESTIONNAIRE

APPENDIX B

AGENDA
OHIO ERTS/SKYLAB DATA USER WORKSHOP

Stouffers University Inn
3025 Olentangy River Road
Columbus, Ohio 43202

March 4-5, 1974
9:00 A.M. - 3:30 P.M.

Monday, March 4, 1974

	PLENARY SESSION - Moderator - Larry L. Long, Chief, Bureau of Land Use Planning, Department of Economic and Community Development
9:00 A.M.	Introduction and Welcome - Dr. David C. Sweet, Director of the Ohio Department of Economic and Community Development
	Skylab and ERTS Films - NASA
	Coffee Break
	ERTS Background and Status - Dr. Herman Mark, NASA Lewis Research Center, and Fred Gordon, NASA Goddard Space Flight Center
	Skylab Background and Status - James E. Powers, NASA Headquarters, Washington, D. C.
	Orbital Survey Data Operational Implications - Dr. Richard C. Gerhan, Baldwin-Wallace College
11:30 A.M.	Lunch
1:00 P.M.	Ohio Satellite Program Summary - Paul G. Pincura, ERTS/Skylab Coordinator, Department of Economic and Community Develop.
	Battelle Program Involvement - George E. Wukelic, Battelle Columbus Laboratories
	Air and Water Applications - George B. Garrett, Ohio Environmental Protection Agency
	Surface Mining Reclamation Implications and Smoke Plume Detection - Dr. Wayne A. Pettyjohn, Ohio State University
	Natural Resource Applications With Emphasis on Strip Mining - Clemens J. Meier, Ohio Department of Natural Resources

Land Use Applications - Terry L. Wells, Department of Natural Resources

Coffee Break

Transportation Applications - Lloyd O. Herd, Ohio Department of Transportation

Forestry and Vegetation Applications - Dr. Dennis M. Anderson, Ohio Biological Survey

3:10 -3:30 Remote Sensing Applications for Ohio Agricultural Resource Planning - James M. Dowdy, Ohio State University

3:30 P.M. Local User Comments - Paul Baldridge, Columbus Department of Community Development; Ray M. Kuchling, Mid-Ohio Regional Planning Commission; David H. Hinson, Soil Conservation Service

Tuesday, March 5, 1974

LABORATORY PROBLEM-SOLVING SESSIONS - Joachim G. Stephan, H. E. Smail, and T. F. Ebbert of Battelle Columbus Laboratories

Note: Laboratory equipment designed to enhance satellite imagery will be present along with corresponding data to provide workshop participants an opportunity to apply ERTS/Skylab data to their regions and discipline interests.

9:00 A.M. Discipline Applications - Water Resources, Land Use, Forestry/Agriculture, Environmental Quality, and Mapping.

10:00 A.M. Functional Applications - Planning, Policy Formulation, and Legislation*

10:45 A.M. Area Analysis - Local, Regional, and State*

11:30 A.M. Lunch

1:00 P.M. Utility Evaluation Sessions - Paul G. Pincura, DECD; George E. Wukelic, BCL

Open Discussion and Comment Upon Data Utility - Workshop participants

* Sessions conducted in concert with DECD and Battelle personnel.

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APPENDIX B

OHIO ERTS/SKYLAB DATA USER QUESTIONNAIRE*

(1) NAME:

(2) AFFILIATION:

(3) Primary Interests:

(4) Who normally collects and analyzes the data?

	Collects	Analyzes
Your own agency		
Hired consultants		
Research organizations		
Other: ______________		
Not Applicable		

(5) What methods or combination of data collection and analysis methods currently provide the most effective results and effective use of manpower and money?

(6) % of your budget spent for data acquisition which could be provided by an operational satellite survey system; if any?

(7) % of your budget spent for data analysis and product generation that could be undertaken with satellite survey data analysis capabilities and equipment.

(8) Do present data acquisition/analysis methods provide adequate products in terms of:

Time:	Yes	No	Cost:	Yes	No
Useable Format:	Yes	No	Manpower:	Yes	No
Detail:	Yes	No			

(9) Utilizing the following categorized numbers, please list in order of use the following sources of data your agency utilizes:

Data Source	Data Frequency	Data Scale	Data Use	Data Cost
1. Existing maps	1. Daily	1. 1:10,000	1. Planning	1. Nominal
2. Existing published data (Census data)	2. Weekly	2. 1:24,000	2. Decision Making	2. Low
3. Ground surveys	3. Monthly	3. 1:50,000	3. Policy formulation	3. Medium
4. Aircraft photography	4. Seasonally	4. 1:125,000	4. Management	4. High
5. Orbital survey systems	5. Yearly	5. 1:250,000	5. Legislation	
6. Other: ________	6. Bi-yearly	6. 1:500,000	6. Educational	
7. No Data Source	7. Bi-decade	7. Other: ________	7. Research	
	8. Decade		8. Enforcement	
	9. Other: ________		9. Other: ________	

* Please return to Paul Pincura, Bureau of Land Use Planning, Department of Economic and Community Development, 65 South Front Street, Columbus, Ohio 43215

(10) From your viewpoint, how does ERTS-1 photographic data compare to the quality of information from other data sources?

More comprehensive	More accurate	More timely	More uniform	Totally new type of info.
Less comprehensive	Less accurate	Less timely	Less uniform	Other, specify

Can it be directly applied to your current program activities?

Yes No Needs to be investigated

From your viewpoint, how does ERTS-1 computerized data compare to the quality of information from other data sources?

More comprehensive	More accurate	More timely	More uniform	Totally new type of info.
Less comprehensive	Less accurate	Less timely	Less uniform	Other, specify

Can it be directly applied to your current program activities?

Yes No Needs to be investigated

(11) From your viewpoint, how does Skylab data photographic products compare to the quality of information from other data sources?

More comprehensive	More accurate	More timely	More uniform	Totally new type of info.
Less comprehensive	Less accurate	Less timely	Less uniform	Other, specify

Can it be directly applied to your current program activities?

Yes No Needs to be investigated

(12) What changes do you suggest should be made in future satellite earth resources survey systems to maximize data use?

Spectral Temporal (repetitive coverage) Resolution

(13) Would your organization be interested in supporting a program to use satellite data?

If yes - as single sponsor
as participant in group program
cost share with Federal Government

(14) Has this Ohio ERTS/Skylab Data User Workshop been worthwhile to you?

(15) Would you attend other such workshops? Yes ___ No___

(16) Is there any sensitivity to releasing information contained on this questionnaire?

Yes ___ No ___

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